PROJECT MANUAL

Fayetteville Regional Airport
FAY 01-05-3022
A.I.P No. 3-37-0027-044-2016

AIRLINE TERMINAL IMPROVEMENTS – Part 1

Owner:
THE CITY OF FAYETTEVILLE

TRANSPORTATION / CIVIL CONSULTANT:
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WILMINGTON, NC

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SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

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 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. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
B. Comply with NEMA MG 1 unless otherwise indicated.
C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS
A. Motor 1/2 HP and Larger: Three phase.
B. Motors Smaller than 1/2 HP: Single phase.
C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

F. 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. Housing shall be degreased, primed and painted both inside and outside with a rust inhibitive primer and corrosion resistant polyester paint. Paint prior to installing motor stator windings.

L. Screens: Provide stainless steel screens at motor ventilation openings.

M. Rotation: Coordinate motor rotation with requirements of the pump or fan.
N. Power Factor Correction Capacitors: Provide motor power factor correction capacitors for all motors rated 600 V or less (except variable frequency controlled motors) with less than 90% uncorrected power factor. Enclosure type shall be NEMA 12.

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. 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, start, capacitor run.
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 220513
SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

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


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

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with
nailing flange for attaching to wooden forms.

G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Presealed Systems.

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

2.5 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.
PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

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

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

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

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane
waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."

3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:


b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:


END OF SECTION 220517
SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

B. One-Piece, Deep- Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.
3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type.
   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 Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
   g. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.

2. Escutcheons for Existing Piping:
   a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
   d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
   e. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.
   f. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.
3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 220518
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Sections:
   1. Division 33 Section "Facility Water Distribution Piping" for domestic and fire-protection water service meters outside the building.

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

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

1. Ashcroft
2. Palmer - Wahl Instruments Inc.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.
5. Taylor

B. Case: Die-cast aluminum or brass, 7 inches long.

C. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass.

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

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

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

2.2 THERMOWELLS

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

1. AMETEK, Inc.; U.S. Gauge Div.
3. Ernst Gage Co.
5. Palmer - Wahl Instruments Inc.
6. Taylor.
7. Trerice, H. O. Co.
8. Weiss Instruments, Inc.

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

2.3 PRESSURE GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AMETEK, Inc.; U.S. Gauge Div.
3. Marsh Bellofram.
4. Palmer - Wahl Instruments Inc.
5. Trerice, H. O. Co.
6. Weiss Instruments, Inc.
7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
8. WIKA Instrument Corporation.

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

1. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
7. Window: Glass.
8. Ring: Brass.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

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

2.4 TEST PLUGS

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

1. Flow Design, Inc.
2. Texas.
3. Richardson.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping. Test plugs shall be 1/4 inch NPT fittings, suitable to receive a 1/8 inch outside diameter probe.
C. Minimum Pressure and Temperature Rating: 1000 psig at 200 deg F.

D. Core Inserts: One or two self-sealing rubber valves.
   1. Insert material for water service at 20 to 200 deg F shall be CR.
   2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS
   A. Install liquid-in-glass thermometers in the outlet of each domestic, hot-water storage tank.
   B. Provide the following temperature ranges for thermometers:
      1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions.
      2. Domestic Cold Water: 30 to 130 deg F, with 2-degree scale divisions.

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

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

K. Adjust faces of thermometers and gages to proper angle for best visibility.

L. On steam systems, provide siphon between gage and cock.

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Iron ball valves.
4. Bronze lift check valves.
5. Bronze swing check valves.
7. Iron swing check valves with closure control.
11. Iron gate valves.
14. Lubricated plug valves.
15. Chainwheels.

B. Related Sections:

1. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
2. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
D. NRS: Nonrising stem.
E. OS&Y: Outside screw and yoke.
F. RS: Rising stem.
G. SWP: Steam working pressure.

1.4 SUBMITTALS
A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE
A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
B. ASME Compliance:
   1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   2. ASME B31.1 for power piping valves.
   3. ASME B31.9 for building services piping valves.
C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set angle, gate, and globe valves closed to prevent rattling.
   4. Set ball and plug valves open to minimize exposure of functional surfaces.
   5. Set butterfly valves closed or slightly open.
   6. Block check valves in either closed or open position.
B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.
PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

A. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

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

   b. Jamesburg.
   c. Milwaukee Valve Company.
2. Description:
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Three piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. DeZurik Water Controls.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Norriseal; a Dover Corporation company.
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: NBR.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.

2.4 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Milwaukee Valve Company.
   f. NIBCO INC.

2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 300 psig.
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: Bronze.

2.5 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Kitz Corporation.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Powell Valves.
   h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Gasket: Asbestos free.
2.6 BRONZE GATE VALVES

A. Class 150, NRS Bronze Gate Valves:

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

      a. Milwaukee Valve Company.
      b. NIBCO INC.
      c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:

      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 300 psig.
      d. Ends: Threaded.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron.

2.7 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

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

      a. Crane Co.; Crane Valve Group; Stockham Division.
      b. Milwaukee Valve Company.
      c. NIBCO INC.
      d. Powell Valves.
      e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:

      a. Standard: MSS SP-70, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Disc: Solid wedge.
      g. Packing and Gasket: Asbestos free.
2.8 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:

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

   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Kitz Corporation.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

2.9 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

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

   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Packing and Gasket: Asbestos free.

2.10 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Description:
   a. Standard: MSS SP-78, Type II.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   d. Pattern: Regular or short.
   e. Plug: Cast iron or bronze with sealant groove.

2.11 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries.
   3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   2. Attachment: For connection to ball, butterfly and plug valve stems.
   3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.

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.
3.2 VALVE INSTALLATION

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

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for ball, butterfly, gate, globe, and plug valves NPS 6 and larger and more than 72 inches above floor. Extend chains to 72 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball, butterfly, or gate valves.
   3. Throttling Service: Globe, ball, or butterfly valves.
   4. Pump-Discharge Check Valves:
      a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
      b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring or iron, center-guided, resilient-seat check valves.
      c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

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

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

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Bronze Ball Valves: Three piece, full port, bronze with stainless-steel trim.
   3. Bronze Swing Check Valves: Class 150, bronze disc.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Bronze Ball Valves: Three piece, full port, bronze with stainless-steel trim.
   3. Iron Swing Check Valves: Class 125, nonmetallic-to-metal seats.
   4. Iron, Center-Guided Check Valves: Class 150, globe, resilient seat.
   5. Iron Gate Valves: Class 125, NRS.

3.6 SANITARY-WASTE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Ball Valves: Three piece, full port, brass with stainless-steel trim.
   3. Bronze Swing Check Valves: Class 150, bronze disc.

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe positioning systems.
7. Equipment supports.

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
3. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

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

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

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

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

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.
2. Fiberglass pipe hangers.
3. Thermal-hanger shield inserts.
4. Powder-actuated fastener systems.
5. Pipe positioning systems.

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

1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Fiberglass strut systems. Include Product Data for components.
4. Pipe stands. Include Product Data for components.
5. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."
3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to,
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

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

B. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. Bergen-Power Pipe Supports.
4. Carpenter & Paterson, Inc.
5. Empire Industries, Inc.
6. ERICO/Michigan Hanger Co.
7. Globe Pipe Hanger Products, Inc.
8. Grinnell Corp.
9. GS Metals Corp.
11. PHD Manufacturing, Inc.
12. PHS Industries, Inc.
13. Piping Technology & Products, Inc.
14. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

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

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

2.3 TRAPEZE PIPE HANGERS

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

2.4 METAL FRAMING SYSTEMS

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

B. Available Manufacturers:

2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.

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

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

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Available manufacturers:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

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

1. Available Manufacturers:

   a. Hilti, Inc.
   b. ITW Ramset/Red Head.
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

B. Available Manufacturers:

2. HOLDRITE Corp.; Hubbard Enterprises.
3. Samco Stamping, Inc.

2.8 EQUIPMENT SUPPORTS

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

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi, 28-day compressive strength.
3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

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

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

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

E. Use padded hangers for piping that is subject to scratching.

F. Pipe guides shall not be used as supports.

G. In no case shall wire or perforated strap be used for pipe or conduit support.

H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-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.
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 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 2 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 20, 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.

I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

J. 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.

K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams,
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Fayetteville, North Carolina
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RMF Engineering, Inc. July 18, 2016

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.

L. 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.

M. 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 absorb 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 absorb expansion and contraction of piping system from
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.

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.

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

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

P. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

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

3.2 HANGER AND SUPPORT INSTALLATION

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

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

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

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. 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.

F. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

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


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

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

K. 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.

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

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

N. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 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 inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

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

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

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

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

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

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

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

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes plumbing piping heat tracing for freeze prevention and waste grease build-up with the following electric heating cables:

1. Self-regulating, parallel resistance.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.


C. Field quality-control test reports.

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

E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
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1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: **10** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Raychem XL-Trace or a comparable product by one of the following:

1. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company.
2. Thermon Manufacturing Co.

B. Heating Element: Pair of parallel No. 16 AWG, nickel-coated stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: Tinned-copper braid and polyolefin outer jacket with UV inhibitor.

E. Maximum Operating Temperature (Power On): 150 deg F.

F. Maximum Exposure Temperature (Power Off): 150 deg F.

2.2 CONTROLS

A. Pipe-Mounting Thermostats for Flow Maintenance:

1. Remote bulb unit with adjustable temperature range from 90 to 120 deg F.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Division 22 Section "Identification for Plumbing Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Install the following type of electric heating cable for the applications described:

1. Temperature Maintenance to prevent grease build-up in grease waste piping: Self-regulating, parallel-resistance heating cable.

3.3 INSTALLATION

A. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written recommendations using cable protection conduit and slack cable to allow movement without damage to cable.

B. Electric Heating Cable Installation to prevent grease build-up in grease waste piping:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install insulation over piping with electric heating cables according to Division 22 Section
HEAT TRACING FOR PLUMBING PIPING

3. Install warning tape on piping insulation where piping is equipped with electric heating cables.

C. Set field-adjustable switches and circuit-breaker trip ranges.

D. Protect installed heating cables, including nonheating leads, from damage.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.5 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.

1. Test cables for electrical continuity and insulation integrity before energizing.
2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 220533
SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Elastomeric hangers.
3. Spring hangers.
4. Pipe riser resilient supports.
5. Resilient pipe guides.

1.3 DEFINITIONS

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Seismic Design Category: C.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
   a. Component Importance Factor: 1.0 (Seismic Restraints are exempt).
   b. Component Response Modification Factor: 2.5.
   c. Component Amplification Factor: 1.0.
3. Site Classification: D
4. Design Spectral Response Acceleration at Short Periods (0.2 Second): 47.7%g.
5. Design Spectral Response Acceleration at 1-Second Period: 24.7%g.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation
device.

2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
   b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Coordination Drawings: Show coordination of seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

C. Welding certificates.

D. Qualification Data: For professional engineer and testing agency.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

   1. Ace Mountings Co., Inc.
   2. Amber/Booth Company, Inc.
   4. Isolation Technology, Inc.
   7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

B. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

C. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

D. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch-thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

E. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch-thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before
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shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS
A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

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

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full
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3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 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. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days’ advance notice.


4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.


7. Measure isolator deflection.

8. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

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

C. Adjust active height of sprint isolators.
D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.6 PLUMBING VIBRATION-CONTROL SCHEDULE

Vibration Isolation Schedule

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Isolation Type</th>
<th>Base Deflection</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Line Pumps</td>
<td>Flexible Neoprene</td>
<td>0.25&quot;</td>
<td></td>
</tr>
<tr>
<td>Piping Hangers Within 50 Feet of Isolated Equipment</td>
<td>Spring Hangers</td>
<td>1.5&quot;</td>
<td></td>
</tr>
<tr>
<td>First Two (2) Pipe Hangers near Non-Isolated Equipment</td>
<td>Spring Hangers</td>
<td>1.0&quot;</td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION 220548
SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.
PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

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

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.


C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch.

F. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

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

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

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

   2. Lettering Size: At least 1-1/2 inches high.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

   1. Stencil Material: Fiberboard or metal.

   2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.

   3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

   2. Fasteners: Brass wire-link chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "Interior Painting."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units.
3. Where flow pattern is not obvious, mark each pipe at branch.

4. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

5. At access doors, manholes, and similar access points that permit view of concealed piping.

6. Near major equipment items and other points of origination and termination.

7. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.


D. Pipe Label Color Schedule:

1. Domestic Cold Water Piping:
   a. Background Color: Green

2. Domestic Hot Water and Hot Water Recirculating Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.

3. Sanitary Waste and Storm Drainage Piping:
   a. Background Color: Green.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   b. Hot Water (includes recirculating HW): 1-1/2 inches round

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION 220553
SECTION 220719 - PLUMBING PIPING INSULATION

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 insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Domestic chilled-water piping for drinking fountains.
5. Sanitary waste piping exposed to freezing conditions.
6. Roof drains and rainwater leaders.
7. Supplies and drains for handicap-accessible lavatories and sinks.

1.3 SUBMITTALS

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

B. 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 attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Qualification Data: For qualified Installer.

E. 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.

F. 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 agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:


1.5 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 sizes and locations of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 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


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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

G. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide one of the following:

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

2.2 INSULATING CEMENTS


1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Ramco Insulation, Inc.; Super-Stik.

2.3 ADHESIVES

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

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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

1. Products: Subject to compliance with requirements, provide one of the following:

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.


1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.4 MASTICS

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

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   b. Vimasco Corporation; 749.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 550.
   e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.

2.5 LAGGING ADHESIVES

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

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:
   c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.

2.6 SEALANTS

A. Joint Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
5. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.7 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.

2.8 FIELD-APPLIED JACKETS

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

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

1. Products: Subject to compliance with requirements, provide one of the following:
a. Johns Manville; Zeston.
c. Proto Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.


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.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
   c. RPR Products, Inc.; Insul-Mate.

   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
   d. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Prefomed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide one of the following:
a. 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.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lb/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.

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

2.10 SECUREMENTS
A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping and Seals.

2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with closed seal.

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

2.11 PROTECTIVE SHIELDING GUARDS
A. Protective Shielding Pipe Covers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Engineered Brass Company.
   b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
   c. McGuire Manufacturing.
   d. Plumberex.
   e. Truebro; a brand of IPS Corporation.
   f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.

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

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.

B. 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. 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, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches 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.

3.4 PENETRATIONS

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

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "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 FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 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.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

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

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

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.10 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, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

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

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
   1. NPS 1 and Smaller: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.
   2. NPS 1-1/4 and Larger: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:
   1. NPS 1-1/4 and Smaller: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.
   2. NPS 1-1/2 and Larger: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

C. Domestic Chilled Water (Potable):
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

D. Horizontal Stormwater and Overflow:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

E. Roof Drain and Overflow Drain Bodies:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

F. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Protective shielding pipe guards.
G. Sanitary Waste Piping Where Heat Tracing Is Installed:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.

H. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Domestic Water Piping:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 2 inches thick.

B. Domestic Hot and Recirculated Hot Water:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 2 inches thick.

C. Sanitary Waste Piping Where Heat Tracing Is Installed:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed:
   1. Color coded PVC.
3.15 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed:
   1. Aluminum, Corrugated with Z-Shaped Locking Seam: 0.020 inch thick.

END OF SECTION 220719
SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
2. Encasement for piping.
4. Flexible connectors.

B. Related Section:

1. Division 22 Section "Facility Water Distribution Piping" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.

1.3 SUBMITTALS

A. Product Data: For the following products:

1. Transition fittings.
2. Backflow preventers and vacuum breakers.
3. Water penetration systems.


C. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Fire-suppression-water piping.
2. Domestic water piping.
3. Compressed air piping.
4. HVAC hydronic piping.
1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
B. Comply with NSF 14 for plastic, potable domestic water piping and components.
C. Comply with NSF 61 for potable domestic water piping and components.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Architect's written permission.

1.6 COORDINATION

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
   4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.
2. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153, ductile iron.
   a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.4 PIPING JOINING MATERIALS

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

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

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.5 TRANSITION FITTINGS

A. General Requirements:

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

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

C. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   b. Harvel Plastics, Inc.
   c. Spears Manufacturing Company.

2. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent
dimensions; one end with threaded brass insert and one solvent-cement-socket or threaded end.

PART 3 - EXECUTION

3.1 EARTHWORK
   A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION
   A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
   B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
   C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
   D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.
   E. Install shutoff valve immediately upstream of each dielectric fitting.
   F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.
   G. Install domestic water piping level without pitch and plumb.
   H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
   I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
   J. 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.
   K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and
coordinate with other services occupying that space.

L. Install piping adjacent to equipment and specialties to allow service and maintenance.

M. Install piping to permit valve servicing.

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

O. Install piping free of sags and bends.

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

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

R. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

S. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

T. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

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

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

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

1. Hose-End Drain Valves: At low points in water mains, risers, and branches.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.

E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for calibrated balancing valves.

3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings.
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3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls.
   Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

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

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

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   6. NPS 6: 10 feet with 5/8-inch rod.
   7. NPS 8: 10 feet with 3/4-inch rod.

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

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

   1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.
   8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

H. Install supports for vertical steel piping every 15 feet.
I. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

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

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

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

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
   3. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:
   1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:
1. Fill domestic water piping from a potable water source. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to a minimum static water pressure of 85 psig, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for a minimum two hours. Leaks and loss in test pressure constitute defects that must be repaired. This test must be witnessed by the engineer.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

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

E. Prepare test and inspection reports.

3.10 ADJUSTING
A. Perform the following adjustments before operation:
1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.
3.11 CLEANING

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

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

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities.

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

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

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

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper
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D. Under-building-slab, domestic water, building service piping, NPS 3 and smaller shall be the following:
   1. Soft copper tube, ASTM B 88, Type K with no joints below slab.

E. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be one of the following:
   1. Soft copper tube, ASTM B 88, Type K with no joints below slab.
   2. Mechanical-joint, ductile-iron pipe; standard pattern mechanical-joint fittings; and mechanical joints.

F. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:
   1. Soft copper tube, ASTM B 88, Type K with no joints below the slab.

G. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:
   1. Hard copper tube, ASTM B 88, Type L wrought-copper solder-joint fittings; and soldered joints.

H. Aboveground domestic water piping, NPS 2-1/2 and larger, shall be the following:
   1. Hard copper tube, ASTM B 88, Type L wrought-copper solder-joint fittings; and brazed joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.

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

END OF SECTION 221116
SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following domestic water piping specialties:

1. Vacuum breakers.
2. Backflow preventers.
5. Temperature-actuated water mixing valves.
7. Outlet boxes.
8. Hose bibbs.
9. Wall hydrants.
10. Drain valves.
12. Air vents.
13. Trap-seal primer valves.
14. Trap-seal primer systems.

B. Related Sections include the following:

1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Division 22 Section "Drinking Fountains and Water Coolers" for water filters for water coolers.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Shop Drawings: Diagram power, signal, and control wiring.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
B. NSF Compliance:
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. FEBCO; SPX Valves & Controls.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   5. Inlet and Outlet Connections: Threaded.
   6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. MIFAB, Inc.
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2.2 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. FEBCO; SPX Valves & Controls.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
   5. Size: Same as pipe, see drawings.
   6. Pressure Loss at Design Flow Rate: 10 psig for sizes NPS 2 and smaller; 10 psig for NPS 2-1/2 and larger.
   7. Body: Bronze for NPS 2 and smaller; stainless steel for NPS 2-1/2 and larger.
   8. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   9. Configuration: Designed for horizontal, straight through flow.
  10. Accessories:
      a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

B. Hose-Connection Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      c. Woodford Manufacturing Company.
   3. Operation: Up to 10-foot head of water back pressure.
   4. Inlet Size: NPS 1/2 or NPS 3/4.
   5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
   6. Capacity: At least 3-gpm flow.
C. Backflow-Preventer Test Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. FEBCO; SPX Valves & Controls.

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

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   c. Zurn Plumbing Products Group; Wilkins Div.

4. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.4 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. ITT Industries; Bell & Gossett Div.
   c. NIBCO INC.

2. Type: Ball valve with two readout ports and memory setting indicator.
3. Body: Bronze,
4. Size: Same as connected piping, but not larger than NPS 2.
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
B. Cast-Iron Calibrated Balancing Valves:

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

   b. ITT Industries; Bell & Gossett Div.
   c. NIBCO INC.

2. Type: Adjustable with Y-pattern globe valve, two readout ports, and memory-setting indicator.

3. Size: Same as connected piping, but not smaller than NPS 2-1/2.

4. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

C. Memory-Stop Balancing Valves:

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

   a. Crane Co.; Crane Valve Group; Stockham Div.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.

2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.

3. Pressure Rating: 400-psig minimum CWP.

4. Size: NPS 2 or smaller.

5. Body: Copper alloy.

6. Port: Standard or full port.

7. Ball: Chrome-plated brass.

8. Seats and Seals: Replaceable.

9. End Connections: Solder joint or threaded.


2.5 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

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

   a. Leonard Valve Company.
   b. Powers; a Watts Industries Co.
   c. Symmons Industries, Inc.


4. Type: Thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 110 deg F.
9. Tempered-Water Design Flow Rate: \(<\text{Insert gpm.}>\)
10. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Leonard Valve Company.
   b. Powers; a Watts Industries Co.
   c. Symmons Industries, Inc.
4. Type: Exposed-mounting, thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.
9. Tempered-Water Setting: 120 deg F.
10. Tempered-Water Design Flow Rate: \(<\text{Insert gpm.}>\)
11. Selected Valve Flow Rate at 45-psig Pressure Drop: \(<\text{Insert gpm.}>\)
12. Pressure Drop at Design Flow Rate: \(<\text{Insert psig.}>\)
15. Cabinet: Factory-fabricated, stainless steel, for surface mounting and with hinged, stainless-steel door.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:
   a. Strainers NPS 2 and Small: 0.033 inch.
   b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch.
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2.7 OUTLET BOXES

A. Refrigerator, Ice Maker and Dishwasher Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. IPS Corporation.
   c. LSP Products Group, Inc.
   d. Oatey.
   e. Plastic Oddities; a division of Diverse Corporate Technologies.

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

2.8 HOSE BIBBS

A. Hose Bibbs:

4. Supply Connections: NPS 1/2 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.
2.9 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

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

4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
12. Operating Keys: Two with each wall hydrant.

2.10 DRAIN VALVES

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

2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

B. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
5. Drain: NPS 1/8 side outlet with cap.
2.11 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

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

   b. Sioux Chief Manufacturing Company, Inc.
   c. Zurn Plumbing Products Group; Specification Drainage Operation.

3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.12 AIR VENTS

A. Welded-Construction Automatic Air Vents:

2. Pressure Rating: 150-psig minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.

2.13 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:

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

   a. Sioux Chief Manufacturing Company, Inc.

5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.
2.14 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

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

2. Standard: ASSE 1044,
3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
7. Number Outlets: See drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

C. Install balancing valves in locations where they can easily be adjusted.

D. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install thermometers and water regulators if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified.

E. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve and pump.
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F. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

G. Install water hammer arresters in water piping according to PDI-WH 201.

H. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

I. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

J. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Reduced-pressure-principle backflow preventers.
5. Primary, thermostatic, water mixing valves.
6. Primary water tempering valves.
7. Outlet boxes.
8. Supply-type, trap-seal primer valves.
9. Trap-seal primer systems.

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

A. Perform the following tests and prepare test reports:

1. Test each pressure vacuum breaker and reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 221119
SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic
      cold- and hot-water circulation:

1.3 SUBMITTALS
   A. Product Data: For each type and size of domestic water pump specified. Include certified
      performance curves with operating points plotted on curves; and rated capacities of selected
      models, furnished specialties, and accessories.
   B. Shop Drawings: Diagram power, signal, and control wiring.
   C. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation,
      and maintenance manuals.

1.4 QUALITY ASSURANCE
   A. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic
      water pumps and are based on the specific system indicated. Refer to Division 01 Section
      "Product Requirements."
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
      Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for
      intended use.
   C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 DELIVERY, STORAGE, AND HANDLING
   A. Retain shipping flange protective covers and protective coatings during storage.
B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 CLOSE COUPLED, IN-LINE, SEALLESS CENTRIFUGAL PUMPS

A. Manufacturers:

1. Armstrong Pumps Inc.
2. Bell & Gossett Domestic Pump; ITT Industries.
3. Taco, Inc.

B. Description: Factory-assembled and -tested, single-stage, close-coupled, in-line, sealless centrifugal pumps as defined in HI 5.1-5.6.

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge-type unit with motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
2. Casing: Bronze, with threaded companion-flange connections.
3. Impeller: Corrosion-resistant material.
4. Motor: Single speed, unless otherwise indicated. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

C. Capacities and Characteristics: Refer to equipment schedules on drawings for information. Refer to equipment schedules on drawings for information.

2.3 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.
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DOMESTIC WATER PUMPS

1. Manufacturers:
   a. Honeywell International, Inc.
   b. Square D.

2. Type: Water-immersion sensor, for installation in hot-water circulation piping.
3. Range: 50 to 125 deg F.
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
7. Settings: Start pump at 105 deg F and stop pump at 20 deg F.

2.4 BUILDING-AUTOMATION-SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system.
   Include the following:
   1. On-off status of each pump.
   2. Alarm status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections
   before pump installation.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.
B. Install pumps with access for periodic maintenance including removal of motors, impellers,
   couplings, and accessories.
C. Install in-line, sealless centrifugal pumps with motor and pump shafts horizontal.
D. Install continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump
   weight. Vibration isolation devices are specified in Division 22 Section "Vibration and Seismic
   Controls for Plumbing Piping and Equipment."

3.3 CONTROL INSTALLATION

A. Install immersion-type thermostats in hot-water return piping.
3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
   1. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.
   2. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and gage connectors.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

F. Connect thermostats to pumps that they control.

G. Interlock pump with water heater burner and time delay relay.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Set thermostats for automatic starting and stopping operation of pumps.
   5. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.
   6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
   7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.6 DEMONSTRATION

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

END OF SECTION 221123
SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Sections include the following:
   1. Division 22 Section "Sanitary Sewerage Pumps."

1.3 DEFINITIONS


B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. LLDPE: Linear, low-density polyethylene plastic.

D. NBR: Acrylonitrile-butadiene rubber.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

G. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   2. Sanitary Sewer, Force-Main Piping: 100 psig.
1.5 SUBMITTALS

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

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPING MATERIALS

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

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class.
B. Gaskets: ASTM C 564, rubber.
C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.4 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.
B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.
C. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
   a. Manufacturers:
      1) ANACO.
      2) Mission Rubber Co.
      3) Tyler Pipe; Soil Pipe Div.

   a. Manufacturers:
      1) ANACO.
      2) Mission Rubber Co.
      3) Tyler Pipe; Soil Pipe Div.

2.5 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Types L and M, water tube, drawn temper.

2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

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


PART 3 - EXECUTION

3.1 EXCAVATION

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

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
B. Aboveground, soil and waste piping shall be the following:
   1. Hubless cast-iron soil pipe and fittings heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

C. Aboveground, vent piping shall be the following:
   1. Hubless cast-iron soil pipe and fittings heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

D. Underground, soil, waste, and vent piping shall be the following:
   1. Service class, cast-iron soil piping; gaskets; and gasketed joints.

E. Aboveground sanitary-sewage force mains shall be the following:
   1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
   2. Steel pipe, pressure fittings, and threaded joints.

F. Underground sanitary-sewage force mains shall be the following:
   1. Soft copper tube, Type L; wrought-copper pressure fittings; and soldered joints.
   2. Steel pipe, pressure fittings, and threaded joints.
      a. Include grooved-joint system fittings and couplings and grooved joints where indicated.
      3. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile-iron fittings; glands, gaskets, and bolts; and mechanical joints.
         a. Include grooved-joint system fittings and couplings and grooved joints where indicated.
   4. Push-on-joint, ductile-iron pipe; push-on-joint ductile-iron fittings; gaskets; and gasketed joints.
      a. Include grooved-joint system fittings and couplings and grooved joints where indicated.
   5. Pressure pipe couplings, if dissimilar pipe materials or piping with small difference in OD must be joined.

3.3 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 33 Section "Facility Sanitary Sewers."

B. Install cleanouts at grade and extend to where building sanitary drains connect to building
sanitary sewers.

C. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

D. Install underground, steel, force-main piping.

E. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."

F. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

G. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

H. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

I. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

K. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

L. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

M. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
N. Cut pipes accurately to measurements established in the field in a neat and workmanlike manner without damage or without forcing or springing.

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.4 JOINT CONSTRUCTION


B. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.

1. Install gate or full-port ball valve for piping NPS 2 and smaller.
2. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Backwater valve are specified in Division 22 Section "Sanitary Waste Piping Specialities."
3.6 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6: 60 inches with 3/4-inch rod.
5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
5. NPS 6: 10 feet with 5/8-inch rod.
6. NPS 8: 10 feet with 3/4-inch rod.

I. Install supports for vertical copper tubing every 10 feet.
J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

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

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:
   1. Sanitary Sewer: To exterior force main or sanitary manhole.
   2. Sewage Pumps: To sewage pump discharge.

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each
test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks. The test shall be witnessed by the Engineer.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained. Caulking of welded or screwed joints, cracks, or holes is not acceptable. Correct leaks in screwed sittings by remarking joints. Cut out and reweld.

6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained. The test shall be witnessed by the Engineer.

4. Prepare reports for tests and required corrective action.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.10 PROTECTION

A. During construction all openings in piping shall be closed with caps or plugs to keep out all foreign matter.
END OF SECTION 221316
SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:

1. Backwater valves.
2. Cleanouts.
3. Floor drains.
4. Roof flashing assemblies.
5. Through-penetration firestop assemblies.
7. Flashing materials.

B. Related Sections include the following:

1. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
2. Division 22 Section "Sanitary Waste Interceptors" for grease interceptors.

1.3 DEFINITIONS


B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PVC: Polyvinyl chloride plastic.
1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


1.6 COORDINATION

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

B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:

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

   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.

3. Size: Same as connected piping.
5. Cover: Cast iron with bolted or threaded access check valve.
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.2 CLEANOUTS

A. Exposed Metal Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Metal Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule cleanout.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Spigot.
8. Closure: Brass plug with straight threads and gasket.
9. Adjustable Housing Material: Cast iron with threads.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Medium Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.3.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
10. Sediment Bucket: Not required.
11. Top or Strainer Material: Nickel bronze.
13. Top Shape: Round.
15. Funnel: See drawings for locations where required.
16. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
17. Trap Material: Cast iron.

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

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

B. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch-thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.


2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hilti
   b. 3M
   c. ProSet Systems Inc.

2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
6. Special Coating: Corrosion resistant on interior of fittings.
2.6 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:
   1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
   2. Size: Same as connected waste piping.

B. Floor-Drain, Trap-Seal Primer Fittings:
   1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Air-Gap Fittings:
   1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
   2. Body: Bronze or cast iron.
   3. Inlet: Opening in top of body.
   4. Outlet: Larger than inlet.
   5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Expansion Joints:
   1. Standard: ASME A112.21.2M.
   2. Body: Cast iron with bronze sleeve, packing, and gland.
   3. End Connections: Matching connected piping.
   4. Size: Same as connected soil, waste, or vent piping.

2.7 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Applications: 12 oz./sq. ft..
   2. Vent Pipe Flashing: 8 oz./sq. ft..

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.
5. Cleanouts shall consist of Y branches with cleanout plugs and covers.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated:

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.

4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

5. Drains installed in water-proofing membranes shall have a flashing clamp device.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

H. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

I. Assemble open drain fittings and install with top of hub 2 inches above floor.

J. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

   1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
   2. Size: Same as floor drain inlet.

K. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

L. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

M. Install wood-blocking reinforcement for wall-mounting-type specialties.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
1. **Lead Sheets:** Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.

2. **Copper Sheets:** Solder joints of copper sheets.

**B.** Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. **Pipe Flashing:** Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.

2. **Sleeve Flashing:** Flat sheet, with skirt or flange extending at least 8 inches around sleeve.

3. **Embedded Specialty Flashing:** Flat sheet, with skirt or flange extending at least 8 inches around specialty.

**C.** Set flashing on floors and roofs in solid coating of bituminous cement.

**D.** Secure flashing into sleeve and specialty clamping ring or device.

**E.** Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

**F.** Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

**G.** Fabricate and install flashing and pans, sumps, and other drainage shapes.

### 3.4 FIELD QUALITY CONTROL

**A.** Perform tests and inspections and prepare test reports.

**B.** Tests and Inspections:

1. **Leak Test:** After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. **Test and adjust controls and safeties:** Replace damaged and malfunctioning controls and equipment.

### 3.5 PROTECTION

**A.** Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

**B.** Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319
SECTION 221323 - SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following types of interceptors outside the building:
   1. Grease interceptors.

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.
B. HDPE: High-density polyethylene plastic.
C. PE: Polyethylene plastic.
D. PP: Polypropylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of interceptor indicated. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.
B. Shop Drawings: For each type and size of cast-in-place-concrete interceptor indicated.
   1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.
   2. Include reports and calculations for design mixes of concrete.
C. Shop Drawings: For each type and size of precast concrete interceptor indicated.
   1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.
D. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Interceptors.
2. Piping connections. Include size, location, and elevation of each.
3. Interface with underground structures and utility services.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Sewer Services: Do not interrupt services to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sewer services according to requirements indicated:

1. Notify Architect and Owner no fewer than seven days in advance of proposed interruption of service.
2. Do not proceed with interruption of sewer services without Owner's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 GREASE INTERCEPTORS

A. Grease Interceptors: Precast concrete complying with ASTM C 913. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.

1. Protective Coating: Plant-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint, 10-mil minimum thickness applied to all exterior and interior concrete surfaces.
2. Structural Design Loads:

3. Resilient Pipe Connectors: ASTM C 923, cast or fitted into interceptor walls, for each pipe connection.
4. Steps: Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of interceptor...
to finished grade is less than 60 inches.

5. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.

6. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch-minimum width flange and 26-inch- diameter cover.

   a. Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
   c. Include indented top design with lettering cast into cover, using wording equivalent to "GREASE INTERCEPTOR."
   d. Protective Coating: Foundry-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to all ferrous surfaces.


PART 3 - EXECUTION

3.1 EARTHWORK

   A. Excavating, trenching, and backfilling are specified in Division 22 Section "Earth Moving."

3.2 INSTALLATION

   A. Install interceptor inlets and outlets at elevations indicated.

   B. Place concrete for cast-in-place interceptors according to ACI 318/318R and ACI 350R.

      1. Refer to Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

   C. Install precast concrete interceptors according to ASTM C 891. Set level and plumb.

   D. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.

   E. Set tops of manhole frames and covers flush with finished surface in pavements. Set tops 3 inches above finish surface elsewhere, unless otherwise indicated.

   F. Set tops of grating frames and grates flush with finished surface.

   G. Clean and prepare concrete surfaces to be field painted. Remove loose efflorescence, chalk, dust, dirt, grease, oils, and release agents. Roughen surface as required to remove glaze. Paint the following concrete surfaces as recommended by paint manufacturer:

      1. Precast Concrete Interceptors: All exterior and interior.
H. Install sheet PE film on earth where cast-in-place-concrete interceptors are to be built.

I. Repair and restore protective coatings to original condition.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION

A. Identification materials and installation are specified in Division 22 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.

1. Use warning tapes or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

END OF SECTION 221323
SECTION 221413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following storm drainage piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.

B. Related Sections include the following:
   1. Division 22 Section "Sump Pumps."

1.3 DEFINITIONS


B. LLDPE: Linear, low-density polyethylene plastic.

C. PE: Polyethylene plastic.

D. PVC: Polyvinyl chloride plastic.

E. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water.
   2. Storm Drainage, Force-Main Piping: 100 psig.
1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 PIPING MATERIALS

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

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

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

2.4 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

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

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

1. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.

   a. Manufacturers:
2.5 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Types L and M, water tube, drawn temper.
   2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
   3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

PART 3 - EXECUTION

3.1 EXCAVATION

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

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground storm drainage piping shall be:
   1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and coupled joints.

C. Underground storm drainage piping shall be:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.

D. Aboveground storm drainage force mains shall be:
   1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.

3.3 PIPING INSTALLATION

A. Storm sewer and drainage piping outside the building are specified in Division 33 Section "Storm Utility Drainage Piping."

B. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties."
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Fayetteville, North Carolina

RMF Engineering, Inc.

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C. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.

D. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

E. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

G. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

H. Install force mains at elevations indicated.

I. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

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

K. Cut pipes accurately to measurements established in the field in a neat and workmanlike manner without damage or without forcing or springing.

L. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

N. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.4 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil
Pipe and Fittings Handbook” for compression joints.


C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sump pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
   1. Vertical Piping: MSS Type 8 or Type 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs: According to the following:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and
minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6: 60 inches with 3/4-inch rod.
5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
5. NPS 6: 10 feet with 5/8-inch rod.
6. NPS 8: 10 feet with 3/4-inch rod.

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

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

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

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

D. Connect force-main piping to the following:

1. Storm Sewer: To exterior force main or storm manhole.
2. Sump Pumps: To sump pump discharge.

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in
after roughing-in.

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

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks. The test shall be witnessed by the Engineer and the City of Fayetteville plumbing inspector.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 100 psig, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired. The test shall be witnessed by the Engineer and the City of Fayetteville plumbing inspector.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

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

END OF SECTION 22 1413
SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes the following storm drainage piping specialties:
      1. Cleanouts.
      2. Through-penetration firestop assemblies.
      3. Roof drains.
      4. Roof overflow draws.
      5. Miscellaneous storm drainage piping specialties.
      6. Flashing materials.

1.3 DEFINITIONS
   B. FOG: Fats, oils, and greases.
   C. FRP: Fiberglass-reinforced plastic.
   D. HDPE: High-density polyethylene plastic.
   E. PE: Polyethylene plastic.
   F. PP: Polypropylene plastic.
   G. PUR: Polyurethane plastic.
   H. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS
   A. Product Data: For each type of product indicated.
1.5 QUALITY ASSURANCE

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

1.6 COORDINATION

A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
   3. Size: Same as connected drainage piping
   4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Countersunk, brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Metal Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      c. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule cleanout.
   3. Size: Same as connected branch.
   4. Type: Cast-iron soil pipe with cast-iron ferrule.
   5. Body or Ferrule: Cast iron.
   6. Clamping Device: [Not required] [Required].
   7. Outlet Connection: Spigot.
   8. Closure: Brass plug with straight threads and gasket.
   9. Adjustable Housing Material: Cast iron with threads.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
15. Size: Same as connected branch.
17. Closure: Stainless steel with seal.
18. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M.
   b. Hilti.
   c. ProSet Systems, Inc.

2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected pipe.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
6. Special Coating: Corrosion resistant on interior of fittings.
2.3 ROOF DRAINS

A. Metal Roof Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   c. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.21.2M.
3. Pattern: Roof drain.
5. Combination Flashing Ring and Gravel Stop: Required.
7. Outlet: Bottom.
8. Dome Material: PE.
10. Underdeck Clamp: Required.

B. Metal Roof overflow Drains:

1. Same as metal Roof Drains except include cast iron extension pipe three (3) inches above roof.

2.4 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Conductor Nozzles:

1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

2.5 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. thickness.

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.


D. Fasteners: Metal compatible with material and substrate being fastened.
E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

F. Solder: ASTM B 32, lead-free alloy.

G. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

F. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.

1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Position roof drains for easy access and maintenance.

G. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

H. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

I. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and
within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423
SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes the following sump pumps and accessories, inside the building, for building
      storm drainage systems:
       1. Submersible sump pumps.

1.3 SUBMITTALS
   A. Product Data: For each type and size of sump pump specified. Include certified performance
      curves with operating points plotted on curves, and rated capacities of selected models, furnished
      specialties, and accessories.
   B. Shop Drawings: Diagram power, signal, and control wiring.
   C. Operation and Maintenance Data: For each sump pump to include in emergency, operation, and
      maintenance manuals.

1.4 QUALITY ASSURANCE
   A. Product Options: Drawings indicate size, profiles, and dimensional requirements of sump pumps
      and are based on the specific system indicated. Refer to Division 01 Section "Product
      Requirements."
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
      Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for
      intended use.

1.5 DELIVERY, STORAGE, AND HANDLING
   A. Retain shipping flange protective covers and protective coatings during storage.
   B. Protect bearings and couplings against damage.
C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

A. Coordinate pump with concrete pits and elevator equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 SUBMERSIBLE SUMP PUMPS

A. Manufacturers: Subject to compliance with requirements, provide Stancor Oil-Minder Model SE-50 ELV or equivalent products by one of the following:

1. Liberty
2. RMC, Inc.

B. General Specification: Provide pump and control systems capable of pumping water while containing the oil in the pit. The system shall function automatically and shall provide for an alarm and separate LED lights in the event of (a) the presence of oil in the sump, (b) high liquid in the sump, or (c) high amps or a locked rotor condition. In addition, LED lights shall be provided for (1) power and (2) pump run function. An alarm that sounds only in the event of a high liquid condition or does not separately identify the above five functions shall not be acceptable.

C. Pump Specification: The pump shall be submersible type, capable of pumping up to 37' TDH and 74 GPM. The pump shall be approved to UL 778 standards and shall include thermal and overload protection. The motor shall be rated ½ H.P., 1 phase, 115V and capable of operating continuously or intermittently. The motor housing shall be constructed of #304 stainless steel and mechanical seats shall be housed in a separate oil-filled compartment.

D. Control Specification: The main control shall be approved to UL 508 standards and housed in a gasketed Nema 4X enclosure with a see-through window for observation of operating functions. The control shall be equipped with an 8-pin twist lock receptacle, dual solid state Oil-Minder relays with variable sensitivity settings, an over current relay, self-cleaning stainless steel sensor probe, high decibel warning horn with alarm silencing switch, dual floats, clearly marked terminal board and remote monitoring contact. A Nema 4X junction box with 8-pin twist-lock electrical receptacle and 25' (additional lengths available in 25' increments) of mating 8 conductor cable shall be provided. All cables between the pump and junction box shall be 16' long and the cable
and plug from the control unit shall be 8’ long. The control unit, junction box, pump, floats and sensor shall be factory assembled as a complete, ready-to-use system and shall be tested and approved as a complete system by a nationally recognized testing laboratory such as ENTELA. The system shall allow for the main control to be located outside of the elevator hoistway to be monitored for all functions without having to enter the elevator shaft.

E. Pump Discharge Piping: Factory or field fabricated, ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe.

2.3 BUILDING AUTOMATION SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:

1. On-off status of each pump.
2. Alarm status.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 SUMP PUMP INSTALLATION

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

B. Install sump pumps according to applicable requirements in HI 1.4.

C. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.

D. Set submersible sump pumps on pit floor. Make direct connections to storm drainage piping.

E. Support piping so weight of piping is not supported by pumps.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Division 22 Section "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to sump pumps to allow service and maintenance.
C. Connect sanitary drainage piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Refer to Division 22 Section “Sanitary Waste and Vent Piping.”

1. Install flexible connectors adjacent to pumps in discharge piping.
2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section “General-Duty Valves for Plumbing Piping” for general-duty valves for drainage piping.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify bearing lubrication.
3. Disconnect couplings and check motors for proper direction of rotation.
4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
5. Verify that pump controls are correct for required application.

B. Start pumps without exceeding safe motor power:

1. Start motors.
2. Open discharge valves slowly.
3. Check general mechanical operation of pumps and motors.

C. Test and adjust controls and safeties.

D. Remove and replace damaged and malfunctioning components.

1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1

Owner: City of Fayetteville
Fayetteville, North Carolina

AP#1515
RMF Engineering, Inc.
July 18, 2016

3.5 DEMONSTRATION

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

END OF SECTION 221429
SECTION 223300 - ELECTRIC DOMESTIC WATER 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. This Section includes the following electric water heaters:
      1. Commercial, storage electric water heaters.
      2. Compression tanks.
      3. Water heater accessories.

1.3 SUBMITTALS
   A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
   B. Shop Drawings: Diagram power, signal, and control wiring.
   C. Product Certificates: For each type of commercial electric water heater, signed by product manufacturer.
   D. Source quality-control test reports.
   E. Field quality-control test reports.
   F. Operation and Maintenance Data: For electric water heaters to include in emergency, operation, and maintenance manuals.
   G. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE
   A. Source Limitations: Obtain same type of electric water heaters through one source from a single manufacturer.
   B. Product Options: Drawings indicate size, profiles, and dimensional requirements of electric water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product
1.5 COORDINATION
A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY
A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including storage tank and supports.
   b. Faulty operation of controls.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period(s): From date of Substantial Completion:
   a. Commercial Electric Water Heaters:
      1) Storage Tank: Five years.
      2) Controls and Other Components: Five years.
   b. Compression Tanks: Five years.

PART 2 - PRODUCTS

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

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

2.2 COMMERCIAL ELECTRIC WATER HEATERS

A. Commercial, Storage Electric Water Heaters: Comply with UL 1453 requirements for storage-tank-type water heaters.

1. Provide AO Smith DSE-120 electric water heaters or equivalent products by one of the following:
   b. Lochinvar Corporation.
   c. PVI Industries, LLC.
   d. RECO USA.
   g. Smith, A. O. Water Products Company.
   h. State Industries, Inc.


   a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

      1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
      2) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

   b. Pressure Rating: 150 psig (kPa).
   c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

   a. Anode Rod: Replaceable magnesium.
   b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
   c. Insulation: Comply with ASHRAE/IESNA 90.1.
   d. Jacket: Steel with enameled finish.
   e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
   f. Temperature Control: Adjustable thermostat.
   g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
ELECTRIC DOMESTIC WATER HEATERS
D. Shock Absorbers: ASSE 1010 or PDI WH 201, Size A water hammer arrester.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.

1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.

2. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.

E. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

F. Install pressure gages on inlet and outlet of commercial electric water-heater piping. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

G. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve, thermometer in each water heater inlet and outlet, and throttling valve in each water heater.
ELECTRIC DOMESTIC WATER HEATERS

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.3 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. Leakage Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

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

END OF SECTION 223300
SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:

1. Faucets for lavatories, showers and sinks.
2. Flushometers.
3. Toilet seats.
4. Protective shielding guards.
5. Fixture supports.
6. Dishwasher air-gap fittings.
7. Water closets.
8. Urinals.
9. Lavatories.
10. Individual showers.
11. Commercial sinks.
12. Service basins.

B. Related Sections include the following:

1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
3. Division 22 Section "Domestic Water Filtration Equipment" for water filters.
4. Division 22 Section "Drinking Fountains and Water Coolers."
5. Division 31 Section "Facility Water Distribution Piping" for exterior plumbing fixtures and hydrants.

1.3 DEFINITIONS


B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and
solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.


1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

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

D. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
6. Vitreous-China Fixtures: ASME A112.19.2M.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
5. Hose-Connection Vacuum Breakers: ASSE 1011.

I. Comply with the following applicable standards and other requirements specified for shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.

J. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

2. Brass and Copper Supplies: ASME A112.18.1.

K. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Disposers: ASSE 1008 and UL 430.
4. Floor Drains: ASME A112.6.3.
7. Off-Floor Fixture Supports: ASME A112.6.1M.

1.6 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures of unit shell.
   b. Faulty operation of controls, blowers, pumps, heaters, and timers.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Commercial Applications: Three years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 10 percent of amount of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 10 of each type.
4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
5. Toilet Seats: Equal to 5 percent of amount of each type installed, but no less than 3.

1.8 FIXTURE CONNECTIONS

A. Provide all plumbing connections required by fixtures which is provided on this project. Certain items of fixtures shall be provided under this section and certain items will be furnished and set under other sections of the specifications. In all cases, provide valved water supplies, waste and vent lines, and, unless noted otherwise, make final connections after fixtures is in place.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets, (P-3, P-4):

1. Manufacturers: Subject to compliance with requirements, provide Loan SF-2350 sensor faucet or equivalent products by one of the following:

   a. Chicago Faucets.
   b. Delta Faucet Company.
   c. Kohler Co.

2. Description: Single-control temperature mixing valve. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.

   b. Finish: Polished chrome plate.
   c. Maximum Flow Rate: 0.5 gpm.
   d. Maximum Flow: 0.25 gal.
   e. Centers: 4 inches.
   f. Mounting: Deck, exposed.
   g. Valve Handle(s): Not applicable.
   h. Inlet(s): NPS 3/8 tubing, plain end.
   i. Spout: Rigid type.
   j. Spout Outlet: Vandal-proof aerator.
   l. Drain: Grid.
   m. Tempering Device: Thermostatic.
2.2 SHOWER FAUCETS

A. Shower Faucets, (P-5):

1. Manufacturers: Subject to compliance with requirements, provide Symmons 1-117-FS-X-B30 or equivalent products by one of the following:
   
a. Powers; a Watts Industries Co.
b. Bradley.
c. Zurn.
d. T & S Brass and Bronze Works, Inc.

2. Description: Single-handle pressure-balance valve. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies and outlet with diverter valve.
   
b. Finish: Polished chrome plate.
c. Maximum Flow Rate: 2.0 gpm, unless otherwise indicated.
d. Diverter Valve: Not integral with mixing valve.
e. Mounting: Concealed.
g. Operation: Compression, manual.
h. Antiscald Device: Integral with mixing valve.
i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
j. Supply Connections: NPS 1/2.
k. Shower Head Type: [Ball joint and head integral with mounting flange and hand held, slide-bar mounted.
l. Shower Head Material: Metallic with chrome-plated finish.
m. Spray Pattern: Adjustable.
n. Integral Volume Control: Required.
o. Shower-Arm Flow-Control Fitting: 2.0 gpm.
p. Temperature Indicator: Not required.

2.3 SINK FAUCETS

A. Sink Faucets, (P-6):

1. Manufacturers: Subject to compliance with requirements, provide Chicago Faucets model 782-VBSCP or comparable products by one of the following:
   
a. Delta Faucet Company.
b. Kohler Co.
c. Moen, Inc.

2. Description: Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
   
b. Finish: Polished chrome plate.
c. Maximum Flow Rate: 2.5 gpm, unless otherwise indicated.
d. Mixing Valve: Two-lever handle.
e. Backflow Protection Device for Hose Outlet: Required.
f. Centers: 8 inches.
g. Mounting: Back/wall, concealed.
h. Handle(s): Knob.
i. Inlet(s): NPS 1/2 NPT female thread.
j. Spout Type: Rigid, solid brass with wall brace.
k. Spout Outlet: Hose thread.
l. Vacuum Breaker: Required.
m. Operation: Compression, manual.
n. Drain: Not required.

B. Sink Faucets, (P-7):
1. Manufacturers: Subject to compliance with requirements, provide Delta model 400-DST or comparable products by one of the following:
   a. Chicago Faucets.
   b. Kohler Co.
   c. Moen, Inc.
2. Description: Kitchen faucet with spray, four-hole fixture. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
   b. Finish: Polished chrome plate.
   c. Maximum Flow Rate: 2.2 gpm, unless otherwise indicated.
   d. Mixing Valve: Single control.
   e. Backflow Protection Device for Side Spray: Required.
   f. Centers: 8 inches.
   g. Mounting: Deck, exposed.
   h. Handle: Lever.
   i. Inlet(s): NPS 3/8 tubing with NPS 1/2 male adapter.
   j. Spout Type: Swing, solid brass.
   k. Spout Outlet: Swivel aerator/spray.
   l. Vacuum Breaker: Not required.
   m. Operation: Compression, manual.
   n. Drain: Grid.

2.4 FLUSHOMETERS

A. Flushometers, (P-1, P-1A, P-1B):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Sloan Valve Company.
   c. Zurn Plumbing Products Group; Commercial Brass Operation.
2. Description: Flushometer for high efficiency water-closet-type fixture. Include brass body
with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.

a. Internal Design: Diaphragm operation.
b. Style: Exposed.
c. Inlet Size: NPS 1.
d. Trip Mechanism: Oscillating, lever-handle actuator.
e. Consumption: 1.28 gal./flush.
f. Tailpiece Size: NPS 1-1/2.

B. Flushometers, (P-2):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Sloan Valve Company.
      c. Zurn Plumbing Products Group; Commercial Brass Operation.
   2. Description: Flushometer for high efficiency urinal-type fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.
      a. Internal Design: Diaphragm operation.
      b. Style: Exposed.
      d. Trip Mechanism: Oscillating, lever-handle actuator.
      e. Consumption: 0.125 gal./flush.

2.5 TOILET SEATS

A. Toilet Seats, (P-1, P-1A):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Church Seats.
      c. Olsonite Corp.
   2. Description: Toilet seat for water-closet-type fixture.
      a. Material: Molded, solid plastic.
      b. Configuration: Open front without cover.
      c. Size: Elongated.
      d. Hinge Type: CK, check.
      e. Class: Heavy-duty commercial.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the
following:

a. McGuire Manufacturing Co., Inc.
b. TRUEBRO, Inc.
c. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

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

2.7 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.

B. Water-Closet Supports, (P-1, P-1A):

1. Description: Combination carrier designed for accessible and standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports, (P-2):

1. Description: Type II, urinal carrier with hanger and bearing plates for wall-mounting, urinal-type fixture. Include steel uprights with feet.

D. Lavatory Supports, (P-4):

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.

2.8 DISHWASHER AIR-GAP FITTINGS

A. Dishwasher Air-Gap Fittings:

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

b. Geberit Manufacturing, Inc.
c. Sioux Chief Manufacturing Company, Inc.
2. PLUMBING FIXTURES

2.9 WATER CLOSETS

A. Water Closets, (P-1, P-1A):

1. Manufacturers: Subject to compliance with requirements, provide American Standard Afwall FloWise or comparable products by one of the following:
   a. Sloan.
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Eljer.
   d. Kohler Co.

2. Description Accessible, wall and Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
   a. Supply: NPS 1 chrome-plated brass or copper with screwdriver stop.
   b. Style: Flushometer valve.
      1) Bowl Type: Elongated with siphon-jet design.
      2) Design Consumption: 1.28 gal./flush.
   c. Flushometer: (P-1, P-1A).
   d. Toilet Seat: (P-1, P-1A).
   e. Fixture Support: Water-closet support (P-1, P-1A) combination carrier.

B. Water Closets, (P-1B):

1. Manufacturers: Subject to compliance with requirements, provide American Standard Madera 16-1/2” Height FlowWise or comparable products by one of the following:
   a. American Standard Companies, Inc.
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Eljer.
   d. Kohler Co.

2. Description: Accessible, floor-mounting, floor-outlet, vitreous-china fixture designed for flushometer valve operation.
   a. Style: Flushometer valve.

d. Watts Brass & Tubular; a division of Watts Regulator Co.
1) Bowl Type: Elongated with siphon-jet design. Include bolt caps matching fixture.
2) Height: Accessible.
3) Design Consumption: 1.28 gal./flush.
4) Color: White.
b. Flushometer: (P-1A).
c. Toilet Seat: (P-1A).

2.10 URINALS
A. Urinals (P-2):
   1. Manufacturers: Subject to compliance with requirements, provide American Standard Washbrook FloWise or comparable products by one of the following:
      a. American Standard Companies, Inc.
      b. Toto
      c. Crane Plumbing, L.L.C./Fiat Products.
      d. Eljer.
      e. Kohler Co.
   2. Description: Accessible, wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
      a. Type: Siphon jet.
      b. Strainer or Trapway: Integral cast strainer with integral trap.
      c. Design Consumption: 0.125 gal./flush.
      f. Outlet Size: NPS 2.
      g. Flushometer:
      h. Fixture Support: Urinal chair carrier.

2.11 LAVATORIES
A. Lavatories, (P-4):
   1. Manufacturers: Subject to compliance with requirements, provide American Standard Lucerne or comparable products by one of the following:
      b. Eljer.
      c. Kohler Co.
   2. Description: Accessible, wall-mounting, vitreous-china fixture.
      a. Type: Ledge back.
      b. Size: 20 by 18 inches rectangular.
      c. Faucet Hole Punching: One hole.
      d. Faucet Hole Location: Top.
      e. Pedestal: Not required.
g. Faucet: Lavatory (P-4).
h. Supplies: NPS 3/8 chrome-plated copper with stops.
i. Drain: Grid.

1) Location: Near back of bowl.

j. Drain Piping: NPS 1-1/4 by NPS 1-1/2 chrome-plated, cast-brass P-trap; NPS 1-1/2, 0.032-inch-thick tubular brass waste to wall; and wall escutcheon.
k. Protective Shielding Guard(s): Required.
l. Fixture Support: Lavatory (P-4).

B. Lavatories, (P-3):

1. Manufacturers: Subject to compliance with requirements, provide Wilsonart BV1512 or comparable products by one of the following:
   a. American Standard Companies, Inc.
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Eljer.
   d. Kohler Co.

2. Description: Accessible, under counter-mounting, solid-surface fixture.
   a. Type: Self-rimming.
   b. Oval Lavatory Size: 15 by 15 inches.
   c. Faucet Hole Punching: One hole in counter.
   d. Faucet Hole Location: Top.
   e. Color: Cream.
   f. Faucet: Lavatory (P-3).
   g. Supplies: NPS 3/8 chrome-plated copper with stops.
   h. Drain: Grid.

1) Location: Near back of bowl.
   i. Drain Piping: NPS 1-1/4 by NPS 1-1/2 chrome-plated, cast-brass P-trap; NPS 1-1/2, 0.032-inch-thick tubular brass waste to wall; and wall escutcheon.

j. Hair Interceptor: Not required.
k. Protective Shielding Guards: Required.

2.12 COMMERCIAL SINKS

A. Commercial Sinks, (P-7):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advance Tabco.
      b. Elkay Manufacturing Co.
      c. Just Manufacturing Company.
2. Description: Two-compartment, counter-mounting, stainless-steel commercial sink with backsplash.
   a. Overall Dimensions: 33” x 22”
   b. Metal Thickness: 0.050 inch.
   c. Each Compartment:
      1) Dimensions: 16” x 16” x 7” deep and 13-1/2” x 16” x 7” deep.
      2) Drain: Grid with NPS 2 tailpiece and twist drain.
         a) Location: Near back of compartment.
   d. Faucet: Sink (P-7).
      1) Number Required: One.
      2) Mounting: Deck.
   e. Supplies: NPS 1/2 chrome-plated copper with stops or shutoff valves.
   f. Drain Piping: NPS 2 chrome-plated, cast-brass P-trap; 0.045-inch-thick tubular brass waste to wall; and wall escutcheon(s).

2.13 INDIVIDUAL SHOWERS

A. Individual Showers, (P-5):

1. Description: Components for built-up shower.
   a. Shower Faucet: (P-5).
   b. Receptor: Not required.

2.14 SERVICE BASINS

A. Service Basins, (P-6):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Fiat
   d. Florestone Products Co., Inc.
   e. Mustee, E. L. & Sons, Inc.

2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard.
   a. Shape: Square.
   b. Size: 24 by 24 inches.
   c. Height: 12 inches.
   d. Tiling Flange: On two sides.
   e. Rim Guard: On front top surfaces.
   f. Color: Not applicable.
   g. Faucet: Sink (P-6).
   h. Drain: Grid with NPS 2 outlet.

B. Service Basins, (P-6A):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Florestone Products Co., Inc.
   d. Mustee, E. L. & Sons, Inc.

2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard.
   a. Shape: Five sided.
   b. Size: 24 by 24 inches.
   c. Height: 12 inches.
   d. Tiling Flange: On three sides.
   e. Rim Guard: On front top surfaces.
   f. Color: Not applicable.
   g. Faucet: Sink (P-6, P-6A).
   h. Drain: Grid with NPS 2 outlet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. All exposed metal parts of all fixtures, including all trim and fittings shall be brass.

C. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.

   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
   4. No wood grounds, wood plugs, or expansion bolts shall be permitted for fixture support.

D. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
E. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

F. Install wall-mounting fixtures with tubular waste piping attached to supports.

G. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

H. Install counter-mounting fixtures in and attached to casework.

I. Install fixtures level and plumb according to roughing-in drawings.

J. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation. All nipples shall be chrome plated brass.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

K. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

L. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

M. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

N. Install toilet seats on water closets.

O. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

Q. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

R. Install shower flow-control fittings with specified maximum flow rates in shower arms.

S. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

T. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or
in wall adjacent to sink if location is not indicated.

U. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install in sink deck. Connect inlet hose to dishwasher and outlet hose to disposer.

V. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."

W. Set service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

X. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

Y. All faucet handles, where possible, shall have color coded “indexes” identifying the service used.

Z. Water supplies for handicapped lavatories and sinks shall be insulated. Waste lines for handicapped lavatories and sinks shall be offset and insulated.

AA. Water supplies for handicapped water closets shall be roughed-in for flush valve handle to be operated from the accessible side of the water closet. Contractor shall coordinate and provide flush handle on the accessible side of all tank type handicapped water closets.

BB. Provide backflow devices on all faucets and fittings requiring backflow prevention. Devices may be inline type when not provided integral with the faucet.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224000
SECTION 224700 - DRINKING FOUNTAINS AND WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following water coolers and related components:
   
   1. Pressure water coolers.
   2. Fixture supports.

1.3 DEFINITIONS

A. Accessible Water Cooler: Fixture that can be approached and used by people with disabilities.

B. Cast Polymer: Dense, cast-filled-polymer plastic.

C. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.

D. Fitting: Device that controls flow of water into or out of fixture.

E. Fixture: Drinking fountain or water cooler unless one is specifically indicated.

F. Remote Water Cooler: Electrically powered equipment for generating cooled drinking water.

G. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS

A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For fixtures to include in emergency, operation, and maintenance manuals.
1.5 QUALITY ASSURANCE

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


C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.


F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

1.6 EXTRA MATERIALS

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

1. Filter Cartridges: Equal to 10 percent of amount installed for each type and size indicated, but no fewer than 2 of each.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Water Coolers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Elkay Model LZWS-EDFP217K drinking fountain with bottle filling station or a comparable product by one of the following:
   a. Halsey Taylor.
   b. Haws Corporation.
   c. Larco, Inc.
   d. Oasis Corporation.
   e. Sunroc Corp.

2. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style W, wall-
mounting water cooler for adult-mounting height.

a. Cabinet: Bi-level with two attached cabinets and with bi-level skirt kit, all stainless steel.
b. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
d. Control: Push button.
e. Supply: NPS 3/8 with ball, gate, or globe valve.
f. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
g. Drain(s): Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.1.
h. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
   1) Capacity: 8 gph of 50 deg F cooled water from 80 deg F inlet water and 90 deg F ambient air temperature.
   2) Electrical Characteristics: Cord/plug; 120-V ac; single phase; 60 Hz.
i. Support: Type II, water cooler carrier. Refer to "Fixture Supports" Article.

2.2 FIXTURE SUPPORTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Josam Co.
2. MIFAB Manufacturing, Inc.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.

C. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.

1. Type I: Hanger-type carrier with two vertical uprights.
2. Type II: Bi-level, hanger-type carrier with three vertical uprights.

DRINKING FOUNTAINS AND WATER COOLERS

Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.
July 18, 2016

224700 - 3
PAR 3 - EXECUTION

3.1 EXAMINATION
A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.
B. Examine walls and floors for suitable conditions where fixtures are to be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS
A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.
B. Use mounting frames for recessed water coolers, unless otherwise indicated.
C. Set freestanding and pedestal drinking fountains on floor.
D. Set remote water coolers on floor, unless otherwise indicated.
E. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION
A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.
B. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.
C. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.
D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
F. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in
Division 22 Section "Escutcheons for Plumbing Piping."

G. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.5 FIELD QUALITY CONTROL

A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.

1. Remove and replace malfunctioning units and retest as specified above.
2. Report test results in writing.

3.6 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust water cooler temperature settings.

3.7 CLEANING

A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 224700
SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

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 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. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
A. Comply with 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 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Expansion compensators.
2. Rubber expansion joints.
3. Flexible-hose expansion joints.
4. Flexible ball joints.
5. Pipe bends and loops.
6. Alignment guides and anchors.

1.3 DEFINITIONS

A. BR: Butyl rubber.
B. Buna-N: Nitrile rubber.
C. CR: Chlorosulfonated polyethylene synthetic rubber.
D. CSM: Chlorosulfonyl-polyethylene rubber.
E. EPDM: Ethylene-propylene-diene terpolymer rubber.
F. NR: Natural rubber.
G. PTFE: Polytetrafluoroethylene plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.
B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.
1.5 SUBMITTALS

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

B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

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

C. Welding certificates.

D. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

E. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, antitorque device, and removable end clip for positioning.

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

   a. Adsco Manufacturing, LLC.
   b. Flexicraft Industries.
   c. Flex-Pression, Ltd.
   d. Flex-Weld, Inc.
   e. Hyspan Precision Products, Inc.
   f. Metraflex, Inc.
   g. Senior Flexonics, Inc.; Pathway Division.
h. Unaflex Inc.

2. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
3. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows and bronze or stainless-steel shroud.
5. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.
7. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Weld.


1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flex-Hose Co., Inc.
   b. Flexicraft Industries.
   c. Flex-Weld, Inc.
   d. Garlock Sealing Technologies.
   e. General Rubber Corp.
   g. Metraflex, Inc.
   h. MG Piping Products Co.
   i. Proco Products, Inc.
   j. Red Valve Company, Inc.
   k. Senior Flexonics, Inc.; Pathway Division.
   l. Tozen America Corp.
   m. Unaflex Inc.
   n. Vibration Mountings & Controls, Inc.

2. Arch Type: Single arches.

3. Material: EPDM.

C. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flex-Hose Co., Inc.
   b. Flexicraft Industries.
   c. Flex-Pression, Ltd.
   d. Metraflex, Inc.
2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.
   a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
   b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

3. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and weld end connections for NPS 2-1/2 and larger.
   a. NPS 2 and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
   b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
   c. NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.

4. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and weld end connections for NPS 2-1/2 and larger.
   a. NPS 2 and Smaller: Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.
   b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.
   c. NPS 8 and Larger: Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

D. Flexible Ball Joints: Carbon-steel assembly with asbestos-free composition packing, designed for 360-degree rotation and angular deflection, and 250 psig at 400 deg F minimum pressure rating; complying with ASME Boiler and Pressure Vessel Code: Section II, "Materials," and with ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
   1. Angular Deflection for NPS 6 and Smaller: 30-degree minimum.
   2. Angular Deflection for NPS 8 and Larger: 15-degree minimum.
   3. End Connections for NPS 2 and Smaller: Threaded.
   4. End Connections for NPS 2-1/2 and Larger: Flanged.

2.2 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adsco Manufacturing, LLC.
b. Advanced Thermal Systems, Inc.
c. Flex-Hose Co., Inc.
d. Flexicraft Industries.
e. Flex-Weld, Inc.
f. Hyspan Precision Products, Inc.
g. Metraflex, Inc.
h. Piping Technology & Products, Inc.
i. Senior Flexonics, Inc.; Pathway Division.

2.3 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
   2. Expansion Plug: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
   1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

F. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

D. All piping shall be installed so that it will in no way be distorted or strained by expansion or contraction.

3.2 PIPE BEND AND LOOP INSTALLATION

A. Attach pipe bends and loops to anchors.


2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

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

3.4 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

C. Do not use pipe guides as supports.
3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 230516
SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Stack-sleeve fittings.
   3. Sleeve-seal systems.
   4. Sleeve-seal fittings.
   5. Grout.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

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


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

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with
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Fayetteville, North Carolina

Owner: City of Fayetteville
RMF Engineering, Inc.

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nailing flange for attaching to wooden forms.

G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Presealed Systems.

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

2.5 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

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

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for
3.2 STACK-SLEEVE-FITTING INSTALLATION

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

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves.
   b. Piping NPS 6 and Larger: Cast-iron wall sleeves.

2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and
         sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and
         sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and
         sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between
         piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:

END OF SECTION 230517
SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
   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 Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
   g. Bare Piping in Equipment Rooms: One-piece, cast-brass type with rough-brass finish.

2. Escutcheons for Existing Piping:
   a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: Split-casting brass type with rough-brass finish.
   g. Bare Piping in Equipment Rooms: Split-casting brass type with rough-brass finish.
   h. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 230518
SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Thermometers.
2. Gages.
3. Test plugs.
4. Flowmeters.
5. Thermal-energy meters.

1.3 DEFINITIONS

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

1.4 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.
B. Shop Drawings: Schedule for thermometers, gages and flowmeters indicating manufacturer's number, scale range, and location for each.
C. Product Certificates: For each type of thermometer, gage and flowmeter, signed by product manufacturer.
D. Operation and Maintenance Data: For flowmeters to include in emergency, operation, and maintenance manuals.
2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

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

1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Die-cast aluminum, 7 inches long.

C. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass.

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

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

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

2.2 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

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

2. KOBOLD Instruments, Inc.
3. Marsh Bellofram.
4. Trerice, H. O. Co.
5. Weiss Instruments, Inc.
6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter.

C. Element: Bourdon tube or other type of pressure element.

D. Movement: Mechanical, connecting element and pointer.
E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: metal.

G. Window: Glass.

H. Ring: Brass or Stainless steel.

I. Connector: Rigid, bottom type.

J. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

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

2.3 THERMOWELLS

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

1. AMETEK, Inc.; U.S. Gauge Div.
3. Ernst Gage Co.
5. Miljoco Corp.
6. Palmer - Wahl Instruments Inc.
7. REO TEMP Instrument Corporation.
8. Tel-Tru Manufacturing Company.
10. Weiss Instruments, Inc.
11. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

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

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

2.4 PRESSURE GAGES

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

1. AMETEK, Inc.; U.S. Gauge Div.
3. Ernst Gage Co.
4. Eugene Ernst Products Co.
5. KOBOLD Instruments, Inc.
7. Palmer - Wahl Instruments Inc.
8. REO TEMP Instrument Corporation.
10. Weiss Instruments, Inc.
11. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

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

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

C. Pressure-Gage Fittings:

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

2.5 TEST PLUGS

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

1. Flow Design, Inc.
2. Peterson Equipment Co., Inc.
4. Trerice, H. O. Co.

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

C. Minimum Pressure and Temperature Rating: 1000 psig at 200 deg F.

D. Core Inserts: One or two self-sealing rubber valves.
1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

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

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

2.6 WAFFER-ORIFICE FLOWMETERS

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

1. ABB, Inc.; ABB Instrumentation.
2. Armstrong Pumps, Inc.
4. Bell & Gossett; ITT Industries.
5. Taco

B. Description: Differential-pressure-design orifice insert for installation between pipe flanges; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.

C. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.

D. Pressure Rating: 300 psig.

E. Temperature Rating: 250 deg F.

F. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.

G. Permanent Indicators: Suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

1. Scale: Gallons per minute.
2. Accuracy: Plus or minus 1 percent between 20 and 80 percent of range.

H. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and
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having two 12-foot hoses in carrying case.

1. Scale: Gallons per minute.
2. Accuracy: Plus or minus 2 percent between 20 and 80 percent of range.

I. Operating Instructions: Include complete instructions with each flowmeter.

2.7 TURBINE FLOWMETERS

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

2. Bailey-Fischer & Porter Co.
3. Data Industrial Corp.
5. ERDCO Engineering Corp.
6. Fischer, George Inc.
7. Hoffer Flow Controls, Inc.
8. ISTEC Corporation.
9. Midwest Instruments & Controls Corp.
10. ONICON Incorporated.
11. SeaMetrics Inc.
12. Sponsler Company, Inc.
13. Thermo Measurement Ltd.

B. Description: Insertion type for inserting turbine into piping and measuring flow directly in gallons per minute.

C. Construction: Bronze or stainless-steel body; with plastic turbine or impeller and integral direct-reading scale.

D. Pressure Rating: 150 psig minimum.

E. Temperature Rating: 180 deg F minimum.

F. Display: Visual instantaneous rate of flow, with register to indicate total volume in gallons.

G. Accuracy: Plus or minus 2-1/2 percent.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the following locations:
1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.

**B.** Install dry-case-type, vapor-actuated dial thermometers at suction and discharge of each pump.

**C.** Provide the following temperature ranges for thermometers:
   1. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions.
   2. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.

### 3.2 GAGE APPLICATIONS

**A.** Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

**B.** Install dry-case-type pressure gages at chilled-water inlets and outlets of chillers.

**C.** Install dry-case-type pressure gages at suction and discharge of each pump.

### 3.3 INSTALLATIONS

**A.** Install direct-mounting thermometers and adjust vertical and tilted positions.

**B.** Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

**C.** Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

**D.** Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).

**E.** Install test plugs in tees in piping.

**F.** Install flow indicators, in accessible positions for easy viewing, in piping systems.

**G.** Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.

**H.** Install flowmeter elements in accessible positions in piping systems.

**I.** Install differential-pressure-type flowmeter elements with at least minimum straight lengths of pipe upstream and downstream from element as prescribed by manufacturer's written instructions.

**J.** Install wafer-orifice flowmeter elements between pipe flanges.

**K.** Install permanent indicators on walls or brackets in accessible and readable positions.
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L. Install connection fittings for attachment to portable indicators in accessible locations.
M. Install flowmeters at discharge of hydronic system pumps and at inlet of hydronic air coils.
N. Assemble components and install thermal-energy meters.
O. Mount meters on wall if accessible; if not, provide brackets to support meters.

3.4 CONNECTIONS
A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.
B. Connect flowmeter-system elements to meters.
C. Connect flowmeter transmitters to meters.

3.5 ADJUSTING
A. Calibrate meters according to manufacturer's written instructions, after installation.
B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 230519
SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Bronze ball valves.
3. Iron ball valves.
5. Bronze lift check valves.
8. Iron swing check valves with closure control.
11. Iron gate valves.
14. Lubricated plug valves.
15. Eccentric plug valves.

B. Related Sections:

1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
2. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.
E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 SUBMITTALS

A. General: Submit the following in accordance with conditions of Contract and Division 01 Specification Sections.

B. Product Data: For each type of valve indicated.

C. Shop Drawings: Submit manufacturer’s assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

D. Maintenance Data; Submit maintenance data and spare parts lists for each type of valve. Include this data, product data, and shop drawings in Maintenance Manual; in accordance with requirements of Division 01.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

D. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged or welded-end valve bodies, comply with ANSI B16.10 “Face-to-Face and End-to-End Dimensions of Ferrous Valves”.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.
B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

I. Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by Installer for installation requirements. Comply with ASME B31.1 for Power Piping.

J. Valve Design: Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.

K. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign materials in piping system can be expected to prevent tight shutoff of metal seated valves.

L. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

M. Fluid Control: Except as otherwise indicated, install ball valves to comply with ANSI B31.9. Where throttling is indicated or recognized as principal reason for valve, install globe valves.

2.2 BRONZE ANGLE VALVES

A. Class 150, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Kitz Corporation.

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

2.3 BRONZE BALL VALVES

A. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

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

   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO Inc.
2. Description:

b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Three piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.4 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. American Valve, Inc.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Flo Fab Inc.
i. Hammond Valve.
j. Kitz Corporation.
k. Legend Valve.
l. Milwaukee Valve Company.
m. Mueller Steam Specialty; a division of SPX Corporation.
n. NIBCO INC.
o. Norriseal; a Dover Corporation company.
q. Spence Strainers International; a division of CIRCOR International.
r. Sure Flow Equipment Inc.
s. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
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2.5 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   e. Ends: Threaded.
   f. Disc: Bronze.

2.6 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Bronze Disc:

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

   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Kitz Corporation.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Red-White Valve Corporation.
   i. Zy-Tech Global Industries, Inc.

2. Description:

   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 300 psig.
   c. Body Design: Horizontal flow.
2.7 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Kitz Corporation.
   f. Legend Valve.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Powell Valves.
   j. Red-White Valve Corporation.
   k. Sure Flow Equipment Inc.
   l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   m. Zy-Tech Global Industries, Inc.

2. Description:
   
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

B. Class 250, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

2.8 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:

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

   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.
   i. Closure Control: Factory-installed, exterior lever and weight.

2.9 IRON, CENTER-GUIDED CHECK VALVES

A. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

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

   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. Val-Matic Valve & Manufacturing Corp.
2. Description:
   b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
   c. NPS 14 to NPS 24, CWP Rating: 250 psig.
   e. Style: Compact wafer.
   f. Seat: Bronze.

B. Class 150, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
   c. NPS 14 to NPS 24, CWP Rating: 250 psig.
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

C. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. DFT Inc.
      d. Flo Fab Inc.
      e. Hammond Valve.
      f. Metraflex, Inc.
      g. Milwaukee Valve Company.
      h. NIBCO INC.
      i. Sure Flow Equipment Inc.
      j. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A 126, gray iron.
e. Style: Compact wafer, spring loaded.
f. Seat: Bronze.

D. Class 250, Iron, Globe, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Flomatic Corporation.
   e. Hammond Valve.
   f. Metraflex, Inc.
   g. Milwaukee Valve Company.
   h. Mueller Steam Specialty; a division of SPX Corporation.
   i. NIBCO INC.
   j. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

2.10 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Flo Fab Inc.
   e. Hammond Valve.
   f. Kitz Corporation.
   g. Legend Valve.
   h. Milwaukee Valve Company.
   i. NIBCO INC.
   j. Powell Valves.
k. Red-White Valve Corporation.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
m. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

B. Class 250, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. NIBCO INC.

d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

C. Class 250, OS&Y, Iron Gate Valves:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Powell Valves.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

3. Additional Materials:
   a. Stem: 13 percent chromium stainless steel.
   b. Disc face and seat rings: 13 percent chromium stainless.
   c. Steel or a combination of 13 percent chromium stainless steel and nickel copper, satellite or a combination of satellite and 13 percent chromium stainless steel as recommended by its manufacturer.

4. Working pressure and temperature ratings shall comply with ANSI B16.34.

2.11 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Hammond Valve.
   d. Kitz Corporation.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Powell Valves.
   h. Red-White Valve Corporation.
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   j. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   d. Ends: Threaded or solder joint.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.
2.12 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Kitz Corporation.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Powell Valves.
   i. Red-White Valve Corporation.
   j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   k. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Packing and Gasket: Asbestos free.

B. Class 250, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 500 psig.
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.

C. **2 Inches and Smaller:** Class 300 globe valve, forged or cast carbon steel body and bonnet, socket weld ends, stainless steel disc and stem; stellite seat ring; bolted bonnet, plug or semi-plug type disc, renewable or integral hard faced seat ring, outside screw and yoke, rising stem, body and bonnet material to conform to A 105 or A 216, Grade WCB. Working pressure and temperature ratings shall comply with ANSI B16.34.

D. **2-1/2 Inches and Larger:** Class 300 steel globe valve, flanged ends, bolted flanged bonnet, outside screw and yoke, rising stem, plug or semi-plug type disc, renewable seat ring and disc. Materials shall be: Body and bonnet, ASTM A 216, Grade WCB or A105; stem, 13 percent chromium stainless steel; seat ring 13 percent chromium stainless steel, disc, 13 percent chromium stainless steel faced. Face to face dimension shall conform to ANSI B16.10. Flanges shall be faced and drilled to ANSI B16.34.

E. Globe Valves shall be utilized in bypass applications.

### 2.13 LUBRICATED PLUG VALVES

A. **Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Homestead Valve; a division of Olson Technologies, Inc.
   b. Milliken Valve Company.
   c. R & M Energy Systems; a unit of Robbins & Myers, Inc.

2. Description:
   
   a. Standard: MSS SP-78, Type IV.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular or short.
   f. Plug: Cast iron or bronze with sealant groove.

B. **Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
   a. Homestead Valve; a division of Olson Technologies, Inc.
   b. Milliken Valve Company.
   c. R & M Energy Systems; a unit of Robbins & Myers, Inc.

2. Description:
a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
e. Pattern: Regular or short.
f. Plug: Cast iron or bronze with sealant groove.

2.14 ECCENTRIC PLUG VALVES

A. 175 CWP, Eccentric Plug Valves with Resilient Seating.

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

   a. Clow Valve Co.; a division of McWane, Inc.
   b. DeZurik Water Controls.
   c. Homestead Valve; a division of Olson Technologies, Inc.
   d. M&H Valve Company; a division of McWane, Inc.
   e. Milliken Valve Company.
   f. Henry Pratt Company.
   g. Val-Matic Valve & Manufacturing Corp.

2. Description:

   b. CWP Rating: 175 psig minimum.
   c. Body and Plug: ASTM A 48/A 48M, gray iron; ASTM A 126, gray iron; or ASTM A 536, ductile iron.
   d. Bearings: Oil-impregnated bronze or stainless steel.
   e. Ends: Flanged.
   f. Stem-Seal Packing: Asbestos free.
   g. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

B. 2 Inches and Smaller: Body shall meet ASTM A108 with straightway pattern, square head with removable lever operator, and threaded ends. Provide with an adjustable open position memory stop for balancing service.

C. 2-1/2 Inch and Larger: Body shall be cast steel meeting ASTM A108 for straightway pattern, square actuating head with removable lever operator, and flanged ends. Valves 8-inch and larger shall utilize manual gear operator. Provide with an adjustable open position memory stop for balancing service. Shutoff class shall meet ANSI 16.104 or better.

2.15 TRIPLE-DUTY VALVES

A. All Sizes: For pump discharge applications on chilled water, and heating water. Furnish a straight-pattern valve designed to perform the functions of a non-slam check valve, isolation valve and a calibrated balancing valve. ANSI class 125 cast ductile iron with flanged
connections. Valve shall be rated for 175 psig at 250 degrees F. The valve shall be fitted with a bronze disc with EPDM seat insert, stainless steel stem, and chatter preventing spring and calibrated nameplate. Valve design shall permit re-packing under full system pressure.

2.16 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to ball, butterfly and plug valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc coating.
4. Chain: Stainless steel, of size required to fit sprocket rim.

PART 3 - - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

A. General Application: Use gate, ball, and butterfly valves for shut-off duty; globe, ball, and butterfly for throttling duty as indicated on the contract drawings. Refer to piping system specification sections for specific valve applications and arrangements.

B. Installation of Swing Check Valves: Install for proper direction of flow and in horizontal position or vertical position with flow direction upwards, and with hinge pin level.
C. Install butterfly valves in a position to allow unrestricted, full movement of disc within piping system.

D. Insulation: Where insulation is indicated for the service, provide valves with extended stems, arranged in manner to receive insulation. Handles shall operate over full range without damaging insulation or vapor barrier seals.

E. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

F. Install by-pass and drain valves per MSS SP-45 or as indicated on the Contract Drawings.

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

H. Locate valves for easy access and provide separate support where necessary.

I. Install valves in horizontal piping with stem at or above center of pipe.

J. Install valves in position to allow full stem movement.

K. Install chainwheels on operators for butterfly, gate and plug valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

L. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service: Ball, butterfly or plug valves.
3. Throttling Service: Globe, ball or butterfly valves.
4. Pump-Discharge Check Valves: Spring-loaded, lift-disc check valves, or triple duty valve.
   a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
   b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check valves.
B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

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

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 150, bronze disc.
3. Ball Valves: Three piece, full port, bronze with stainless-steel trim.
4. Bronze Swing Check Valves: Class 150, bronze disc.

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

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
4. High-Performance Butterfly Valves: Class 150, single flange.
5. Iron Swing Check Valves: Class 125, metal seats.
6. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
8. Iron Gate Valves: Class 250, NRS.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 150, bronze disc.
3. Ball Valves: Three piece, full port, bronze with stainless-steel trim.
4. Bronze Swing Check Valves: Class 150, bronze disc.
B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
4. High-Performance Butterfly Valves: Class 150, single flange.
5. Iron Swing Check Valves: Class 125, metal seats.
6. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
8. Iron Gate Valves: Class 250, NRS.

3.7 SOCKET WELD CONNECTIONS

A. Make all socket weld connections in accordance with ASME Power Piping Code B31.1.

3.8 THREADED CONNECTIONS

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.9 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.10 FIELD QUALITY CONTROL

A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.
3.11 ADJUSTING AND CLEANING

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Valve Identification: Tag each valve with non-corrosive tag and Owner approved numbering scheme.

C. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

END OF SECTION 230523
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, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
3. Division 23 Section “Expansion Fittings and Loops for HVAC Piping” for pipe guides and anchors.
4. Division 23 Section “Vibration and Seismic Controls for HVAC Piping and Equipment” for vibration isolation devices.
5. Division 23 Section "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

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

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."
1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Fiberglass pipe hangers.
   3. Thermal-hanger shield inserts.
   4. Powder-actuated fastener systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Fiberglass strut systems. Include Product Data for components.
   4. Pipe stands. Include Product Data for components.
   5. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   2. AWS D1.3, "Structural Welding Code--Sheet Steel."
   3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
   4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 STEEL PIPE HANGERS AND SUPPORTS

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

B. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. Bergen-Power Pipe Supports.
4. Carpenter & Paterson, Inc.
5. Empire Industries, Inc.
6. ERICO/Michigan Hanger Co.
7. Globe Pipe Hanger Products, Inc.
8. Grinnell Corp.
9. GS Metals Corp.
11. PHD Manufacturing, Inc.
12. PHS Industries, Inc.
13. Piping Technology & Products, Inc.
14. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

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

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

2.3 TRAPEZE PIPE HANGERS

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

2.4 METAL FRAMING SYSTEMS

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

B. Manufacturers:
2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

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

1. Manufacturers:
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.
July 18, 2016

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

2.7 PIPE STAND FABRICATION

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

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.

2.8 EQUIPMENT SUPPORTS

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

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

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

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

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

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
RMF Engineering, Inc.
July 18, 2016

9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-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.
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 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 2 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 20, 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.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. 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.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system
Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. 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 absorb 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 absorb 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 absorb 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.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
D. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping and support
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1

Owner: City of Fayetteville
Fayetteville, North Carolina
RMF Engineering, Inc.
July 18, 2016

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

2. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   a. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   b. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 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 inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

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

3.4 METAL FABRICATIONS
A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.
B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

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

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

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 Painting Sections.

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

END OF SECTION 230529
SECTION 230533 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes heat tracing with the following electric heating cables:
   2. Self-regulating, parallel resistance.

1.3 SUBMITTALS
A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
   1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.
   1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Easy Heat Inc.
   2. Raychem; a division of Tyco Thermal Controls.
   3. Watts Radiant Inc.

D. Comply with IEEE 515.1.

E. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.

F. Electrical Insulating Jacket: Minimum 4.0-mil Kapton with silicone jacket or Tefzel.

G. Cable Cover: Aluminum braid and silicone or Hylar outer jacket.

H. Maximum Operating Temperature: 300 deg F.

I. Capacities and Characteristics: See schedule on drawings.

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   1. Easy Heat Inc.
   2. Raychem; a division of Tyco Thermal Controls.
   3. Thermon Manufacturing Co.

D. Heating Element: Pair of parallel No. 18 AWG, nickel-coated stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

E. Electrical Insulating Jacket: Flame-retardant polyolefin.

F. Cable Cover: Stainless-steel braid, and polyolefin outer jacket with UV inhibitor.

G. Maximum Operating Temperature (Power On): 150 deg F.

H. Maximum Exposure Temperature (Power Off): 185 deg F.

I. Maximum Operating Temperature: 300 deg F.

J. Capacities and Characteristics: See schedule on drawings.

2.3 CONTROLS

A. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.4 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Division 23 Section "Identification for HVAC Piping and Equipment."
C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
   2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written recommendations using slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Division 23 Section "HVAC Piping Insulation."

E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

G. Protect installed heating cables, including nonheating leads, from damage.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
3.4 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
   1. Test cables for electrical continuity and insulation integrity before energizing.
   2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 230533
SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. [Freestanding] [Restrained] [Freestanding and restrained] spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. [Freestanding] [Restrained] [Freestanding and restrained] air-mounting system.
12. Restrained vibration isolation roof-curb rails.
15. [Steel] [Inertia] [Steel and inertia], vibration isolation equipment bases.

1.3 DEFINITIONS

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 100 MPH.
2. Building Classification Category: III.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.
2. Assigned Seismic Design Category as Defined in the IBC: C.
   a. Component Importance Factor: 1.0.
   b. Component Response Modification Factor: 2.5.
   c. Component Amplification Factor: 2.5.
3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 30.7%.
4. Design Spectral Response Acceleration at 1-Second Period: 10.4%.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, wind forces required to select vibration isolators, wind restraints, and for designing vibration isolation bases.
   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.

3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

4. Wind-Restraint Details:
   a. Design Analysis: To support selection and arrangement of wind restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.

E. Qualification Data: For professional engineer and testing agency.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

F. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
   1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
   2. Base: Factory drilled for bolting to structure.
   3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel up or down before contacting a resilient collar.

G. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

H. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

I. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick neoprene. Include steel and neoprene vertical-limit
stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

J. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Isolation Technology, Inc.
5. Mason Industries.
6. Thybar Corporation.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic forces.

C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind restraint.
   a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
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Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.

2. VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
2.1 Minimum Additional Travel: 50 percent of the required deflection at rated load.
2.2 Lateral Stiffness: More than 80 percent of rated vertical stiffness.
2.3 Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.3 VIBRATION ISOLATION EQUIPMENT BASES
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amber/Booth Company, Inc.
   2. California Dynamics Corporation.
   3. Isolation Technology, Inc.
   5. Mason Industries.
   7. Vibration Isolation.
   8. Vibration Mountings & Controls, Inc.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
   1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
      a. Include supports for suction and discharge elbows for pumps.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

   1. Design Requirements: Lowest possible mounting height with not less than 1-inch
clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.4 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and wind-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to
receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:
   1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
   2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

C. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   3. Brace a change of direction longer than 12 feet.

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

E. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

G. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to
3.4 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. Provide evidence of recent calibration of test equipment by a testing agency acceptable to
      authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to
      restrained component (unless post-connection testing has been approved), and with at least
      seven days' advance notice.
   3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary
      load-spreading members.
   4. Test at least four of each type and size of installed anchors and fasteners selected by
      Architect.
   5. Test to 90 percent of rated proof load of device.
   7. Measure isolator deflection.
   8. Verify snubber minimum clearances.
   9. If a device fails test, modify all installations of same type and retest until satisfactory
      results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

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

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.
E. Adjust restraints to permit free movement of equipment within normal mode of operation.

F. Adjust snubbers according to manufacturer’s recommendations.

3.6 DEMONSTRATION

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

3.7 HVAC VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

Vibration Isolation Schedule

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Isolation Type</th>
<th>Base Deflection</th>
<th>Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan in AHU’s</td>
<td>Floor Spring</td>
<td>1.5&quot;</td>
<td>Base-Inertia Base</td>
<td>Thrust Restraints</td>
</tr>
<tr>
<td>Suspended Fans</td>
<td>Hanger Spring</td>
<td>1.5&quot;</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Roof Mounted Fans</td>
<td>Roof Isolator</td>
<td>1.5&quot;</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Base-Mounted Pumps</td>
<td>Floor Spring</td>
<td>0.75&quot;</td>
<td>Base-Inertia Base</td>
<td></td>
</tr>
<tr>
<td>In-Line Pumps</td>
<td>Flexible Neoprene</td>
<td>0.25&quot;</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Pumps, Air Compressors, and Vacuum Pump Flexible Piping Connectors</td>
<td>Flexible Metallic Hoses</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Piping Hangers Within 50 Feet of Isolated Equipment</td>
<td>Spring Hangers</td>
<td>1.5&quot;</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>First Two (2) Pipe Hangers near Non-Isolated Equipment</td>
<td>Spring Hangers</td>
<td>1.0&quot;</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION 230548
SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.
C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Material and Thickness: Polished brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch.
   5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
   1. Material and Thickness: ASTM D 709, type I cellulose, phenolic-resin-laminate engraving stock; Grade ES-s, black surface, black phenolic core, with white membrane sub-core and having predrilled holes for attachment hardware.
   4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 1-1/2 inches by 4 inches.
   6. Minimum Letter Size: 1/2 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Background Color: Red.
D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch.
F. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
G. Fasteners: Stainless-steel rivets or self-tapping screws.
H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick.
B. Letter Color: Yellow.
C. Background Color: Black.
D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch (64 by 25 mm).

F. Minimum Letter Size: 3/4 inch (20 mm) for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Polished brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

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

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

C. Provide minimum ¾" round stick-on dots on the ceiling grid for identification of equipment hidden above the ceiling. Color code as follows:
   1. Yellow: HVAC equipment.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "Interior Painting."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles, complying with ASME A13.1, on each piping system.
   1. Identification Paint: Use for contrasting background.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units.
      Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

D. Pipe Label Color Schedule:
1. Chilled-Water Piping (CHWS/CHWR):
   a. Background Color: Safety Blue (DC 9800).
   b. Letter Color: Black.
2. Heating Water Piping (HWS/HWR):
   a. Background Color: Oxide Yellow (DC 8800).
   b. Letter Color: Black.
3. Natural Gas Piping (GAS):
   a. Background Color: Medium Yellow (DC 8600).
   b. Letter Color: Black.
4. Refrigerant Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.

3.4 DUCT LABEL INSTALLATION
A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For ducts.
   2. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.
C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION
A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
1. Identification for HVAC Piping and Equipment

d. Natural Gas: 1-1/2 inches, round.

2. Valve-Tag Color: N/A, brass tags are used

3. Letter Color:
   b. Refrigerant: Black.
   c. Hot Water: Black.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION 230553
SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Balancing Air Systems:
   a. Constant-volume air systems.
   b. Variable-air-volume systems.
   c. Witness all high and medium pressure duct leakage tests, leakage tests on all field erected AHU’s, all sectionally shipped factory fabricated AHU’s and all low pressure duct mains, and low pressure duct risers.

2. Balancing Hydronic Piping Systems:
   a. Variable-flow systems.
   b. Primary-secondary systems.

3. HVAC equipment quantitative-performance settings.
4. Indoor-air quality measuring.
5. Existing systems impacted by the renovation TAB.
6. Verifying that automatic control devices are functioning properly.
7. Reporting results of activities and procedures specified in this Section.
8. Domestic water recirculation.

1.3 DEFINITIONS


B. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

C. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

D. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings.
that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

E. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.


G. NC: Noise criteria.

H. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

I. RC: Room criteria.

J. Report Forms: Test data sheets for recording test data in logical order.

K. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

L. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

M. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

N. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

O. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

P. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

Q. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.


S. TABB: Testing, Adjusting, and Balancing Bureau.

T. TAB Specialist: An entity engaged to perform TAB Work.

U. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
V. Test: A procedure to determine quantitative performance of systems or equipment.

W. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.


C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit copies of reports as required prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two sets of sample TAB report forms.

F. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

G. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

   a. Submittal distribution requirements.
c. TAB plan.
d. Work schedule and Project-site access requirements.
e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.


E. Instrumentation Type, Quantity, and Accuracy: As described in ASHRAE 111, Section 5, “Instrumentation.”

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
   1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner may occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

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

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.
1.8 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC’s "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section "Metal Ducts" and 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. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions.
different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

G. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

J. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

K. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

L. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

M. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning 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, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."
4. Do not place holes in bottom of wet ductwork.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.
3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling unit components.

L. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.
   a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures to determine actual static pressure as follows:
   a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

4. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

5. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

6. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.
3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record the final fan performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
   a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Architect and comply with requirements in Division 23 Section "Hydronic Pumps."

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
   a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 5 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.
1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
   1. Determine the balancing station with the highest percentage over indicated flow.
   2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
   3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems’ pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS
   A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS
   A. Balance the primary system crossover flow first, then balance the secondary system.

3.11 PROCEDURES FOR MOTORS
   A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
      1. Manufacturer, model, and serial numbers.
      4. Efficiency rating.
      5. Nameplate and measured voltage, each phase.
      6. Nameplate and measured amperage, each phase.
      7. Starter thermal-protection-element rating.

   B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.
3.12 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. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
3. Power factor if factory-installed instrumentation is furnished for measuring kilowatt.
4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatt.
5. Capacity: Calculate in tons of cooling.
6. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.13 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.14 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

B. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Refrigerant Coils: Measure the following data for each coil:
1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.16 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.17 PROCEDURES FOR INDOOR-AIR QUALITY MEASUREMENTS

A. After air balancing is complete and with HVAC systems operating at indicated conditions, perform indoor-air quality testing.

B. Observe and record the following conditions for each HVAC system:

1. The distance between the outside-air intake and the closest exhaust fan discharge, flue termination, or vent termination.
2. Specified filters are installed. Check for leakage around filters.
3. Cooling coil drain pans have a positive slope to drain.
4. Cooling coil condensate drain trap maintains an air seal.
5. Evidence of water damage.
6. Insulation in contact with the supply, return, and outside air is dry and clean.

C. Measure and record indoor conditions served by each HVAC system. Make measurements at multiple locations served by the system if required to satisfy the following:

1. Most remote area.
2. One location per floor.
3. One location for every 5000 sq. ft.

D. Measure and record the following indoor conditions for each location two times at two-hour intervals, and in accordance with ASHRAE 113:

1. Temperature.
2. Relative humidity.
3. Air velocity.
5. Concentration of carbon monoxide (ppm).
7. Formaldehyde (ppm).

3.18 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Existing systems to be balanced is limited to existing systems modified under this contract. The chilled water and heating piping systems will need to be re-balanced as well as any duct systems modified by this renovation. Existing air systems that are not affected by the renovation are not intended to be re-balanced.

B. 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 condition of filters.
   4. Check the condition of coils.
   5. Check the operation of the drain pan and condensate drain trap.
   6. Check bearings and other lubricated parts for proper lubrication.

C. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.
   1. New filters are installed.
   2. Coils are clean and fins combed.
   3. Drain pans are clean.
   4. Fans are clean.
   5. Bearings and other parts are properly lubricated.
   6. Deficiencies noted in the preconstruction report are corrected.

D. 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, filter, and coil face velocity.
   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 and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
   4. Air balance each air outlet.
3.19 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.20 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.21 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.

3.22 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers’ test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of TAB firm.
   3. Project name.
   4. Project location.
   5. Architect’s name and address.
   6. Engineer’s name and address.
   7. Contractor’s name and address.
   9. Signature of TAB firm who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents including the following:

      a. Indicated versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.

   12. Nomenclature sheets for each item of equipment.
   13. Data for terminal units, including manufacturer, type size, and fittings.
   14. Notes to explain why certain final data in the body of reports varies from indicated values.
   15. Test conditions for fans and pump performance forms as required by AABC.

      a. Settings for outside-, return-, and exhaust-air dampers.
E. Vibration Measurement Reports:

1. Date and time of test.
2. Vibration meter manufacturer, model number, and serial number.
3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
4. Diagram of equipment showing the vibration measurement locations.
5. Measurement readings for each measurement location.
7. Description of predominant vibration source.

F. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:

1. Date and time of test. Record each tested location on its own NC curve.
2. Sound meter manufacturer, model number, and serial number.
3. Space location within the building including floor level and room number.
4. Diagram or color photograph of the space showing the measurement location.
5. Time weighting of measurements, either fast or slow.
6. Description of the measured sound: steady, transient, or tonal.
7. Description of predominant sound source.

G. Indoor-Air Quality Measurement Reports for Each HVAC System:

1. HVAC system designation.
2. Date and time of test.
3. Outdoor temperature, relative humidity, wind speed, and wind direction at start of test.
4. Room number or similar description for each location.
5. Measurements at each location.
6. Observed deficiencies.

H. Instrument Calibration Reports:

1. Report Data:
   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.

I. Thermal performance of each item of heat exchange equipment. Agency is to perform measurements and certify to 5% thermal balance.

3.23 INSPECTIONS

A. Initial Inspection:
1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.

2. Randomly check the following for each system:
   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure water flow of at least 5 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Measure sound levels at two locations.
   e. Measure space pressure of at least 10 percent of locations.
   f. Verify that balancing devices are marked with final balance position.
   g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

   1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Engineer.
   2. TAB firm test and balance engineer shall conduct the inspection in the presence of the Engineer.
   3. Engineer shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
   4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
   5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
   6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
   7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

   1. 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 contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.
3.24 ADDITIONAL TESTS

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

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593
SECTION 230713 - DUCT INSULATION

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 insulating the following duct services:

1. Indoor, concealed supply, return, exhaust and outdoor air.
2. Indoor, exposed supply, return, exhaust and outdoor air.

B. Related Sections:

1. Division 23 Section "HVAC Equipment Insulation."
2. Division 23 Section "HVAC Piping Insulation."

1.3 SUBMITTALS

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

B. 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 elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12 inches square.
2. Sheet Jacket Materials: 12 inches square.
3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Qualification Data: For qualified Installer.

E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation.
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.
July 18, 2016

materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

F. 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 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.

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 sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 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


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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM 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. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; SoftTouch Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Friendly Feel Duct Wrap.
   d. Manson Insulation Inc.; Alley Wrap.
   e. Owens Corning; SOFTR All-Service Duct Wrap.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Insulation Board.
   e. Manson Insulation Inc.; AK Board.
   f. Owens Corning; Fiberglas 700 Series.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.


1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.3 MASTICS

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

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
2.4 LAGGING ADHESIVES

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

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:
   c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
   d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 TAPES

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

1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.8 SECUREMENTS

A. Bands:
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. ITW Insulation Systems; Gerrard Strapping and Seals.
      b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated.
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) AGM Industries, Inc.; CWP-1.
         2) GEMCO; CD.
         3) Midwest Fasteners, Inc.; CD.
         4) Nelson Stud Welding; TPA, TPC, and TPS.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) AGM Industries, Inc.; CHP-1.
         2) GEMCO; Cupped Head Weld Pin.
         3) Midwest Fasteners, Inc.; Cupped Head.
         4) Nelson Stud Welding; CHP.
   3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
         2) GEMCO; Perforated Base.
3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
2) GEMCO; Peel & Press.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

d. Adhesive-backed base with a peel-off protective cover.

5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

6. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1) GEMCO.
2) Midwest Fasteners, Inc.

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

2.9 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

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.

B. 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.

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 ducts and fittings.

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

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

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

F. Keep insulation materials dry during application and finishing.
G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

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

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

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

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

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

3.4 PENETRATIONS

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

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
   1. Comply with requirements in Division 07 Section "Penetration Firestopping" firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:
   1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   
a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not overcompress insulation during installation.

e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 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 ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be
limited to one location for each duct system defined in the "Duct Insulation Schedule, General" Article.

D. All insulation applications will be considered defective work if sample inspection reveals noncompliance with requirements.

3.7 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
   1. Indoor, concealed supply, return, exhaust and outdoor air.
   2. Indoor, exposed supply, return, exhaust and outdoor air.

B. Items Not Insulated:
   1. Factory-insulated flexible ducts.
   2. Factory-insulated plenums and casings.
   3. Flexible connectors.
   5. Factory-insulated access panels and doors.

3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 3-lb/cu. ft. nominal density.

B. Concealed, round and flat-oval, return-air duct insulation shall be the following:

C. Concealed, round and flat-oval, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 3-lb/cu. ft. nominal density.

D. Concealed, round and flat-oval, exhaust-air duct insulation shall be the following:

E. Concealed, rectangular, supply-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 2 inches thick and 3-lb/cu. ft. nominal density.

F. Concealed, rectangular, return-air duct insulation shall be the following:

G. Concealed, rectangular, outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches thick and 3-lb/cu. ft. nominal density.

H. Concealed, rectangular, exhaust-air duct insulation shall be the following:

I. Concealed, return-air plenum insulation shall be one of the following:

J. Exposed supply-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

K. Exposed return-air duct insulation shall be the following:

L. Exposed, rectangular, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

M. Exposed exhaust-air duct insulation shall be the following:

N. Exposed, return-air plenum insulation shall be the following:

O. Exposed, outdoor-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

P. Exposed, exhaust-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

END OF SECTION 230713
SECTION 230716 - HVAC EQUIPMENT INSULATION

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 insulating the following HVAC equipment that is not factory insulated:

1. Chilled-water pumps.
2. Heating, hot-water pumps.
3. Steam condensate pumps.
5. Air separators.

B. Related Sections:

1. Division 23 Section "Duct Insulation."
2. Division 23 Section "HVAC Piping Insulation."

1.3 SUBMITTALS

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

B. 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 attachment and covering of heat tracing inside insulation.
3. Detail removable insulation at equipment connections.
4. Detail application of field-applied jackets.
5. Detail application at linkages of control devices.
6. Detail field application for each equipment type.

C. Qualification Data: For qualified Installer.

D. 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.
E. 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 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 sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. 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 in "Breeching Insulation Schedule" and "Equipment Insulation Schedule" articles for where insulating materials shall be applied.
B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

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

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

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. K-Flex USA; Insul-Sheet and K-FLEX LS.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide insulation with factory-applied ASJ jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; CertaPro Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Insulation Board.
   e. Manson Insulation Inc.; AK Board.
   f. Owens Corning; Fiberglas 700 Series.

H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Manson Insulation Inc.; AK Flex.
   e. Owens Corning; Fiberglas Pipe and Tank Insulation.
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.
July 18, 2016

2.2 ADHESIVES

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

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Aeroflex USA, Inc.; Aeroseal.
      b. Armacell LLC; Armaflex 520 Adhesive.
      d. K-Flex USA; R-373 Contact Adhesive.
   2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following:
      b. Eagle Bridges - Marathon Industries; 225.
      d. Mon-Eco Industries, Inc.; 22-25.
   2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

D. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, provide one of the following:
      b. Eagle Bridges - Marathon Industries; 225.

d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.3 MASTICS

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

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   
   b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.


C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

   
   b. Eagle Bridges - Marathon Industries; 550.
   
   
   
   e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.

2.4 LAGGING ADHESIVES

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

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
4. Service Temperature Range: 0 to plus 180 deg F.

2.5 SEALANTS

A. ASJ Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.
2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

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

   a. Sheet and roll stock ready for shop or field sizing.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   d. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

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

1. Products: Subject to compliance with requirements, provide one of the following:
   a. 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.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.

   2. Width: 2 inches.
   3. Thickness: 3.7 mils.
   5. Elongation: 5 percent.
   6. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   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, 3/4 inch wide with closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with closed seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated.
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) AGM Industries, Inc.; CHP-1.
      2) GEMCO; Cupped Head Weld Pin.
      3) Midwest Fasteners, Inc.; Cupped Head.
      4) Nelson Stud Welding; CHP.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.
      b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
      c. Spindle: Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
      d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers, Series.
      2) GEMCO; Peel & Press.
      3) Midwest Fasteners, Inc.; Self Stick.
      b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
      c. Spindle: Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina

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2.10 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

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

1. Verify that systems and equipment to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

B. 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:

d. Adhesive-backed base with a peel-off protective cover.

5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

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

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
J. Apply adhesives, mastic, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

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

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

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
5. Handholes.
6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

   1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

   1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt
flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from stainless steel, at least 0.050 inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 FIELD-APPLIED JACKET INSTALLATION

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

3.6 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.7 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: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
3.8 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor equipment that is not factory insulated.

C. Chilled-water pump, expansion tank and air separator insulation shall be the following:
   1. Closed cell elastomeric or rigid foam: 2 inches thick and 3-lb/cu. ft. nominal density.

D. Heating-hot-water pump insulation shall be the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

E. Heating-hot-water expansion/compression tank insulation shall be[ one of] the following:
   1. Mineral-Fiber Board: 1 inch thick and 3-lb/cu. ft. nominal density.

F. Heating-hot-water air-separator insulation shall be one of the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

G. Steam flash-tank insulation shall be one of the following:
   1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

3.9 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:
   1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. Aluminum, Smooth 0.024 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
   1. Aluminum, Smooth with: 0.032 inch thick.
END OF SECTION 230716
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 insulating the following HVAC piping systems:

1. Condensate drain piping, indoors.
2. Chilled-water piping, indoors.
3. Heating hot-water piping, indoors.
4. Refrigerant suction and hot-gas piping, indoors.

B. Related Sections:

1. Division 23 Section "HVAC Equipment Insulation."
2. Division 23 Section "Duct Insulation."

1.3 SUBMITTALS

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

B. 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 attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Sheet Form Insulation Materials: 12 inches square.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Qualification Data: For qualified Installer.

E. 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.

F. 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 sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.
1.7 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


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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Block Insulation: ASTM C 552, Type I.
2. Special-Shaped Insulation: ASTM C 552, Type III.
3. Board Insulation: ASTM C 552, Type IV.
4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials, lap seal. Comply with ASTM C 534, Type I for tubular materials.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
H. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000-Degree Pipe Insulation.
   d. Manson Insulation Inc.; Alley-K.
   e. Owens Corning; Fiberglas Pipe Insulation.

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

2.2 ADHESIVES

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

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:


2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic
Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.

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

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.3 MASTICS

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

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      b. Eagle Bridges - Marathon Industries; 550.
      e. Vimasco Corporation; WC-1/WC-5.
   2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: 60 percent by volume and 66 percent by weight.

2.4 LAGGING ADHESIVES
   A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Products: Subject to compliance with requirements, provide one of the following:
      c. Vimasco Corporation; 713 and 714.
   3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   4. Service Temperature Range: 0 to plus 180 deg F.

2.5 SEALANTS
   A. Joint Sealants:
1. Joint Sealants for Cellular-Glass, Products: Subject to compliance with requirements, provide one of the following:
   b. Eagle Bridges - Marathon Industries; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.

B. ASJ Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
   5. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   6. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.6 FACTORY-APPLIED JACKETS
   A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
      1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH
   A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.
   B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.8 FIELD-APPLIED CLOTHS
   A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

2.9 FIELD-APPLIED JACKETS
   A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
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B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Metal Jacket:
   1. Products: Subject to compliance with requirements, provide one of the following:
      b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
      c. RPR Products, Inc.; Insul-Mate.
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Moisture Barrier for Indoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
      d. Moisture Barrier for Outdoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
      e. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Products: Subject to compliance with requirements, provide one of the following:
      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.
   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.

2.11 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 3/4 inch wide with closed seal.

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

C. Wire: 0.062-inch soft-annealed, stainless steel.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches 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. Handholes.
   5. Cleanouts.

3.4 PENETRATIONS

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

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

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

F. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "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.
3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

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

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

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

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of cellular-glass insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 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.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

3.10 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

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

C. Tests and Inspections:
   
   1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   
   1. Drainage piping located in crawl spaces.
   2. Underground piping.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:
   
   1. All Pipe Sizes: Insulation shall be one of the following:
      
      b. Flexible Elastomeric: 1 inch thick.

B. Chilled Water, above 40 Deg F:
   
   1. NPS 12 and Smaller: Insulation shall be one of the following:
      
      a. Flexible Elastomeric: 2 inch thick.

C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
   
   1. NPS 12 and Smaller: Insulation shall be one of the following:
      
      a. Cellular Glass: 2 inches thick.
      b. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.
D. Refrigerant Suction and Hot-Gas Piping:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 1 inch thick.

E. Refrigerant Suction and Hot-Gas Flexible Tubing:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Flexible Elastomeric: 1 inch thick.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Cellular Glass: 3 inches thick.
      b. Flexible Elastomeric: 3 inches thick.

B. Refrigerant Suction and Hot-Gas Piping:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 2 inches thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 2 inches thick.

3.15 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.

B. Chilled Water, All Sizes: Cellular glass, 2 inches thick.

C. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F and Below: Cellular glass, 3 inches thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed:
   1. 0.03 inch pre-colored PVC jacket, color to match piping system color described in specification 23 0553.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed:
   1. Aluminum, corrugated with Z-Shaped Locking Seam: 0.024 inch thick.

3.18 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment and installation for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-furnished controls.

B. This Section includes an Energy Reporting and Data Analytics software package.

C. See "Sequences of Operation" for requirements that relate to this Section.

1.2 RELATED DOCUMENTS

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

1. Division 01 – General and Special Requirements
2. Division 01 – Submittal Requirements
3. Division 01 – Materials and Equipment
4. Division 23 – Common Work Results for HVAC
5. Section 23 – Variable Frequency Drives
6. Division 23 – Sequences of Operation
7. Division 23 – Testing, Adjusting, and Balancing for HVAC
8. Division 26 – General Electrical Provisions for Electrical Work
9. Division 26 – Common Work Results for Electrical
10. Division 26 – Low Voltage Electrical Power Conductors and Cables
11. Division 26 – Hangers and Supports for Electrical Systems
12. Division 26 – Raceway and Boxes for Electrical Systems
13. Division 26 – Identification for Electrical Systems
14. Division 26 – Wiring Devices
15. Division 26 – Network Lighting Controls

1.3 ABBREVIATIONS

A. AAC: Advanced Application Controller

B. AHU: Air Handling Unit.

C. ALN: Automation Level Network

D. ASC: Application Specific Controller
E. ASHRAE: American Society of Heating Refrigerating and Air-Conditioning Engineers

F. BAS: Building Automation System

G. BC: Building Controller

H. BIBB: BACnet Interoperability Building Blocks

I. BIM: Building Information Modeling

J. BMS: Building Management System.

K. CFM: Cubic Feet per Minute.

L. DCV: Demand Controlled Ventilation

M. DDC: Direct digital controls

N. EIA: Electronics Industries Alliance

O. EMI: Electro-Magnetic Interference

P. EP: Electric-to-Pneumatic

Q. FAS: Fire Alarm System.

R. FLN: Floor Level Network

S. FCU: Fan Coil Unit

T. HMI: Human Machine Interface

U. HVAC: Heating, Ventilating and Air Conditioning.

V. IEEE: Institute of Electrical and Electronic Engineers

W. I/O: Input/Output

X. IP: Internet Protocol

Y. IT: Information Technology

Z. LAN: Local area network.

AA. LCD: Liquid Crystal Display

BB. LED: Light Emitting Diode

CC. MER: Mechanical Equipment Room.
DEFINITIONS

A. BACnet: An industry standard data communication protocol for Building Automation and Control Networks. Refer to the latest version of AHSRAE standard 135.

B. Scope Terminology

1. Provide = Furnish equipment, engineer, program and install
2. Furnish = Furnish equipment, engineer and program
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
RMF Engineering, Inc.
July 18, 2016

3. Mount = securely fasten or pipe
4. Install = mount and wire
5. Wire = wire only

1.5 WORK INCLUDED

A. The BAS Contractor shall provide a complete and operational system that will perform the sequences of operation as described herein.

B. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all system controllers, logic controllers, and all input/output devices. Items of work included are as follows:

1. Provide a submittal that meets the requirements below for approval.
2. Coordinate installation schedule with the mechanical contractor and general contractor.
3. Provide installation of all panels and devices unless otherwise stated.
4. Provide power for panels and control devices unless otherwise stated.
5. Provide all low voltage control wiring for the DDC system.
6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.
7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.
8. Provide testing, demonstration and training as specified below.

C. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer.

D. Provide Energy Reporting and Data Analytics software package.

1.6 SUBMITTALS

A. Provide submittals for fast track items that need to be approved and released to meet the schedule of the project. Provide submittals for the following items separately upon request:

1. Valve schedule and product data
2. Damper schedule and product data
3. Mounting and wiring diagrams for factory-installed control components
4. Thermostat locations

B. Provide a complete submittal with all controls system information for approval before construction starts. Include the following:

1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
2. Wiring Diagrams: Power, signal, and control wiring. Detail the wiring of the control
devices and the panels. Show point-to-point wiring from field devices to the control panel. Show point-to-point wiring of hardwired interlocks. Show a ladder diagram or schematic of wiring internal to the panels, including numbered terminals. Clearly designate wiring that is done at a factory, at a panel shop or in the field.

3. Details of control panel faces, including sizes, controls, instruments, and labeling.

4. Schedule of dampers and actuators including size, leakage, and flow characteristics. If dampers are furnished by other, submit a damper actuator schedule coordinating actuator sizes with the damper schedule.

5. Schedule of valves including leakage and flow characteristics.


7. Network riser diagram showing wiring types, network protocols, locations of floor penetrations and number of control panels. Label control panels with network addresses and BACnet device instance numbers. Show all routers, switches, hubs and repeaters.

8. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.

9. Starter and variable frequency drive wiring details of all automatically controlled motors.

10. Reduced size floor plan drawings showing locations of control panels, thermostats and any devices mounted in occupied space.

11. Product Data: Include manufacturer's technical literature for each control device indicated, labeled with setting or adjustable range of control. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

12. Submit BACnet Protocol Implementation Conformance Statements (PICS) for all direct digital controllers, software and other system components that will communicate on the BAS utilizing BACnet.

C. Wireless Communication: If wireless sensors and/or network are used, submit a radio signal layout showing the signal reach of every wireless mesh device. Show where repeaters are needed so that wireless signals overlap.

D. Submit a description of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.

E. Submit blank field check-out and commissioning test reports, customized for each panel or system, which will be filled out by the technician during start-up.

F. Variance letter: Submit a letter detailing each item in the submission that varies from the contract specification or sequence of operation in any way.

G. After the BAS system is approved for construction, submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change setpoints, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.

H. Operation and Maintenance Data: In addition to items specified in Division 1 Section
"Operation and Maintenance Data," include the following:

1. Product data with installation details, maintenance instructions and lists of spare parts for each type of control device.
3. Inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.
4. Calibration records and list of set points.

1.7 PROJECT RECORD DOCUMENTS

A. Project Record Documents: Submit three (3) copies of record (as-built) documents upon completion of installation. Submittal shall consist of:

1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD compatible files in electronic format and as 11 x 17 inch prints.
2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements in the Control System Demonstration and Acceptance section of this specification.
   a. As-built versions of the submittal product data.
   b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
   c. Operator’s Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
   d. Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
   e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
   f. Documentation of all programs created using custom programming language, including setpoints, tuning parameters, and object database.
   g. Graphic files, programs, and database on electronic media.
   h. List of recommended spare parts with part numbers and suppliers.
   i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
   j. Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
   k. Licenses, guarantees, and warranty documents for equipment and systems.

B. Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum include the following:
1. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.
2. Description of manual override operation of all control points in system.
3. BMS system manufacturers complete operating manuals.

C. Provide maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. As a minimum include the following:

1. Complete as-built installation drawings for each building system.
2. Overall system electrical power supply schematic indicating source of electrical power for each system component. Indicate all battery backup provisions.
3. Photographs and/or drawings showing installation details and locations of equipment.
4. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.
5. Parts list with manufacturer's catalog numbers and ordering information.
6. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.
7. Manufacturer's operation, set-up, maintenance and catalog literature for each piece of equipment.
8. Maintenance and repair instructions.
9. Recommended spare parts.

D. Provide Programming Manual to serve as training and reference manual for all aspects of system programming. As a minimum include the following:

1. Complete programming manuals, and reference guides.
2. Details of any custom software packages and compilers supplied with system.
3. Information and access required for independent programming of system.

1.8 QUALITY ASSURANCE

A. Codes

1. Perform all wiring in accordance with Division 26, NEC, local codes and Owner’s requirements.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
6. All equipment shall be UL listed and approved and shall meet with all applicable NFPA standards, including UL 916 - PAZX Energy Management Systems,
   a. Provide written approvals and certifications after installation has been completed.
7. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

8. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-14001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

B. Qualifications

1. Installing contractor shall be in the business of installing and servicing DDC controls for mechanical systems, temperature and ventilation control, environmental control, lighting control, access and security, life safety and energy management as their primary business.

2. Installer Qualifications: An experienced installer who is the authorized representative of the automatic control system manufacturer for both installation and maintenance of controls required for this Project.

3. Engineering, drafting, programming, and graphics generation shall be performed by the local branch engineers and technicians directly employed by the Building Automation System Contractor.

4. Supervision, checkout and commissioning of the system shall be by the local branch engineers and technicians directly employed by the Building Automation System Contractor. They shall perform commissioning and complete testing of the BAS system.

C. The BAS contractor shall maintain a service organization consisting of factory trained service personnel and provide a list of ten (10) projects, similar in size and scope to this project, completed within the last five years.

D. Final determination of compliance with these specifications shall rest solely with the Engineers and Owner who will require proof of prior satisfactory performance.

E. For any BAS system and equipment submitted for approval, the BAS contractor shall state what, if any, specific points of system operation differ from these specifications.

F. All portions of the system must be designed, furnished, installed, commissioned and serviced by manufacturer approved, factory trained employees.

G. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to building controllers, advanced application controllers, application specific, personal operator workstations and portable operator's terminals, to be connected and directly communicate with any new BAS system equipment without bridges, routers or protocol converters.
1.9 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

B. Deliver, store, protect, and handle products to site under provisions of the contract Documents. Coordinate all site delivers with Construction project Manager.

C. Protect products from construction operations, dust, and debris, by storing materials inside, protected from weather in a conditioned space.

1.10 COORDINATION

A. Coordinate IP drops, network connections, user interfaces, firewall, etc with Owner’s IT representative.

B. Coordinate location of thermostats, humidistats, panels, and other exposed control components with plans and room details before installation.

C. Coordinate equipment with Division 28 "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate power for control units and operator workstation with electrical contractor.

E. Coordinate equipment with provider of starters and drives to achieve compatibility with motor starter control coils and VFD control wiring.

F. Coordinate scheduling with the mechanical contractor and general contractor. Submit a schedule for approval based upon the installation schedule of the mechanical equipment.

G. Coordinate installation of taps, valves, airflow stations, etc. with the mechanical contractor.

H. Products Furnished but Not Installed Under This Section

1. Hydronic and Refrigerant Piping accessories:
   a. Control Valves
   b. Temperature Sensor Wells and Sockets
   c. Pressure Sensor Wells and Sockets
   d. Flow Switches
   e. Flow Meters
   f. Differential Pressure Transmitters

2. Sheet metal accessories
   a. Dampers
   b. Airflow Stations
   c. Terminal Unit Controls
I. Products Installed but Not Furnished Under This Section

1. Refrigeration Equipment:
   a. Refrigerant Leak Detection System
   b. Proof of flow pressure switches

2. Rooftop Air Handling Equipment:
   a. Thermostats
   b. Duct Static Pressure Sensors

J. Products Integrated To but Not Furnished or Installed Under This Section

1. Lighting Control panels

1.11 WARRANTY

A. Provide warranty per Division 20 Section “General Mechanical Requirements” and as supplemented in this section.

B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of 12 months from completion of system demonstration.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.

D. During normal building occupied hours, failure of items that are critical for system operation shall be provided within 4 hours of notification from the Owner’s Representative.

E. This warranty shall apply equally to both hardware and software.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. The Building Automation System (BAS) contractor shall furnish and install a networked system of HVAC controls. The contractor shall incorporate direct digital control (DDC) for central plant equipment, building ventilation equipment, supplemental heating and cooling equipment, and terminal units.

B. Provide networking to new DDC equipment using industry accepted communication standards. System shall utilize BACnet communication according to ANSI/ASHRAE standard 135-2010 for interoperability with smart equipment, for the main IP communication trunk to the BAS.
Server and for peer-to-peer communication between DDC panels and devices. The system shall not be limited to only standard protocols, but shall also be able to integrate to a wide variety of third-party devices and applications via drivers and gateways.

C. Provide standalone controls where called for on the drawings or sequences.

D. Provide an Energy Reporting and Data Analytics packages described herein.

2.2 BUILDING AUTOMATION SYSTEM NETWORK

A. All networked control products provided for this project shall be comprised of an industry standard open protocol internetwork. Communication involving control components (i.e. all types of controllers and operator interfaces) shall conform to ASHRAE 135-2010 BACnet standard. Networks and protocols proprietary to one company or distributed by one company are prohibited.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

1. Software applications, features, and functionality, including administrative configurations, shall not be separated into several network control engines working together.

C. Provide at a minimum 1 operator interface to be designated as the BAS Server with server application software. Additional operator interfaces shall use operator workstation licenses or connect via a thick or thin-client application.

D. BAS Server shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.

E. Any break in Ethernet communication from the server to the controllers on the Primary Network shall result in a notification at the server.

F. Any break in Ethernet communication between the server and standard client workstations on the Primary Network shall result in a notification at each workstation.

G. The network architecture shall consist of three levels of networks:

1. The Management Level Network (MLN) shall utilize BACnet/IP over Ethernet along with other standardized protocol, such as web services, html, JAVA, SOAP, XML, etc., to transmit data to non-BAS software applications and databases. The BAS Server and Operator Workstations shall reside on this level of the network architecture.

2. The Automation Level Network (ALN) shall utilize BACnet/IP over Ethernet. It shall connect BACnet Building Controllers to the BAS Server and Operator Workstations. Controllers for central plant equipment and large infrastructure air handlers shall reside on the ALN backbone BACnet/IP network. The building’s Ethernet LAN shall be utilized for the ALN backbone and all ALN devices shall be connected to the building’s
LAN. Coordinate IP drops with Owner.

3. The Floor Level Network shall utilize BACnet/IP over Ethernet or BACnet MS/TP over RS-485 to connect all of the DDC-controlled terminal heating and cooling equipment on a floor or in a system that are controlled with BACnet Advanced Application Controllers or BACnet Application Specific Controllers. FLN devices are networked to a router that connects to the Automaton Level Network backbone.

H. Provide a router for each RS-485 subnetwork to connect them to the base building backbone level network. The router shall connect BACnet MS/TP subnetworks to BACnet over Ethernet. Routers shall be capable of handling all of the BACnet BIBBs that are listed for the controller that reside on the subnetwork.

I. The Building Level Controllers shall be able to support subnetwork protocols that may be needed depending on the type of equipment or application. Subnetworks shall be limited to:

1. BACnet MS/TP
2. Apogee FLN
3. Modbus
4. Wireless Mesh network compatible with Apogee FLN

J. BACnet MSTP Setup rules

1. Addressing for the MSTP devices shall start at 00 and continue sequentially for the number of devices on the subnetwork.
2. No gaps shall be allowed in the addresses.
3. Set the MaxMaster property to the highest address of the connected device.
4. MaxMaster property shall be adjusted when devices are added to the subnetwork.

K. Provide all communication media, connectors, repeaters, bridges, switches, and routers necessary for the internetwork.

L. Controllers and software shall be BTL listed at the time of installation.

M. The system shall meet peer-to-peer communication services such that the values in any one BACnet Building Controller or BACnet Advanced Application Controller can be read or changed from all other controllers without the need for intermediary devices. The software shall provide transparent transfer of all data, control programs, schedules, trends, and alarms from any one controller through the internetwork to any other controller, regardless of subnetwork routers.

N. Systems that use variations of BACnet using Point-to-Point (PTP) between controllers, gateways, bridges or networks that are not peer-to-peer are not allowed.

O. Remote Communications: Provide a TCP/IP compatible communication port for connection to the Owner’s network for remote communications. Provide coordination with the Owner for addressing and router configuration on both ends of the remote network.

P. The system shall be installed with a 10% spare capacity on each subnetwork for the addition of future controllers.
Q. On each floor, wing or major mechanical room provide an Ethernet RJ45 connection that allows connection to the BACnet network. An open port shall always be available and shall not require any part of the network to be disconnected. The location shall be accessible to the base building personnel and not in a location where the tenant can restrict the access.

R. Distributed Control Requirements:

1. The loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.
2. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
4. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller on the network without dependence upon a central processing device. DDC Controllers shall also be able to send alarms to multiple operator workstations without dependence upon a central or intermediate processing device.
5. Operators shall have the ability to make database changes at the central system server while operator workstations are on-line without disrupting other system operations.
6. The DDC control panel shall be mounted in the same mechanical room as the equipment being controlled, or an adjacent utility room.
7. Multiple systems can be programmed on the same controller as long as they are in the same room. Systems on separate floors shall have separate controllers.
8. VAV boxes subnetworks shall be connected to the AHU controller that feeds those boxes. If multiple subnetworks are needed, then the VAV shall be grouped into subnetworks in an orderly method, such as per floor, per wing, etc.
9. Remote sensors shall be wired to the control panel of the equipment it is controlling, not across the network.
10. Signals to remote motor control centers shall be hard wired to the control panel, not across the network.
11. Terminal units shall each have their own controller. Only exceptions are:
   a. Groups of reheat coils
   b. Groups of exhaust fans
   c. Groups of chilled beams serving same zone or several adjacent zones

2.3 BUILDING AUTOMATION SYSTEM SERVER HARDWARE

A. BAS Server application and database shall be installed on an Owner-provided server.
BACNET ADVANCED WORKSTATION SOFTWARE

A. Interface Description

1. The software shall provide, as a minimum, the following functionality:

   a. Real-time graphical viewing and control of the BMS environment.
   b. Reporting of both real-time and historical information.
   c. Scheduling and override of building operations.
   d. Collection and analysis of historical data.
   e. Point database editing, storage and downloading of controller databases.
   f. Configuration of and navigation through default and personalized hierarchical “tree” views that include workstation and control system objects.
   g. Event reporting, routing, messaging, and acknowledgment.
   h. Definition and construction of dynamic color graphic displays.
   i. Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
   j. On-screen access to User Documentation, via online help or PDF-format electronic file.
   k. Automatic database backup at the operator interface for database changes initiated at Building Controllers.
   l. Display dynamic trend data graphical plot.

   1) Must be able to run multiple plots simultaneously.
   2) Each plot must be capable of supporting 10 pts/plot minimum.
   3) Must be able to command points from selection on dynamic trend plots.
   4) Must be able to plot real-time data without prior configuration.
   5) Must be able to plot both real-time and historical trend data simultaneously.

   m. Program editing
   n. Transfer trend data to third-party spreadsheet software
   o. Scheduling reports
   p. Operator Activity Log

2. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications.

3. Users must be able to build multiple, separate, personalized hierarchical “tree” views that represent the workstation, control systems, geographical facility layouts, and mechanical equipment relationships.

4. 256-character point identification (names) must be supported to provide clearly descriptive identification.

5. On-line help must be available.

6. The user interface shall display relevant information for a selection in multiple panes of a single window without the need for opening multiple overlapping windows on the desktop.

7. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a “point and click” approach to menu selection and a “drag and drop” approach to inter-application navigation.

8. Software navigation shall be user friendly by utilizing “forward & back” capability.
between screens and embedded links to graphics, documents, drawings, trends, schedules, as well as external documents (.doc, .pdf, .xls, etc.) or web addresses that are related to any selected object.

9. Primary selection of objects in the operator interface software shall be available from user defined hierarchical Views, from graphics, or from events in an Event List.

10. Secondary selection of objects in the operator interface software shall be available from links to any objects or external documents related to the primary selection.

11. Links to information related to any selected objects shall be displayed in a consistent manner and automatically defined based on where an object is used in the system.

12. The operator workstation shall be capable of displaying web pages and common document formats (.doc, .xls, .pdf) within the operator workstation application.

13. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously.

14. System database parameters shall be stored within an object-oriented database.

15. Standard Windows applications shall run simultaneously with the BMS software.

16. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.

17. Provide automatic backup and restore of all Building Controller databases on the workstation hard disk.

18. System configuration, programming, editing, graphics generation shall be performed on-line from the operator workstation software.

19. User shall be able to edit point configuration of any configurable BACnet point that resides in a devices that supports external editing.

20. The software shall also allow the user to configure the alarm management strategy for each point.

21. Users shall have the ability to view the program(s) that is\are currently running in a Building Controller. The display shall mark the program lines with the following: disabled, comment, unresolved, and trace bits.

B. Certifications and Approvals

1. BAS software shall have been tested against the following norms and standards:

   a. BACnet Revision 1.13, certified by BACnet Testing Laboratory as BACnet Advanced Workstation Software (BTL B-AWS)
   b. IT security compliant with the ISA-99/IEC 62443 Security Level: SL1
   c. OPC DA V2.05a and V3.0 Server, certified by the OPC Foundation certification program
   d. UL-listed to UL864 9th edition Standard for Control Units and Accessories (when installed on a UL-approved computer)

C. Client-Server Connectivity

1. Client sessions must be allowed to run on the server and on other devices connected to the server via Intranet, Extranet, or Internet connections.

2. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the owner as required to support remote access features.

3. The following client options must be supported
a. Installed Client.
   1) Software application installed from installation media on to the client machine.
   2) Installed client software must be configurable to allow it to run in a Closed Mode such that the BAS software can lock down the client machine and prevent users without permission from minimizing the application or running other Windows applications that might cover the BAS software interface.
   3) Communication between the server and Installed Clients must be monitored so that any break in communication between the server and an installed client results in notification at the Server and Installed Client machine.
   4) Installed client machines communicate directly with the BAS server.

b. Web Client.
   1) Software that runs in a browser on the client machine as a Full Trust client application.
   2) Connected to the BAS software server via Microsoft IIS Server.

   1) Software application downloaded from the BAS server to run on the client machine like an installed application.
   2) Application must be automatically updated whenever new apps are available at the server.
   3) Connected to the BAS software server via Microsoft IIS Server.

4. Each of the client options shall provide the same functionalities including operation and configuration capabilities.

D. Access Rights and User Privileges
   1. Access to any client user session must be password protected.
   2. Users shall be able to create local user accounts specific to the application software.
   3. Users shall be able to link application user accounts to Active Directory user accounts for consistent management with domain user accounts.
   4. Operator-specific password access protection shall be provided to allow the administrator/manager to limit users’ workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned user name and password.
   5. Operator privileges shall follow the operator to any workstation logged onto.
   6. The administrator or manager shall be able to further limit operator privileges based on which console an operator is logged on to.
   7. The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation application.

E. Activity Logging
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
RMF Engineering, Inc. July 18, 2016

AP#1515

1. The operator interface software shall maintain a log of the actions of each individual operator.
2. The software shall provide an application that allows querying based on object name, operator, action, or time range.
3. The software shall provide the ability to generate reports showing operator activity based on object name, operator, action, or time range.

F. Graphics Application

1. All graphics shall be available with the same look and functionality whether they are displayed at an installed client console or in a browser.
2. User shall be able to add/delete/modify system graphics for floor plan displays and system schematics for each piece of mechanical equipment (including, air handling units, chilled water systems, hot water boiler systems, and room level terminal units) from standard user interface without the need of any external or specialized tools.
3. The software shall include all necessary tools and procedures for the user to create their own graphics.
4. The software shall provide the user the ability to display real-time point values by animated motion or custom picture control visual representation.
5. The software shall provide animation that depicts movement of mechanical equipment, or air or fluid flow.
6. The software shall provide users the ability to depict various positions in relation to assigned point values or ranges.
7. The software shall provide the ability to add custom gauges and charts to graphic pages.
8. The software must include a library of at least 400 standard control application graphics and symbols for visualizing common mechanical systems, including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams, piping, and laboratory symbols.
9. The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller’s control values and parameters, without the need to create separate and individual graphic files for each controller.
10. The Graphics application shall be capable of automatically assigning the appropriate symbol for an object (point) selected to be displayed on the graphic based on what the object represents (fan, duct sensor, damper, etc.) when the object is placed on a graphic.
11. The Graphics application shall allow a user to manually override the automatically assigned symbol for an object when a different symbol is desired.
12. The user shall have the ability to add custom symbols to the symbol library.
13. The software shall permit the importing of AutoCAD or scanned pictures for use in graphics.
14. Graphics must be automatically associated to any points or system objects that are rendered on the graphic, so that selection of a system object will allow a user to simply navigate to any associated graphic, without the need for manual association.
15. The software must allow users to command points directly off graphics application.
16. Graphic display shall include the ability to depict real-time point values dynamically with text or animation.
17. Navigation through various graphic screens shall be optionally achieved through a hierarchical “tree” structure.
18. Graphics viewing shall include dynamic pan zoom capabilities.
19. Graphics viewing shall include the ability to switch between multiple layers with different information on each layer.
20. Graphics shall include a decluttering capability that allows layers to be programmatically hidden and displayed based on zoom level.
21. Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
22. The software must provide the ability to create dashboard views consisting of gauges and charts that graphically display system and/or energy performance.

G. System Performance

1. Comply with the following performance requirements:
   a. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 5 seconds.
   b. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 5 seconds.
   c. Object Command: Reaction time of less than 5 seconds between operator command of a binary object and device reaction.
   d. Object Scan: Transmit change of state and change of analog values to control units or workstation within 5 seconds.
   e. Alarm Response Time: Annunciate alarm at workstation within 2 seconds. Multiple workstations must receive alarms within five seconds of each other.
   f. Program Execution Frequency: Programmable controllers shall execute DDC PI control loops, and scan and update process values and outputs at least once per second.
   g. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

   1) Water Temperature: Plus or minus 1 deg F.
   2) Water Flow: Plus or minus 5 percent of full scale.
   3) Water Pressure: Plus or minus 2 percent of full scale.
   4) Space Temperature: Plus or minus 1 deg F.
   5) Ducted Air Temperature: Plus or minus 1 deg F.
   6) Outside Air Temperature: Plus or minus 2 deg F.
   7) Dew Point Temperature: Plus or minus 3 deg F.
   8) Temperature Differential: Plus or minus 0.25 deg F.
   9) Relative Humidity: Plus or minus 2 percent.
   10) Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
   11) Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   12) Airflow (Terminal): Plus or minus 10 percent of full scale.
   13) Air Pressure (Space): Plus or minus 0.01-inch wg.
   14) Air Pressure (Ducts): Plus or minus 0.1-inch wg.
   15) Carbon Monoxide: Plus or minus 5 percent of reading.
   16) CarbonDioxide: Plus or minus 50 ppm.
   17) Electrical: Plus or minus 5 percent of reading.
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Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.
July 18, 2016

H. Reports

1. The software must allow reports shall be executed on demand.
2. The software must allow reports shall be executed via pre-defined schedule.
3. As a minimum, the system shall allow the user to easily obtain the following types of reports:
   a. A general listing of all or selected points in the network
   b. A status report showing present value and alarm status
   c. List of all points currently in alarm
   d. List of all points currently in override status
   e. List of all disabled points
   f. System diagnostic reports including, list of Building panels on line and communicating, status of all Building terminal unit device points
   g. List of alarm strategy definitions
   h. List of Building Control panels
      i. Point totalization report
      j. Point Trend data listings
      k. Initial Values report
      l. User activity report
      m. Event history reports

I. Scheduling

1. The software shall provide a calendar type format for simplification of time and date scheduling and overrides of building operations.
2. The software shall support the definition of BACnet schedules that are defined at the workstation and are downloaded to Building Controller to ensure time equipment scheduling when PC is off-line, such that the operating software is not required to execute time scheduling. The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
   a. Fully support all BACnet Schedule, Calendar, and Command objects.
   b. Daily and Weekly schedules
   c. Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., all Building 1 lights)
   d. Ability to schedule for a minimum of up to ten (10) years in advance.
3. The software shall support the definition of schedules that are configured and executed to run at the workstation, to support scheduling of workstation software activities and to support field systems that do not include internal scheduling mechanisms. The software must provide the following capabilities for BACnet scheduling capabilities as a minimum:
   a. Schedule predefined reports
   b. Schedule Trend collections
   c. Schedule automated system backups
   d. Schedule commands to be sent to field panels
   e. Daily and weekly schedules
f. Setting up and executing Holiday schedules  
g. Ability to combine multiple points into a logical Command Groups for ease of scheduling (e.g., all Building 1 lights)  
h. Ability to schedule for a minimum of up to ten (10) years in advance.  

4. The software shall provide the ability for users to override regular weekly schedules through menu selection, graphical mouse action or function key.  
5. The software shall provide a timeline view, showing the results of any number of combined selected workstation and field panel controller schedules for an overview of facility operation.  

J. Trending  
1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time.  
2. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable.  
3. Trend data shall be collected and stored on hard disk for future diagnostics and reporting.  
4. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of equipment.  
5. System shall support trending in the same device as the monitor point or in an external device.  
6. The software must support configuration of panels that have a trending level threshold, above which the data will be automatically uploaded to the BMS server to prevent overwriting the data in the field panel. The trending level will be user defined in % of available space (e.g., automatically upload when the trend buffer is at 75% of allocated space).  
7. Trend data reports shall be provided to allow the user to view all trended point data.  
8. Trend data reports may be customized to include individual points or predefined groups of selected points.  
9. The software shall allow the user to view real-time trend data on trend graphical plot displays.  
   a. A minimum of ten points may be plotted  
   b. A combination of real-time and historical data may be plotted  
   c. Dynamic graphs shall continuously update point values  
   d. At any time the user may redefine sampling times or range scales for any point  
   e. The user may pause the display and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis  
   f. Exact point values may be viewed on the Trend plot  
   g. Trend graphs may be printed  
   h. Operator shall be able to command points by selecting them on the trend plot. Operator shall be able to zoom in on a specific time range within a plot.  
   i. The Trend Viewer must allow users to configure separate left and right axis for easier differentiation of point values.  
   j. The Trend Viewer must allow users to display historical data for the same group of points at different times simultaneously for easy comparison of system behavior over time.
K. Event Management

1. Event Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each event: name, value, event time and date, event status, priority, acknowledgement information, and alarm count.
2. Only events for which the logged on user has privileges to view shall be displayed on each workstation.
3. The software shall provide the ability to users to limit the list of events displayed at each workstation (e.g. only show fire events at this workstation, no matter who is logged on).
4. Each event shall have the ability to sound an audible notification based on the category of the event.
5. Event List shall have the ability to list and sort the events based on event status, point name, ascending or descending activation time.
6. Directly from the Event List, the user shall have the ability to acknowledge, silence the event sound, print, or erase each event.
7. The interface shall provide the option to inhibit the erasing of active acknowledged events, until they have returned to normal status.
8. The user shall have the ability to navigate to all information related to a selected point in order to command, launch an associated graphic or trended graphical plot, or run a report on a selected point directly from the Event List.
9. Each event shall have a direct link from the Event List to further user-defined point informational data.
10. The user shall have the ability to also associate real-time electronic annotations or notes to each event.
11. Software shall provide the option to configure detailed operating procedures that guide a user through predetermined standard operating procedures for handling critical events. Users shall be able to log completion of each operating step as it is performed.

L. Remote Notification (RENO)

1. Workstations shall be configured to send out messages to numeric pagers, alphanumeric pagers, SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition.
2. Email notification must support POP3, IMAP, and SMTP with SSL/TSL
3. Communication with external software must be encrypted.
4. There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices which can receive messages from the system.
5. On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
6. System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.
7. Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.
8. Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.
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M. External Data Access

1. The software shall provide the ability to expose configuration properties and real-time values through CSV files, OPC DA, OPC UA, or REST-based Web Services.
2. The software shall provide the ability for external applications to change configuration and real-time values through OPC DA, OPC UA, or REST-based Web Services.
3. The software shall provide the ability for external applications to access historical Trend data through CSV files or REST-based Web Services.
4. External data access must be secured using the level of permissions configured for users and operator workstations.
5. Web service interfaces must allow for exchanging data (object’s values, events and trend series) between workstation and external applications such as facility management systems, enterprise applications, mobile applications or other value-added services.
6. Documentation describing web services interfaces must be included to allow external developers to write applications that leverage the data exchange.

N. Licensing

1. Software licensing must be allowed to be bound to a dongle or to physical PC hardware.
2. User licenses from all client types shall be from a common pool of client licenses. Licenses for installed and browser-based clients shall not be in separate pools.
3. Provide the number of client licenses as called for here or in the Sequence of Operations.

O. Data Security

1. The BAS software must allow that all communication paths between clients and the server are encrypted and protected against replay attacks as well as data manipulation.
2. Any runtime data transfer between the system server and Web Server (IIS) must be allowed to be encrypted by Desigo CC.
3. Communication between any Web Server (IIS) and the Web Clients must be allowed to be encrypted.
4. Passwords must be handled with encrypted storage and transmission
5. The software must support the use of public domain algorithms for cryptographic functions, including AES, DiffieHellmann, RSA, and SHA-2. No self-coded algorithms shall be allowed.
6. All symmetrical encryption must use 256 bit AES or stronger.
7. All asymmetrical encryption must use 2048 bit or stronger.
8. The software must support the use of commercial certificates for securing client-server communications.
9. The software must support the use of self-signed certificates to allow local deployments without the overhead of obtaining commercial certificates.
10. When using self-signed certificates, the owner of the Desigo CC system is responsible for maintaining their validity status, and for manually adding them to and removing them from the list of trusted certificates.
11. The BAS software shall be compatible with the following Virus Scanners:
   a. Kaspersky
   b. Avira
   c. McAfee
d. Bitdefender  
e. TrendMicro Office Scan  

P. Virtualization  
1. The BAS software must be compatible with following Virtualization software packages:  
   a. VMware®:  
      1) Virtualization platform: VSphere 6.0 or higher  
      2) Fault-tolerant software: ESXi 6.0b managed by VCenter Server Appliance v6.0.0 or higher  
   b. Stratus®:  
      1) Virtualization platform: KVM for Linux CentOS v7.0 or higher  
      2) Fault-tolerant software: everRun Enterprise 7.2 or higher  
      3) Virtualization platform: Citrix XenServer 6.0.2 or higher  
      4) Fault-tolerant software: everRun MX 6.2 or higher

Q. Subsystem Connectivity  
1. The BAS application software must be capable of connecting simultaneously to multiple control systems and data sources.  
2. Interface software shall simultaneously communicate with and share data between multiple Ethernet-connected building level networks.  
3. The BAS application software must support the following standard protocols:  
   a. BACnet IP (standard Revision 1.13)  
   b. OPC (OLE for Process Control) OPC DA 2.05, 3.0  
   c. Modbus TCP  
   d. SNMP (Agent V1 and V2)  
4. Any break in system controller communication must result in a notification at the server.

R. BACnet  
1. The Operator Workstation Software shall be capable of BACnet IP communications.  
2. The Operator Workstation Software shall have demonstrated interoperability during at least one BTL Interoperability Workshop.  
3. The Operator Workstation Software shall have demonstrated compliance to BTL B-AWS device classification through BTL listing as specified in ANSI/ASHRAE 135 under revision 1.13 or higher.  
4. The BAS software shall meet the BACnet device profile of an Advanced Workstation Server (B-AWS) and Operator Workstation (B-OWS) and shall support the following BACnet BIBBs:  
   a. Data Sharing
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1) DS-RP-A Data Sharing-ReadProperty-A
2) DS-RP-B Data Sharing-ReadProperty-B
3) DS-RPM-A Data Sharing-ReadPropertyMultiple-A
4) DS-RPM-B Data Sharing-ReadPropertyMultiple-B
5) DS-WP-A Data Sharing-WriteProperty-A
6) DS-WP-B Data Sharing-WriteProperty-B
7) DS-WPM-A Data Sharing-WritePropertyMultiple-A
8) DS-COV-A Data Sharing-ChangeofValue-A
9) DS-COVP-A Data Sharing – ChangeofValueProperty-A
10) DS-V-A Data Sharing - View - A
11) DS-AV-A Data Sharing - Advanced View - A
12) DS-M-A Data Sharing - Modify - A
13) DS-AM-A Data Sharing - Advanced Modify - A

b. Scheduling
1) SCHED-VM-A Scheduling-View and Modify-A
2) SCHED-AVM-A Scheduling-Advanced View and Modify-A
3) SCHED-WS-A Scheduling-Weekly Schedule-A

c. Alarm and Event Management
1) AE-N-A Alarm and Event-Notification-A
2) AE-ACK-A Alarm and Event-ACK-A
3) AE-LS-A Alarm and Event-LifeSafety - A
4) AE-VM-A Alarm and Event Management - View and Modify - A
5) AE-AVM-A Alarm and Event Management - Advanced View and Modify - A
6) AE-VN-A Alarm and Event Management - View Notifications - A
7) AE-AVN-A Alarm and Event Management - Advanced View Notifications - A

d. Trending
1) T-V-A Trending-Viewing and Modifying Trends-A
2) T-ATR-A Trending-Automated Trend Retrieval-A
3) T-AVM-A Trending-Advanced View and Modify -A

e. Network Management
1) NM-CE-A Network Management-Connection Establishment-A

f. Device Management
1) DM-DDB-A Device Management-Dynamic Device Binding-A
2) DM-DDB-B Device Management-Dynamic Device Binding-B
3) DM-DOB-A Device Management-Dynamic Object Binding-A
4) DM-DOB-B Device Management-Dynamic Object Binding-B
5) DM-DCC-A Device Management-DeviceCommunicationControl-A
5. The BAS Server and Workstations shall support the following Data Link Layers:
   a. BACnet IP Annex J
   b. BACnet IP Annex J Foreign Device
   c. ISO 8802-3, Ethernet (Clause 7)

6. The BAS Server and Workstations shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable

7. The BAS Server and Workstations shall support transmitting and receiving segmented messages.

8. The BAS Server and Workstation shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.

2.5 WEB BASED OPERATOR INTERFACE SOFTWARE

A. Provide a Web-based graphical interface that allows users to access the BAS data via the Internet, extranet, or Intranet (TCP/IP). The Web-based graphical interface shall use HTML-based pages to send and receive data directly from a network of BAS Field Panels to a Web browser.

B. The web server shall support browser access via Microsoft Internet Explorer 6.0 (or later), Firefox, or any browser that supports the compatible plug-in.

1. Cookies are allowed for compatibility
2. Microsoft Java Applet (JVM) is allowed for compatibility
3. Adobe Flash Player shall be allowed for compatibility
C. The web server shall support access via handheld, web enabled devices through apps. The apps shall be available for download from public sites, such as Blackberry App World or Android Market.

D. If a field panel cannot serve up the graphics, then dedicated PC-based Web servers or separate “Web Appliance” devices may be allowed for this purpose.

E. The Web server shall allow monitor and control of data in any field panels networked together on the same automation level TCP/IP Ethernet network.
   1. The Web server must provide a common alarm display that shows alarms in all field panels on the network.
   2. The Web server must be able to provide common graphics that simultaneously display the current value and status for points residing in multiple field panels.
   3. The Web server must be able to display daily mode schedules for points from multiple field panels simultaneously.

F. Access to the Web interface shall be username and password protected. A user’s rights and privileges to database objects within the BAS shall be configurable on a per-user basis. An option shall exist to only allow users “read” access to BAS objects via the Web browser. Operator sessions shall be configurable for “auto-logoff” after a designated period of user inactivity.
   1. A graphic selector list shall allow or limit the graphic displays that a user account has access to.
   2. The embedded Web server shall support an unlimited number of user accounts. A minimum of five concurrent user sessions shall be available for simultaneous operator access to the Web server’s pages.
   3. The embedded Web server shall be compatible with and allow coexistence within standard IT security policies and tools (e.g., Firewall protection).

G. The embedded Web server shall provide the following functionality to users via Web browser, based on their access and privilege rights:
   1. Point Navigation – Provide a screen that allows users to see all of the points that are active in the system. The points shall include hardwired, software, schedules, trends, alarms and network setup.
      a. The point navigation shall display the point name, descriptor, command priority, alarm status, and current value.
      b. The user shall be able to run and print a pre-configured point log report through a web interface client that shows the point name, descriptor, command priority, alarm status, and current value.
      c. The interface and report shall allow selection filter such that the operator can select or deselect the types of point that are visible.
   2. Alarm Display – displays current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge active alarms, erase resolved alarms, and directly link to the Point Commanding feature.
a. The alarm display must provide a filter that displays all alarms whether acknowledged or not.
b. The alarm display must provide a filter that displays only alarms that have not yet been acknowledged.
c. The alarm display must provide a persistent indication whenever there is one or more unacknowledged alarm in any connected field panel.

3. Point details – users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.

4. Point Commanding – users will be able to override and command points they have access to via the Web browser interface.

5. Scheduling – allows operators, depending on their current user privileges, to override schedules selected by date, and to modify the properties of a selected schedule.

   a. The scheduler display must be able to represent facility mode schedules in a graphical format.

6. Trend Data Report – allows users to run and print a pre-configured trend data report for historical data reporting, including a representation of the alarm status of the each point for each Trend sample. The report shall allow selection of individual points or wildcard selection of points.

   a. Trend data shall be exportable to a data file, such as .csv or other comparable.

7. Network navigation - Provide a screen that allows users to navigate to the panels and terminal units via the network architecture.

H. Graphic Displays – The BAS contractor shall provide a graphical display for each system that is controlled.

   1. Display of system graphics shall be available for viewing over the Web browser. Graphic displays will automatically refresh with the latest change of values. Users shall have the ability to command and override points directly from the graphic display as determined by their user accounts rights. The Graphic Display shall accommodate a minimum of 10 customized graphics.

   2. The Graphic Display shall accommodate the terminal unit graphics related to the Application Specific Controllers tied in to the Field Panels within the system.

I. The web server shall be able to send SMTP text messages to notify users of alarm status. The owners shall provide a mail server and a connection port. SSL shall not be required.

J. The operator shall be able to add modify and delete controller database program, including points, schedules, alarms, and trends.

   1. The operator shall be able to edit the custom program in the field panel that executes the sequences of operations, control loops and logic for the systems controlled.

   2. The operator shall be able to add terminal unit controllers that reside on field panel subnetworks.
K. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the Web access feature. Coordinate networking, security, and user access to the Web Server interface with the Owner’s IT representative.

2.6 ENERGY REPORTING AND DATA ANALYTICS SOFTWARE PLATFORM

A. Acceptable Manufacturers
   1. Siemens Industry – Advantage Navigator Software

B. Acceptable Installers
   1. Installer and programmers shall be factory trained representatives of the manufacturer of the software.

C. Provide software to accumulate, log, compile and display energy consumption data and related parameters and measures.

D. Provide an automated reporting software package which will allow utilization of data collected from a sub-metering system and data network. The system should address the following areas:
   1. Utility bill tracking
   2. Account tracking
   3. Savings and analysis
   4. Weather Data
   5. Weather Normalization
   6. Reporting
   7. Interval data tracking including meters and equipment data
   9. Web-based hosted solution
   10. Customization and Interfaces

E. The software shall integrate to devices provided in other sections of this specification. The contractor shall refer to other sections for the scope of the devices to be integrated into this software, including: [edit to match the project]
   1. Division 23 Building Automation System
   2. Division 23 Sequences of operations
   3. Division 23 Gas sub meters
   4. Division 23 Water sub meters
   5. Division 23 Utility meters
   6. Division 26 Electrical panel boards (if specified with smart meters)
   7. Division 26 Lighting controls (based on networked to one location and data available via BACnet/IP protocol)
   8. Division 26 Electric meters
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F. Coordinate networking, security, and user access to the Web Server interface with the customer’s IT representative. Internet connections, ISP services, firewalls or proxy servers shall be provided by the owner as required to support the Web access feature.

G. Functionality Requirements

1. User Functionality
   a. The system shall support multiple user roles in which permissions and access to functions can be defined on a customer basis as described in User Setup.
   b. The system shall support a user licensing system.

2. Reliability
   a. The system shall have measures in place to ensure reliability. This includes but is not limited to 99.x% uptime, a backup of all databases, and redundant servers.
   b. The system shall have a staging and quality control environment to ensure system reliability.
   c. The hosting servers shall be on UPS power supply for a minimum of 100 minutes.
   d. The hosting facility shall be monitored by personnel 24/7, including the facility, server hardware, and software applications.
   e. The hosting facility shall demonstrate strict security access.
   f. The hosting facility shall demonstrate that the servers operate in a well controlled and protected environment including temperature and humidity control, fire detection, water protection and server safe fire extinguishing.

3. Development
   a. The system shall have an continuous development process with ongoing version releases to support continual system enhancements and the addition of new features.

4. Data Quality and Import / Export
   a. They system must have measures in place to ensure the reliability and quality of data. This includes but is not limited to Automated Meter Reset Adjustment features.
   b. The system shall have the ability to normalize data for weather by meeting ASHRAE VBDD (Variable-Based Degree Day) method
   c. The system shall incorporate a staging environment and have a quality control process to ensure consistency and accuracy of data.
   d. The system shall be able to support the import of data from external sources. This includes Utility Bill data – which shall be disaggregated and normalized, manual entry of data, and any interval trend data including meters and BAS points.
   e. The system shall have the ability to receive and monitor data on a 1, 5, 15, 30, and 60 minute resolution.
   f. The system shall have the ability to import and prorate utility bill data by calendar month.
   g. The system shall have an interface allowing users to manually enter data.
h. The system shall have the ability to import any interval trend data including but not limited to meters and BAS points.

i. The system shall provide external data accessibility through a REST (Representational State Transfer) API service.

j. The system shall allow users to export data from the system.

k. At the termination of the service, all data shall be owned by the customer

5. General Functionality

a. Data within the energy management system shall be owned by the customer.
b. The system shall have supported at least 1000 buildings in order to prove the scalability of the system.

H. Security

1. The application and database servers shall operate in a “demilitarized zone” (DMZ), meaning that the application is protected by firewalls from the internet as well as general access by the provider, software maker and the host’s intranet.

2. Passwords shall be disabled after 5 login attempts with incorrect password.

3. Passwords shall require a minimum of 6 characters

4. Data transfers between your PC / browser and Advantage Navigator shall be protected with 256-bit SSL encryption

5. The system shall use e-mail validation to reset a forgotten password

6. The system shall support the use of data validation certificates

7. The system shall support strong authentication via SMS one-time passwords

I. Reporting Requirements

1. The system shall provide the following ad-hoc reporting capabilities

a. The system shall allow data to be displayed in multiple chart types. At a minimum it shall support the following charts:

   1) Line
   2) Bar
   3) Stepped Area
   4) Area
   5) Carpet Plot (Ability to show each day on the x axis and each hour of the day on the y axis. Each cell provides an automated color coding that indicates the intensity of energy usage of the data point)
   6) Stepped line

b. The system shall allow multiple data points to be overlaid on a single chart.
c. The system shall allow the user to save any pre-configured ad-hoc reporting view.
d. The system shall allow the user to compare data sets between user selectable time frames using multiple meters including a rolling most recent period or a fixed period.
e. Data Export
1) The system shall allow the user to export charts in graphical formats including but not limited to PNG, JPG or PDF.
2) The system shall allow the user to export charts in text format including but not limited to CSV.

f. Chart manipulation
   1) The system shall allow the user to drag and drop data points.
   2) The system shall allow the user to zoom in and zoom out on charts.
   3) The system shall allow the user to view data in a tabular format.
   4) The system shall allow the user to view at least four charts simultaneously.
   5) The system shall allow multiple X or Y axis in a single chart.
   6) The system shall allow the user to show/hide the X or Y axis.
   7) The system shall allow the user to change the scale on the X or Y axis.
   8) The system shall allow the user to select colors displayed in each chart.
   9) The system shall allow the user to change the chart type.
  10) The system shall allow the user to stack bar and area chart types.

2. The system shall provide the following reporting delivery capabilities:
   a. Report access via a web-based interface
   b. E-mailed delivery of standardized reports to the customer via a web-based scheduling interface
   c. Allow users to schedule recurring automated e-mail of standardized reports to an unlimited number of e-mail addresses
   d. Allow users to save report parameters for easy access of favorite reports

3. The system shall include the following report types and KPIs as listed in Report Types.
4. The system shall have Environmental Reporting including but not limited to EPA EGRID factors and manual entry of Emission Factors.
5. The system shall allow the user to export data and charts in HTML, XLS, CSV, PDF and PPT.
6. The system shall provide the ability to automate reporting on data quality issues

J. Technical Requirements
   1. Remote Access
      a. The system shall provide secure remote access that is Certified ISO / IEC 27001.

   2. Management Dashboard
      a. Google Maps with integrated Geo Pin functionality allowing the user to Toggle KPIs Geo Pin Location based on at least three color coded thresholds definable per individual location
      b. A site ranking system based on energy use index (EUI), energy cost index (ECI), CO2 per square foot, energy consumption versus prior year, cost versus prior year, CO2 versus prior year, energy consumption versus budget, energy star score ranking
c. The dashboard shall provide the ability to trend data over time

3. User Interface
   a. The system shall be hosted in a centrally located data center.
   b. The system shall be accessible via a web browser.
   c. The system shall allow unlimited concurrent users.
   d. The system shall allow administrators to assign different security access by user role as specified in User Setup.
   e. The system shall provide a tree view system supporting multiple tree view structures and orientations.
   f. The system shall support a tree view system at least six levels deep.
   g. The system shall support property inheritance of tree node properties.

4. Language Requirements
   a. The system shall support at least 20 languages.
   b. The system shall support 2 bit (nvar) characters.
   c. The system shall support languages left to right and right to left as necessary.

5. Unit Requirements
   a. The system shall support both Imperial and Metric units.
   b. The system shall allow the user to toggle units for select reports.

6. General Technical Requirements
   a. The system shall allow the software setup and configuration process to be conducted all through a web based interface without any non-web based tools required.
   b. The system shall allow aggregation through property inheritance in tree structure for knowledge meters.
   c. The system shall support properties of a building showing both square feet and geo coordinates.
   d. The system shall support the ability to track consumption and cost budgets versus actual.
   e. The system shall support the ability to track consumption and cost baseline versus actual. This provides the ability to compare energy consumption and cost against a baseline.
   f. The system shall provide the ability to display on and off peak usage, day vs. night usage, demand charges, customer charges based on actual rate tariff.
   g. The system shall provide average cost of consumption.

K. User Setup
   1. The system shall provide capability to set up specific users with corresponding capabilities according to need or security. At minimum provide the following setup types:
a. Super User

1) The Super User shall have all rights and access to all functions that are offered by the software application. Only one user per customer may have this role. However, the Super User will be able to Add Super User Substitutes who automatically have the same rights as the actual Super User.

b. Partner User

1) Super Users may Add Partners. The partner role enables Super Users to delegate entire branches (e.g. a building pool) of their tree view to a partner (e.g. to a regional manager within the same organization, or to an external facility management service provider). This gives the Partner User full access rights for the node assigned to him or her, including all of the lower-level nodes and meters it contains.

2) The Partner User has the same rights as the Super User on the delegated node, but can only display the part of the tree view assigned to him or her. The Partner User has an own user management facility, and is therefore able to Add new users (of type Basic User and Advanced User, see next page) and assign nodes to them (within the given part of the tree view).

3) Such Partner Users are invisible to Super Users outside of the partner company. Like the Super User, Partner Users can Add Super User Substitutes but they do not have the authorization to add additional Partners.

c. Advanced User

1) Each node in the tree view (site, building, etc.) can be assigned to an Advanced User who has the following rights:

   a) Reading rights - Example: generate and subscribe to reports, display meter lists
   b) Writing rights - Example: Add new buildings and meters, or enter metering data

2) Deleting rights - Example: delete values, meters or nodes for which the user is the contact person. Note: When a User deletes a meter, the meter and all entered values are automatically moved to the "deleted meters" node (the Super User’s "recycle bin"). Therefore, the Super User has the possibility to finally delete meters, or to restore them.

d. Basic User

1) Alternatively, each node can be assigned to a Basic User who has the following rights:

   a) Reading rights - Example: generate and subscribe to reports, display meter lists
   b) Writing rights - Enter and edit meter readings only (no meter exchange)
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c) Deleting rights - Delete individual meter readings only

L. Report Types

1. The software shall support the following report types:

a. Load Profiles (Arrangement of all load levels over time)

1) Daily Max kW
2) Monthly Max kW
3) # of Occ. Of peak load
4) Trend of a single KPI
5) Daily Avg kW
6) Demand
7) Monthly Avg kW
8) Daily Total kWh
9) Gas
10) Monthly Total kWh
11) Daily Avg kWh
12) Steam
13) Monthly Avg kWh
14) On Peak
15) Temperatures
16) Off Peak
17) Fuel / Oil
18) % Breakdown by load
19) Chilled Water
20) Flow
21) Frequency (Any trend data from a BAS System)

b. Operational Analysis

1) Daily Max
2) Daily Min
3) Total usage
4) Daily Avg Usage

c. Performance Indicators

1) Opportunity Score - Ranked by opportunity to reduce energy use
2) Target Energy Use Intensity

d. Consumption

1) Daily Max
2) Total portfolio energy usage
3) Total portfolio emissions usage
4) Electricity
5) Absolute and pct breakdown of energy usage (electricity)
6) Spikes
7) Total and Average (electricity)
8) Total
9) Total portfolio cumulative energy usage
10) Daily Min
11) Energy Use Intensity
12) Emissions Use Intensity
13) Demand
14) Gas
15) Average and r-value correlation (Electricity vs. outside air temp)
16) Total usage
17) Average energy usage
18) Average emissions usage
19) Steam
20) Gaps and missing data
21) Daily Avg Usage
22) Fuel
23) Temperatures
24) Fuel / Oil
25) Chilled Water
26) Flow
27) Target Energy Use Intensity
28) Yearly Energy use intensity
29) Prior Yr Abs Deviation
30) Prior Yr Abs Deviation
31) Prior Yr % Deviation

e. Emissions
1) Total portfolio emissions usage
2) Emissions Use Intensity
3) Average emissions usage

f. Chilled Water Reports
1) Daily Max tons
2) Total usage
3) Daily Avg tons
4) Daily Total ton-hr
5) Daily Avg ton-hr
6) On Peak
7) Off Peak
8) % Breakdown by load

g. Steam Reports
1) Daily Max tons
2) Total usage
3) Daily Avg tons
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4) Daily Total ton-hr
5) Daily Avg ton-hr
6) On Peak
7) Off Peak
8) % Breakdown by load

h. Energy Budgeting

1) Electricity
2) Demand
3) Gas
4) Steam
5) Temperatures
6) Fuel / Oil
7) Chilled Water
8) Budget
9) Deviation absolute
10) Deviation % (Ability generate a report with multiple sites and rank by % deviation from a budget)

i. Cost Analysis / Budgeting

1) Total portfolio energy cost
2) Energy cost Intensity
3) Average energy cost
4) Electricity
5) Demand
6) Gas
7) Steam
8) Fuel / Oil
9) Chilled Water
10) Budget
11) Deviation absolute
12) Deviation %

j. Energy Star / Weather Normalization

1) Energy Star Score
2) Total consumption (Electricity & Gas)
3) Weather normalized consumption (System shall support a Variable-Base Degree Day Model (VBDD) program to automatically calculate a customized Balance Point Temperature for each site.)
4) Absolute deviation from prior year
5) % deviation from prior year

k. Critical Environments (if such as system is included in the project)

1) % of ventilation in occupied mode due to Baseline airflow, cooling and ventilation
2) % of ventilation in the Unoccupied mode due to baseline airflow, cooling and ventilation
3) Air Volume and reheat valve position
4) % of Satisfactory Temperature
5) Savings in CFM and currency
6) Statement of Performance criteria
7) Air volume reduction
8) Target Hood Ratio Benchmark
9) % of Satisfactory Exhaust Volume
10) % of Satisfactory Exhaust Volume
11) % of Satisfactory Directional Airflow
12) % of Satisfactory Ventilation

1. Chiller Plant Optimization (if such as system is included in the project)
   1) Plant Efficiency (kW/Ton)
   2) Target Savings
   3) Actual Savings
   4) Total Operating Hours
   5) Total Chilled Water usage
   6) Savings: Actual vs. Predicted

m. Site ranking by customized building attributes
   1) Energy use index (EUI)
   2) Energy cost index (ECI)
   3) Total CO2
   4) Energy consumption versus prior year
   5) Cost versus prior year
   6) Energy consumption versus budget
   7) Energy cost versus budget
   8) Energy star score

2.7 WEB BASED CONTROLLER SOFTWARE FOR CONFIGURATION, PROGRAMMING AND OPERATORS

A. The purpose of this specification is to allow the Owner/Operator to have the same controller programming capabilities as the Controls Contractor Technician without additional software, tools, or licenses.

1. The controller programming shall be accessible to any user via a Web Services application over an IP or Internet connection through port 80.

B. The following types of controllers shall have this feature:

1. All BACnet BC level controllers
2. Network Engine Controllers
3. Controllers on equipment or sequences customized for this job
C. Manufacturer:
   1. Siemens Launch Pad™ (compatible with PXC controllers with 3.2.5 firmware)
   2. Controllers from other manufacturers shall meet the capabilities of this specification

D. The controller shall come with the software built-in and delivered with the controller as part of the controller purchase. It shall not require a separate software license to enable the software capability.

   1. The software shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer or another controller for execution.

E. The software application shall be accessible from a PC using Web Services, but shall use all of its own services and data files so as to not be susceptible to Microsoft Windows operating systems based viruses.

F. Access to the controller software shall be username and password protected. User shall be authenticated by the controller.

G. The embedded Web Services shall provide the following functionality to users, based on their access and privilege rights:

   1. Point Navigation – Provide a screen that allows users to see all of the points that are active in the system. The points shall include hardwired, software, schedules, trends, alarms and network setup.
      
      a. The point navigation shall display the point name, descriptor, command priority, alarm status, and current value.
      b. The user shall be able to run and print a pre-configured point log report through a web interface client that shows the point name, descriptor, command priority, alarm status, and current value.
      c. The interface and report shall allow selection filter such that the operator can select or deselect the types of point that are visible.

   2. Alarm Display – displays current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge active alarms, erase resolved alarms, and directly link to the Point Commanding feature.
      
      a. The alarm display must provide a filter that displays all alarms whether acknowledged or not.
      b. The alarm display must provide a filter that displays only alarms that have not yet been acknowledged.
      c. The alarm display must provide a persistent indication whenever there is one or more unacknowledged alarm in any connected field panel.

   3. Point details – users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.

   4. Point Commanding – users will be able to override and command points they have access
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2.8 CONTROL PANEL GRAPHICAL TOUCHSCREEN INTERFACE

A. Manufacturer: Siemens
   1. Basis of design – Siemens Apogee Facility Prime™

B. Provide a device that can see system graphics and data without connecting to a BAS Server, Web server, network controller or any intermediary device. The device shall communicate directly with the controller to operate the systems that are on that controller and its sub-networked devices.
C. Provide an iPad and native iPad iOS application to directly communicate with BACnet/IP and/or Siemens APOGEE P2 Ethernet field panels. Software connection through a web browser is not acceptable.

D. iPad and application shall connect to the DDC panel via:
   1. The site’s WiFi (802.11 a/b/g/n) network (Site Wi-Fi network shall be provided/managed by the Owner) or
   2. Remote cellular connection via the customer’s VPN access or
   3. For additional cost, a dedicated WiFi network connected to the DDC controller can be requested by the Owner.

E. The application shall have the following capabilities as a minimum
   1. Graphical view of real time environmental conditions and linked HVAC equipment
   2. Graphical animation by displaying different image files for changed object status
   3. “View only” capability requiring no logon once application has been opened.
   4. Application can stay open and active without user interaction or time-out.
   5. A reporting function must capture current information shown on the graphical view and save the image as a PDF file and/or attach it to an email.
   6. Charts: A Charts tab shall provide key information, such as current or historical values plotted as scatter, bar, or pie charts.
   7. After proper access credentials are authenticated between the DDC control panel and the User, a User can command points (e.g. data values and device settings) and equipment.
   8. Commands logging: The BAS that is supervising the DDC controller must be able to log the User’s activity within the BAS Server, even when commands are made on the iPad Application.
   9. Users must be able to navigate the graphics using custom links, from a menu list, or by scanning QR codes.
   10. Alarm Indication and Acknowledgment – must allow for display of points in alarm, both unacknowledged and acknowledged. Acknowledgement of alarm conditions from within the application is required.

F. QR Code Application: The application shall be compatible with a QR Code reading application. QR Code reading shall be able to hyperlink to graphics and data associated with that QR Code.

G. Editing Tool: An optional Editing Tool must be able to be purchased by the Owner. It shall operate within the application to create and manage graphics. The Tool must include the following:
   1. Graphical elements library including gauges, sensors, trends, point blocks, command buttons, embedded documents, and imported images.
   2. Ability to import documents, photos, and images to be used in graphics.
   3. Ability to link elements to graphics by entering point address information or by utilizing browser and auto-discover sequences.
   4. Capability to transfer graphics to other iPads

H. Contractor shall coordinate with Owner to purchase and load application onto iPad via Owner
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designated iTunes account per Apple© Terms and Conditions.

I. Contractor shall spend three days with Owner to assist with initial setup, provide initial graphics/monitoring/control functions, and training on all aspects of the application

J. Contractor shall carry the cost of the application, an iPad (wi-fi + cellular) and any interface devices required to communicate with the BAS

K. Cellular data plan shall be provided by Owner as needed

2.9 DIRECT DIGITAL CONTROLLER SOFTWARE

A. Provide a full capability user license to the owner for the operator to be able to see, modify, create, upload, download and save control programs to the DDC controllers.

B. The software program shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer or another controller for execution.

C. The software application shall be accessible from a PC using the Windows environment, but shall use all of its own services and data files so as to not be susceptible to Microsoft Windows operating systems based viruses.

D. The software shall be provided with an interactive HELP function to assist operators with syntax, abbreviations, commands and saving programs.

E. Point naming and communication format:
   1. All points, panels, and programs shall be identified by a 30-character name. All points shall also be identified by a 16-character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
   2. All digital points shall have a consistent, user-defined, two-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).
   3. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop, have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, Annex L.

F. System Security
   1. User access shall be secured using individual security passwords and user names.
   2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
   3. Building Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for
every point shall be fully programmable and adjustable.
4. User Log On/Log Off attempts shall be recorded.
5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
6. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the DDC controller software.

G. User Defined Control Applications: The applications software shall program DDC routines to meet the sequences of operations.

1. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
2. The Building Controllers shall have the ability to perform the following pre tested control algorithms:
   a. Two position with differential control and time delays
   b. Floating control
   c. Proportional control
   d. Proportional plus integral control
   e. Proportional, integral, plus derivative control
   f. Automatic tuning of control loops
   g. Model-free adaptive control
   h. Start Stop Time Optimization

3. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
4. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

H. Peer-to-peer access to other DDC controllers

1. It shall be possible to use any actual or virtual point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
2. Any process shall be able to issue commands to points in any and all other controllers in the system.
3. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of an advanced annunciation feature, such as:
   a. Generate a report
   b. Annunciate an alarm
   c. Issue a text message or email
I. Alarm Management

1. Alarm management shall be provided within the controller software to monitor and direct alarm information to operator devices.

2. Each Building Controller shall perform distributed, independent alarm analysis, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

3. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.

4. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).

5. Binary Alarms. Each binary alarm object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

6. Analog Alarms. Each analog alarm object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.

7. All alarm shall include the point's user-defined language description and the time and date of occurrence.

8. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print reports, be logged in the event log, generate custom messages, and display graphics.

9. The user shall be able to add a 200-character alarm message to each alarm point to more fully describe the alarm condition or direct operator response. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assigned to any number of points in the Controller.

10. Operator-selected alarms shall be capable of initiating a trigger to an advanced annunciation, such as text, email, etc.

11. An alarm history log shall report the start of the alarm condition, acknowledgement by a user and return of the alarm to normal condition.

J. Scheduling:

1. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time.

2. Schedules shall reside in the building controller and shall not rely on external processing or network.

3. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.

4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.

5. The operator shall be able to define the following information:

   a. Time, day
   b. Commands such as on, off, auto, etc.
   c. Time delays between successive commands.
   d. There shall be provisions for manual overriding of each schedule by an authorized operator.
6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
   a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
   b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

K. Peak Demand Limiting (PDL):
   1. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
   2. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
   3. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
   4. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
   5. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

L. Temperature-compensated duty cycling
   1. User defined conditions shall be able to initiate a Duty Cycle Control Program.
   2. The Duty Cycle Control Program (DCCP) shall be configured to periodically stop and start loads according to various patterns.
   3. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

M. Automatic Daylight Savings Time Switchover. The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

N. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

O. Enthalpy switchover (economizer). The Building Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover setpoint the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly change over to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

P. Control Loop Algorithm
1. Provide a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, setpoint, and weighting parameters shall be accessible from the operator workstation.

Q. Adaptive Loop Tuning

1. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a monthly, seasonal, quarterly, annual period.
2. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).
3. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.
   a. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
   b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

R. Logic programming: Provide a software routine that can build ladder logic to control using many conditional statements.

1. The logic programming syntax shall be able to combine ladder logic with other software features, such as combining status, scheduling, PDL and alarm conditions into one conditional decision.
2. Logic programming shall be able to reference conditions in any other controller in the system.

S. Staggered Start:

1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable in an application and shall not require written scripts or ladder logic.
2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

T. Totalization Features:
1. **Run-Time Totalization.** Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.

2. **Consumption totalization.** Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

3. **Event totalization.** Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

### U. Data Collection:

1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.

2. **Building Controllers** shall store point history data for selected analog and digital inputs and outputs:

3. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.

4. Two methods of collection shall be allowed: either by up to four pre-defined time intervals or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided.

5. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.

6. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in third-party personal computer applications.

#### 2.10 BACNET BUILDING CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Siemens PX Modular and Compact Controllers (PXC).

C. This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall support the following BACnet BIBBs:

1. **Data Sharing**
   
   a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
   
   b. Data Sharing-Read Property Multiple-Initiate, Execute (DS-RPM-A,B)
   
   c. Data Sharing-Write Property-Initiate, Execute (DS-WP-A,B)
   
   d. Data Sharing-Write Property Multiple-Execute (DS-WPM-B)
   
   e. Data Sharing-COV-Initiate, Execute (DS-COV-A,B)
f. Data Sharing-COV-Unsolicited- Initiate, Execute (DS-COVU-A,B)

2. Scheduling
   a. Scheduling-Internal- Execute (SCHED-I-B)
   b. Scheduling-External- Execute (SCHED-E-B)

3. Trending
   a. Trending-Viewing and Modifying Trends - Initiate (T-VMT-A)
   b. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
   c. Trending-Viewing and Modifying Trends-External- Execute (T-VMT-E-B)
   d. Trending-Automated Trend Retrieval- Execute (T-ATR-B)

4. Network Management
   a. Network Management-Connection Establishment- Initiate (NM-CE-A)

5. Alarming
   a. Alarm and Event-Notification- Initiate (AE-N-A)
   b. Alarm and Event-Notification Internal- Execute (AE-N-E-B)
   c. Alarm and Event-Notification External- Execute (AE-N-E-B)
   d. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
   e. Alarm and Event –Alarm Summary- Execute (AE-ASUM-B)
   f. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-A,B)
   g. Alarm and Event –Information- Initiate, Execute (AE-ESUM-A,B)

6. Device Management
   a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
   b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
   c. Device Management-Device Communication Control- Execute (DM-DCC-B)
   d. Device Management-Private Transfer- Initiate, Execute (DM-PT-A,B)
   e. Device Management-Text Message- Initiate, Execute (DM-TM-A,B)
   f. Device Management-Time Synchronization- Execute (DM-TS-B)
   g. Device Management-Reinitialize Device- Execute (DM-RD-B)
   h. Device Management-Backup and Restore- Execute (DM-RD-B)
   i. Device Management-List Manipulation- Execute (DM-RD-B)
   j. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)

7. The Building Level Controller shall support the following Data Link Layers:
   a. BACnet IP Annex J
   b. BACnet IP Annex J Foreign Device
   c. MS/TP Master (Claus 9)

8. The Building Level Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as
they relate to features in the workstation software:

a. Calendar –Creatable, Deletable
b. Command –Creatable, Deletable
c. Event Enrollment –Creatable, Deletable
d. Notification Class –Creatable, Deletable
e. Schedule - Creatable, Deletable

9. The Building Level Controller shall support transmitting and receiving segmented messages.
10. The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.
11. The Building Level Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP.

D. This level of controller shall be used for the following types of systems:

1. Chiller plant systems
2. Heating plant systems
3. Cooling Towers
4. Pumping systems
5. VAV air handlers
6. Air handlers over 15,000 cfm
7. Systems with over 24 input/output points
8. Rooftop systems

E. Computing power and memory minimum:

1. A 32-bit, stand-alone, multi-tasking, multi-user, real-time 100MHz digital control microprocessor module.
2. Inputs shall be 16-bit minimum analog-to-digital resolution
3. Outputs shall be 10-bit minimum digital-to-analog resolution
4. Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.
5. Real time clock and battery
6. Data collection/ Data Trend module sized for 10,000 data samples.
7. Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.

F. Onboard or Modular hardware and connections:

1. Primary Network communication module, if needed for primary network communications.
2. Secondary Network communication module, if needed for secondary network communications.
3. RJ45 port 10/100Mbaud
4. RS485 ports for subnetworks and point expansion
5. Man to Machine Interface port (MMI)
6. USB Port
7. Wireless Mesh Network Floor Level communication ability
8. Local Controller Interface. A local user interface to the controller shall be provided. The interface shall be hot swappable, and may be mounted on any building controller and automatically read and initiate commands of local database points without further set-up or configuration. The Controller Interface shall be provided for interrogating and editing data, commanding point values at user defined priorities, viewing and acknowledging alarms, and viewing point monitoring reports. An optional system security password shall be available to prevent unauthorized use of the local controller interface and display.

G. Input and Output Points Hardware

1. Input/output point modules as required including spare capacity.
2. Input/output point modules shall have removable terminal blocks.
4. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
5. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
6. Graduated intensity LEDs or analog indication of value for each analog output.
7. Optional HOA (hand-off-auto module) with software configurability and LED status indicators.

H. Code compliance

1. Approvals and standards: UL916; CE; FCC
2. Provide UL864-UUKL where called for in the sequences of operations.

I. Accessories:

1. Appropriate NEMA rated metal enclosure.
2. Power supplies as required for all associated modules, sensors, actuators, etc.

J. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.

K. Each Building Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.
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L. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.

M. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

N. Building Level control panels shall provide at least two serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications, operation of permanently connected modems, printers or terminals.

O. Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and BACnet objects. Provide software, drives and programming.

P. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

Q. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

R. Environment.

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
4. Controller hardware shall be optionally suitable for rooftop environments.

S. Immunity to power and noise.

1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
   a. RF-Conducted Immunity (RFCl) per ENV 50141 (IEC 1000-4-6) at 3V.
   b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
   c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).

4. Isolation shall be provided at all Building Controller’s AC input terminals to suppress induced voltage transients consistent with:
   b. UL 864 Supply Line Transients
   c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.11 BACNET ADVANCED APPLICATION CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.

B. Basis of design is Unitary Equipment Controller (PXCxx-UCM).

C. The Advanced Application Controller Software shall be capable of BACnet communications. The BACnet Advanced Application Controller (B-AAC) shall have demonstrated compliance to BTL through BTL listing and shall substantially conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004 or ANSI/ASHRAE 135-2008. Supported BIBBS shall include:

1. Data Sharing
   a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
   b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
   c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
   d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
   e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)

2. Scheduling
   a. Scheduling-Internal- Execute (SCHED-I-B)

3. Trending
   a. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
   b. Trending-Automated Trend Retrieval- Execute (T-ATR-B)

4. Network Management
   a. Network Management-Connection Establishment- Initiate (NM-CE-A)

5. Alarming
   a. Alarm and Event-Notification Internal- Execute (AE-N-I-B)
   b. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
   c. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-B)
   d. Alarm and Event –Information- Execute (AE-INFO-B)

6. Device Management
a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
c. Device Management-Device Communication Control- Execute (DM-DCC-B)
d. Device Management-Time Synchronization- Execute (DM-TS-B)
e. Device Management-Reinitialize Device- Execute (DM-RD-B)
f. Device Management-Backup and Restore- Execute (DM-BR-B)
g. Device Management-List Manipulation- Execute (DM-LM-B)
h. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)

7. The Advanced Application Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:
   a. Calendar – Creatable, Deletable
   b. Command – Creatable, Deletable
   c. Event Enrollment – Creatable, Deletable
   d. Notification Class – Creatable, Deletable
   e. Schedule - Creatable, Deletable

8. The Advanced Application Controller shall support transmitting and receiving segmented messages.

D. Communication:

1. BAS Network: The Advanced Application Controller shall support the following Data Link Layers:
   a. MS/TP Master

2. Serial Communication: Temporary use of portable devices shall not interrupt the BAS communication, nor the normal operation of permanently connected printers or terminals.
   a. Provide at least one EIA-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator’s terminals.
   b. A USB port shall alternatively be available to support local HMI tools connection.

E. Software

1. The software programs specified in this section shall be provided as an integral part of Advanced Application Controllers and shall not be dependent upon any higher level computer or another controller for execution.

2. Advanced Application Controllers shall have the ability to perform energy management routines including but not limited to
   a. scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides
   b. automatic daylight savings time switch over
   c. night setback control
d. economizer switch over using enthalpy, dry bulb or a combination

e. peak demand limiting,
f. temperature-compensated duty cycling

g. heating/cooling interlock

h. supply temperature reset

i. priority load shedding

j. power failure restart

3. The software shall have a routine for automatic tuning of control loops

4. System Security in the Field Panel

a. User access shall be secured using individual security passwords and user names.
b. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
c. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
d. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

5. User Defined Control Applications:

a. Controllers shall be fully-programmable. Controllers shall execute custom, job-specific sequences to automatically perform calculations and special control routines. Factory installed or pre-configured sequences shall only be allowed if they exactly match the sequence specified herein.
b. Programs shall combine control logic, control loop algorithms, and energy management routines

c. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.
d. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

F. Adaptive Loop Control.

1. Each AAC controller shall come standard with an Adaptive Control Loop Algorithm

a. Tuning parameter shall automatically adjust for non-linear applications

2. Model-Free Adaptive (MFA) algorithm

a. The algorithm shall not require modeling of the non-linear system in order to maintain control at all points of the non-linear load.
b. The controlled variable, setpoint, and weighting parameters shall be user-selectable.

3. Output shall be analog or shall stage a series of outputs.

4. Adaptive Control shall take the place of Proportional, Proportional + Integral, and PID type algorithms for non-linear applications. Adaptive Control routines shall:
a. Improve response time
b. Improve System efficiency
c. Improve Stability
d. Result in Consistent outputs
e. Reduce cycling and repositioning
f. Reduce wear and tear on actuators

5. Adaptive control shall auto-adjust to compensate for

a. mode changes
b. load changes
c. seasonal changes
d. Heating and cooling changeover
e. Heating or cooling capacity changes on the primary side
f. Flow changes on the primary or secondary side
g. Airflow changes across coil
h. Flow across a heat exchanger

6. Adaptive control shall auto-adjust to compensate for

a. Non-linear coils and heat exchangers
b. Hot water and chilled water reset routines
c. Water flow reset routines
d. Duct Static reset routines

7. Auto-Tune PID loops are not acceptable substitutions.

8. If Adaptive Loop Control is not available, then the BAS contractor shall provide re-tuning of the control loops for coils and heat exchangers for each of the following conditions:

a. Low heating supply water, high heating supply water
b. Low load on steam coil, high load on steam coil
c. Chilled water coil, non dehumidification and condensing
d. Chilled water coil, low airflow, high airflow, economizer
e. Dual temperature systems tune for heating and cooling modes
f. Each of 4 seasons

G. This level of controller shall be used for the following types of systems:

1. Systems with custom sequences that meet all of the criteria below:
2. No primary pumping systems
3. Secondary Pumping systems that are remote from Central Plants
4. Air handlers up to 15,000 cfm
5. Systems up to 20 input/output points
6. Room control sequences that cannot be achieved with an application specific controller
7. BAS Network or Architecture or Sequences do not require the system to be on an IP network
8. No systems that require integration to meters, VFDs or other smart equipment
9. Integration to smart thermostats is allowed
H. Input/Outputs

1. Inputs shall be 16-bit minimum digital resolution
2. Outputs shall be 10-bit minimum digital resolution
3. The following I/O port types shall be available on the controller
   
a. Universal Input (software configurable):
      
      1) Digital Input choices:
         
         a) Pulse Accumulator
         b) Contact Closure Sensing
         c) Dry Contact/Potential Free inputs only
         d) Digital Input (10 ms settling time)
         e) Counter inputs up to 20 Hz, minimum pulse duration 20 ms (open or closed)

      2) Analog Input Choices:
         
         a) 0-10 Vdc
         b) 4-20 mA
         c) 1K Ni RTD @ 32°F (Siemens, JCI, DIN Ni 1K)
         d) 1K Pt RTD (375 or 385 alpha) @ 32°F
         e) 10K NTC Type 2 or Type 3 Thermistor
         f) 100K NTC Type 2 Thermistor

b. Universal Input or Output (software configurable):

   1) All of the above input types
   2) Analog Output Types:
      
      a) 0 to 10 Vdc @ 1 mA max

c. Super Universal Input or Output (software configurable):

   1) All of the above input types
   2) All of the above output types
   3) Super digital output type:
      
      a) 0 to 24 Vdc, 22 mA max. (for controlling pilot relay)

   4) Super Analog Output Choices:
      
      a) 0 to 20 mA @ 650 Ω max.

4. Provide software configurable I/O ports such that a programmer make a port either an input or an output

I. Each System Level Control Panel shall, at a minimum, be provided with:
1. Appropriate NEMA rated metal enclosure.
2. A 32-bit, multi-tasking, real-time 100 MHz digital control microprocessor with plug-in, enclosed processors.
3. Each Advanced Application Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.
4. Real time clock and battery
5. Data collection/ Data Trend module sized for 10,000 data samples.
6. Power supplies as required for all associated modules, sensors, actuators, etc.
7. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
8. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
9. Each control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
10. Graduated intensity LEDs or analog indication of value for each analog output.

J. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for the operating system software and firmware.

1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. Brownout protection and power recovery circuitry protect the controller board from power fluctuations.
3. Battery backup shall be provided to support the real-time clock for 10 years.
4. The program and database information stored SDRAM memory shall be battery backed for a minimum of 30 days and up to 60 days. This eliminates the need for time consuming program and database re-entry in the event of an extended power failure.

K. Database Restore: Each AAC controller shall automatically save the latest programmed database. The controller shall be able to automatically restore a lost or corrupt database without involvement from the operator.

L. Each System Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

M. Each Control Panel shall support firmware upgrades without the need to replace hardware.

N. System Level control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as operator terminals, and additional memory. Control panels shall allow temporary use of portable operator interface devices without interrupting the normal communications.

O. Immunity to noise.
1. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
2. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
   a. RF- Conducted Immunity (RFCl) per ENV 50141 (IEC 1000-4-6) at 3V.
   b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
   c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
   d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
3. Isolation shall be provided at all Advanced Application Controller’s AC input terminals to suppress induced voltage transients consistent with:
   b. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

P. Agency Compliance
   1. UL UL916 PAZX (all models)
   2. UL916 PAZX7 (all models)
   3. FCC Compliance CFR47 Part 15, Subpart B, Class B

Q. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

R. Local Operator Interfaces
   1. Controllers shall support an optional Operator Interface Module.
   2. Optional local user interface to the controller shall be hot swappable, and may be mounted on any building controller and automatically read and initiate commands of local database points without further set-up or configuration. The Controller Interface shall be provided for interrogating and editing data, commanding point values at user defined priorities, viewing and acknowledging alarms, and viewing point monitoring reports. An optional system security password shall be available to prevent unauthorized use of the local controller interface and display.

2.12 BACNET APPLICATION SPECIFIC CONTROLLERS (DXR)

A. Each Application Specific Controller shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each Application Specific Controller shall provide standard applications and programmability to provide both reliability and flexibility. Each application specific controller shall be a microprocessor-based, multi-tasking, digital control processor.
B. Basis of design is the programmable Siemens DXR controller.

C. Configurable control applications. Each Application Specific Controller model must have a set of pre-loaded, selectable and field-adjustable control applications appropriate for the secondary HVAC equipment that the controller model is intended to control. Specific applications must be configurable to meet the user’s control strategy requirements, allowing for additional system flexibility.

D. Programmability: Application Specific Controllers shall be programmable. Program language shall be graphical.

E. The Application Specific Controller shall include all point inputs and outputs necessary to perform the specified HVAC control sequences. The controller shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control output signals shall not be acceptable. Controllers shall provide outputs utilized either for two-state, modulating floating, or proportional control, allowing for additional system flexibility.

1. Analog inputs shall be software configurable to accept sensors using 0-10v (such as RH or CO2 sensors), NTC3k, NTC10k, NTC100k, Ni1000, PT1K 385, and resistance sensors of 1000Ω, 2500 Ω, 10K Ω, and 100k Ω. 24vDC power to drive active sensors shall be an option available from the controller.

2. Digital input

3. Analog Outputs shall support 0-10v HVAC control signals.

4. Digital outputs shall be AC 24V high-side switching triacs, able to switch loads of 250 mA / 6 VA per output.

5. Every installed Application Specific Controller shall be prepared for the addition of occupancy, CO2 and humidity sensors.

6. Additional sensors and output modules for occupancy, lighting and shade control within the same space as the HVAC control shall be connected as needed via a sub-network connection on each Application Specific Controller.

7. The Application Specific Controller shall be compatible with a Siemens Room Unit which combines a display with CO2, temperature and humidity sensing in 1 wall device.

8. The Application Specific Controller shall be compatible with a Siemens Room Unit which combines a display with temperature sensing and configurable switches for lighting, shade and scene control in 1 wall device.

F. Application Specific Controller communication

1. Communication over floor level network shall be BACnet over MS/TP or BACnet IP over Ethernet.

2. A maximum of 96 controllers may be configured on individual BACnet MS/TP networks.

3. Each controller that uses BACnet IP shall provide at least two Ethernet ports allowing the controllers to be wired in a daisy-chain configuration of up to at least 20 controllers per chain, utilizing standard Ethernet cables of up to 300ft in length between each controller.

G. The Application Specific Controller shall have the BTL listing and meet the BACnet device profile of an Application Specific Controller (B-ASC) as specified in ANSI/ASHRAE 135-
2012. The controller shall support the following BACnet BIBBs:

1. Data Sharing
   a. DS-RP-A: Data Sharing – Read Property-A
   b. DS-RP-B: Data Sharing – Read Property-B
   c. DS-RPM-A: Data Sharing – Read Property Multiple-A
   d. DS-RPM-B: Data Sharing – Read Property Multiple-B
   e. DS-WP-A: Data Sharing – Write Property-A
   f. DS-WP-B: Data Sharing – Write Property-B
   g. DS-WPM-A: Data Sharing – Write Property Multiple-A
   h. DS-WPM-B: Data Sharing – Write Property Multiple-B
   i. DS-COV-A: Data Sharing – Change of Value -A
   j. DS-COV-B: Data Sharing – Change of Value -B
   k. DS-COVP-A: Data Sharing – Change of Value Property -A
   l. DS-COVP-B: Data Sharing – Change of Value Property –B

2. Alarm and Event
   a. AE-N-I-B: Alarm and Event – Notification Internal-B
   b. AE-ACK-B: Alarm and Event – ACK-B
   c. AE-ASUM-B: Alarm and Event – Alarm Summary-B
   d. AE-ESUM-B: Alarm and Event – Enrollment Summary-B
   e. AE-INFO-B: Alarm and Event – Information-B
   f. AE-EL-I-B: Alarm and Event – Event Log Internal-B

3. Trending
   a. T-VMT-I-B: Trending – Viewing and Modifying Internal-B
   b. T-ATR-B: Trending – Automated Trend Retrieval-B

4. Device Management
   a. DM-DDB-A: Device Management – Dynamic Device Binding-A
   b. DM-DDB-B: Device Management – Dynamic Device Binding-B
   c. DM-DOB-B: Device Management – Dynamic Object Binding-B
   d. DM-DCC-B: Device Management – Device Communication Control-B
   e. DM-TS-B: Device Management – Time Synchronization-B
   f. DM-UTC-B: Device Management – UTC Time Synchronization-B
   g. DM-RD-B: Device Management – Reinitialize Device-B
   h. DM-BR-B: Device Management – Backup and Restore-B
   i. DM-R-B: Device Management – Restart-B
   j. DM-LM-B: Device Management – List Manipulation-B

5. The Application Specific Controller shall support the following Data Link Layers:
   a. BACnet MS/TP Master (Clause 9)
   b. BACnet IP, Foreign Device
H. The Application Specific Controller shall provide for control of each piece of equipment, including, but not limited to the following:

1. Variable Air volume (VAV)
2. Constant Air volume (CAV)
3. Hot water and electric reheat Coils (RH)
4. Fan Coil Units (FCU)
5. Fan Powered Boxes (FPB)
6. Unit Conditioners
7. Unit Ventilators
8. Baseboard radiator
9. Chilled/heated ceiling panels
10. DX cooling and chilled water coils

I. Applications for VAV terminals:

1. The following VAV terminal box equipment configurations must be supported with pre-loaded, pre-tested applications that can be selected and configured during commissioning:

   a. VAV w/cool air only
   b. VAV w/hot or cool air, automatic switchover
   c. VAV w/ HW reheat
   d. VAV w/ CHW
   e. VAV w/ HW reheat and CHW
   f. VAV w/ Electric reheat
   g. VAV w/ Series fan and HW reheat
   h. VAV w/ Series fan and Electric reheat
   i. VAV w/ Parallel fan and HW reheat
   j. VAV w/ Parallel fan and Electric reheat

2. All VAV applications must support the following options (where appropriate):

   a. Demand Control Ventilation using CO2 measurement
   b. Minimum ventilation control and flow set points configurable for each application operating mode
   c. Separate minimum and maximum flow set points for heating, cooling and ventilation
   d. Supply temperature cascade control
   e. Configuration for Constant Volume control
   f. Chilled/heated ceiling
   g. 2-pipe HW/CHW coil valve control
   h. Variable speed fan control (fan-power applications only)
   i. Multi-speed fan control (fan-power applications only)
   j. Auxiliary/Base-board/Radiator heating, valve, two position or modulating and electric.
   k. Analog or 3-point floating control valve/damper actuation, including 6-way heating/cooling valve via standard BACnet Analog Output objects.
   l. Fault Detection for automatic change to pressure dependent control.
m. Built in air balancing support.

n. User initiated rapid ventilation to assist in purging the space for a configurable time with a separate flow set point

o. Occupancy sensor

J. Applications for Fan Coil terminals:

1. The following Fan Coil terminal box equipment configurations must be supported with pre-loaded, pre-tested applications that can be selected and configured during commissioning.

2. Heating sources

   a. 2-pipe HW coil
   b. 2-pipe HW/CHW coil, automatic switchover
   c. Electric reheat

3. Cooling sources

   a. 2-pipe CHW coil
   b. DX Cooling

4. All Fan Coil applications must support the following options (where appropriate):

   a. VAV pressure dependant control of a damper (no flow sensor)
   b. Heating/cooling control with no fan
   c. Chilled/heated Ceiling
   d. Single or multi-speed or variable speed fan control
   e. Auxiliary/Base-board heating, valve modulating or two position and electric
   f. Analog or 3-point floating control valve actuation, including 6-way heating/cooling valve via standard BACnet Analog Output objects.
   g. Occupancy sensor

K. Applications for Unit Ventilator terminals:

1. The following Unit Ventilator terminal box equipment configurations must be supported with pre-loaded, pre-tested applications that can be selected and configured during commissioning.

   a. Heating and/or Cooling with Outdoor air damper control

2. All Unit Ventilator applications must support the following options (where appropriate):

   a. DX or CHW cooling
   b. Electric or HW heating
   c. 2-pipe HW/CHW coil, automatic switchover
   d. Discharge temperature control
   e. Demand Control Ventilation for each application operating mode
   f. Single or multi-speed or Variable speed fan control
   g. Auxiliary/Base-board heating, valve modulating or two position and electric
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina

AP#1515
RMF Engineering, Inc.
July 18, 2016

h. Analog control or floating control valve/damper actuation, including 6-way heating/cooling valve via standard BACnet Analog Output objects.
i. Cooling via economizer control of outside air damper.
j. Occupancy sensor

L. Provide centralized control functions for secondary HVAC control, Lighting, and Shading

1. Functions for coordinating control across a grouping of rooms, a floor area, entire floor, façade, mechanical or electrical supply chains, or different combinations thereof shall be provided.
2. Support commanding of all group members to a common position or state.
3. Support consolidation of common information from group members for calculation or optimization purposes.
4. Central functions shall reside in an Application Specific Controller dedicated to the central control functions specified herein.
5. Members of the groups used by the central functions specified herein shall be assigned and be changeable through standard BACnet services.

M. Central functions for Secondary HVAC

1. Utilize the HVAC control status and conditions in a large number of Application Specific Controllers in order to support optimization of primary HVAC plants.
2. Central Supply Air function collects air demand data from rooms (Application Specific Controller flow control loops) to support demand-based run/stop decisions for air handler. Rooms indicate need for primary heating, cooling and ventilation.
3. Central Supply Air function collects data from rooms (Application Specific Controller flow loops) to minimize duct pressure. Application Specific Controllers provide multiple signals to support duct pressure reset, including damper command, damper saturation signal and air flow deviation signal. All are available for collection by Central Air application.
4. Central Supply Air function collects data from rooms (Application Specific Controller control loops) to support dynamically optimizing the primary supply air temperature. Data available from the Application Specific Controller includes cooling demand and demand in the room for reheat.
5. Central Supply Air function collects data from rooms (Application Specific Controller control loops) to support dynamically optimizing the outside air intake. Data available from the Application Specific Controller includes ventilation demand and CO2 levels.

N. Coordination between Application Specific Controllers. In situations where more than one controller is serving a common space, it must be possible through configuration only (not reprogramming) to subordinate one or more Application Specific Controllers to another Application Specific Controller allowing multiple controllers to coordinate HVAC control in a large space.

O. Application Operating Modes - All of the following operating modes shall be supported, with configurable operation of each controlled device during each mode.

1. Comfort, Standby (Pre-comfort), Economy, and Building Protection modes
a. Comfort: Space is occupied
b. Standby: Space has been or will be unoccupied for a short time
c. Economy: Space has been or will be unoccupied for a longer time
d. Building Protection: Space has been or will be unoccupied for more than a day

2. Configurable set points and limits for each mode.
   a. The operating mode can be changed by system schedule or command or by conditions in the space such as by presence detection.
   b. All controlled devices shall respond to changes in operating mode in a configurable way such as set point resets after a configurable time to optimize energy consumption.

P. Room Units / HMIs shall provide an intuitive user alert to indicate energy-efficient operation or when there is unnecessary energy consumption, and provide occupants with a one-touch release to return to efficient, comfortable control. Energy efficient operation shall be determined by configurable and programmable algorithms provided by the Application Specific Controller and shall include (but not be limited to) the following conditions:

1. Temperature set point is set outside customer-specified limits
2. Fan Speed is overridden to a higher speed than is required for automated temperature control

Q. The energy efficiency status for each Application Specific Controller and space shall also be available as BACnet object at the BMS for operating and monitoring.

R. Scene control. The Application Specific Controller shall provide a set of configurable and field-adjustable presets of HVAC, lighting and shading levels that can be activated by pressing assigned buttons on the Room Unit / HMI.

S. Application Specific Controller Configuration and Commissioning Tool

1. Provide industry standard, commercially available laptop to host the Application Specific Controller Configuration and Commissioning Tool. The tool shall plug directly into all controllers as described below:
2. Functionality of the Configuration and Commissioning Tool connected to any Application Specific Controller shall include:

   a. Provide connection capability at either the controller, a related room unit, through a BACnet router or through a Siemens Apogee Field Panel controller to access controller information.

      1) When connected via a related room unit to a controller, the tool shall be able to access information of the controller the room unit is connected to and all controllers connected to the same MS/TP or IP network.
      2) Connection of the Tool to a controller shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.
      3) Tool access to controller shall be password-controlled. Password protection
shall be configurable for each operator based on function, points (designating areas of the facility), and edit/view capability.

b. Provide device discovery, configuration and setup for addressing and network management of multiple devices from one connection point (location) in parallel.
c. Select, view, command, change, and enable/disable features and functionality of the control application.
d. Load pre-designed templates of configuration settings and allow copying of templates to other controllers in order to speed the commissioning process.
e. Provide status, setup, balancing and control reports to support commissioning and troubleshooting activities.
f. Backup and restore of application configurations
g. Air flow balancing.

1) For every air flow sensing channel in the Application Specific Controller control application, the Tool shall offer an interface and menu specifically designed to support the Test, Adjust, and Balance functions. Through the balancing menu, the controller enables the following operations:

a) Select the operating point for the test from a list of named operating points, including maximum and minimum cooling, maximum and minimum ventilation and maximum and minimum heating.
b) Accept the balancer’s flow measurement as a manually entered value.
c) Automatically calculate and display the revised flow calibration factor.
d) Apply the new calibration factor on command.

2) The Application Specific Controller shall maintain a BACnet object reflecting the TAB state of the controller as: Initial, Balancing, Balanced. The Application Specific Controller records data representing the TAB process, and stores for later retrieval. The controller delivers the data when called for producing reports. Stored data includes:

a) Air balancer’s air flow measurement.
b) Controller’s air flow measurement after correction.
c) Named test point (max cooling, etc.).
d) Initial calibration factor.
e) Applied selected calibration factor

h. The tool should allow configuring, loading and balancing multiple controllers from one connection point (location) in parallel
i. The Ethernet / IP Application Specific Controller models shall provide web pages for troubleshooting and operation and monitoring which can be accessed via a standard web browser

T. Each Application Specific Controller shall, at a minimum, be provided with:

1. Appropriate NEMA rated enclosure
2. Power supplies as required for all associated modules, sensors, actuators, etc.
3. Each controller measuring air volume shall include a differential pressure transducer
4. Approvals and standards: UL916 PAZX; CUL; FCC

U. Each Application Specific Controller shall continuously perform self-diagnostics on all hardware and secondary network communications. The Application Specific Controller shall provide both local and remote annunciation of any detected component failures or repeated failure to establish communication to the system.

V. Power Supply. The Application Specific controller shall be powered from a 24 VAC source and shall function normally under an operating range of -15% / +20%.

W. All controller configuration settings and programs shall be stored in non-volatile memory. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.

X. Environment. The controllers shall function normally under ambient conditions of 23 to 122°F (-5 to 50°C) and 5% to 95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

2.13 CONTROL PANELS

A. Controllers in mechanical rooms shall be mounted in NEMA 1 enclosures.

B. Controllers in areas where moisture is a concern shall be mounted in NEMA 12 enclosures.

C. Controllers installed outdoors shall be mounted in NEMA 4X enclosures. Provide heaters where freezing temperatures are normally experienced.

D. Mount on walls at an approved location or provide a free standing rack.

E. Panels shall be constructed of 16 gauge, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with ANSI 61 gray polyester-powder painted finish, UL listed. Provide common keying for all panels.

F. Provide power supplies for control voltage power.

G. Dedicate 1 power supply to the DDC controller. Other devices shall be on a separate power supply, unless the power for the control device is derived from the controller terminations.

H. Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.

I. All power supplies for 24V low voltage wiring shall be class 2 rated and less than 100VA. If low voltage devices require more amps, then provide multiple power supplies. If a single device requires more amps, then provide a dedicated power supply in a separate enclosure and run a separate, non-class 2 conduit to the device.

J. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator’s workstations.
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K. All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.

L. Provide a pocket to hold documentation.

2.14 SENSORS

A. General

1. Provide mounting hardware for all devices, including actuator linkages, wells, installation kits for insertion devices, wall boxes and fudge plates, brackets, etc.
2. If a special tool is required to mount a device, provide that tool.

B. Terminal Unit Space Thermostats

1. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The space temperature sensor shall be available in wired and wireless versions.
   a. Plain Space Temperature Sensors – Wired: Where called for in the sequences or on the drawings, provide sensors with plain covers.
   b. The sensing element for the space temperature sensor shall be thermistor type providing the following.
      1) Element Accuracy: + /- 1.0°F
      2) Operating Range: 55 to 95°F
      3) Set Point Adjustment Range: 55 to 95°F
      4) Calibration Adjustments: None required
      5) Installation: Up to 100 ft. from controller
      6) Auxiliary Communications Port: as required
      7) Local LCD Temperature Display: as required
      8) Setpoint Adjustment Dial as required
      9) Occupancy Override Switch as required
   c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator’s terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator’s terminal.

2. Digital Display temperature sensor specifications – Wired:

a. As called for in the sequences of operations or on the drawings, provide temperature sensors with digital displays.
b. The sensing element for the space temperature sensor must be IC-based and provide the following.
   1) Digitally communicating with the Application Specific Controller.
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2) Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.
3) IC Element Accuracy: +/− 0.9°F
4) Operating Range: 55 to 95°F
5) Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F
6) Display of temperature setpoint with numerical temperature values
7) Display of temperature setpoint graphically, with a visual Hotter/Colder setpoint indication
8) Calibration: Single point, field adjustable at the space sensor to +/- 5°F
9) Installation: Up to 100 ft. from controller
10) Auxiliary Communications Port: included
11) Local OLED Temperature Display: included
12) Display of Temperature to one decimal place
13) Temperature Setpoint Adjustment included
14) Occupancy Override Function included

c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator’s terminal.

3. Provide the following options as they are called for in the sequences or on the drawings:

a. Setpoint Adjustment. The setpoint adjustment function shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator’s terminal.

b. Override Switch. An override button shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator’s terminal.

c. Space Combination Temperature and Humidity Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.

C. Temperature Sensors
1. All temperature sensors shall meet the following specifications:
   a. Accuracy: Plus or minus 0.2 percent at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Vibration and corrosion resistant
2. Space temperature sensors shall meet the following specifications:
   a. 10k ohm type 2 thermisters
3. Insertion Elements in Ducts shall meet the following specifications:
   a. Single point 10k ohm thermister
   b. Use where not affected by temperature stratification
   c. The sensor shall reach more than 1/3 the distance from the duct wall
   d. Junction box for wire splices
4. Averaging Elements in Ducts shall meet the following specifications:
   a. 72 inches (183 cm) long
   b. Flexible
   c. Use where prone to temperature stratification, in front of coils, or where ducts are larger than 9 sq. ft.
   d. Junction box for wire splices
5. Insertion Elements for Liquids shall meet the following specifications:
   a. Platinum RTD with 4-20mA transmitter
   b. Threaded mounting with matching well
   c. Brass well with minimum insertion length of 2-1/2 inches for pipes up to 4” diameter
   d. Brass well with insertion length of 6 inches for pipes up to 10” diameter
   e. Junction box for wire splices
6. Outside-Air Sensors Platinum RTD with 4-20mA transmitter:
   a. Watertight enclosure, shielded from direct sunlight
   b. Circulation fan
   c. Watertight conduit fitting

D. Where called for in the sequences of operations, provide the following feature on space sensors and thermostats:

1. Security Sensors: Stainless-steel cover plate with insulated back and security screws
2. Space sensors with setpoint adjust: Plain white plastic cover with slide potentiometer to signal a setpoint adjustment to the DDC
3. Space Sensors with LCD display:
   a. Operator buttons for adjusting setpoints, setting fans speeds and overriding unit to
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on/off
b. Graphical LCD icons for signaling heating/cooling mode, fans speed, schedule mode, actual temperature and current setpoint

E. Humidity Sensors shall meet the following specifications:
   1. Bulk polymer sensor element
   2. Accuracy: 2 percent full range with linear output
   3. Room Sensors: With locking cover matching room thermostats, span of 0 to 100 percent relative humidity
   4. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity

F. Air Static Pressure Transmitter shall meet the following specifications:
   1. Non-directional sensor with suitable range for expected input, and temperature compensated.
   2. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   3. Output: 4 to 20 mA.
   4. Building Static-Pressure Range: 0 to 0.25 inches wg.
   5. Duct Static-Pressure Range: 0 to 5 inches wg.

G. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.

H. Equipment operation sensors as follows:
   1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.
   2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
   3. Status Inputs for direct drive electric motors: Current-sensing relay with current transformers, adjustable and sized for 175 percent of rated motor current.
   4. Status inputs for belt drive electric motors: Current sensing transmitter with linear 4-20mA output

I. Electronic Valve/Damper Position indication: Visual scale indicating percent of travel and 0 to 10 V dc, feedback signal.

J. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vapor proof type.

K. Air Differential Pressure Switches: Diaphragm type air differential pressure switches with die cast aluminum housing, adjustable setpoint, minimum 5 amp switch rating at 120VAC, SPDT switches, and the switch pressure range shall be suited for the application. Provide Dwyer or equal. These switches shall be utilized for filter status.

L. Leak detectors: Provide spot leak detectors that can be secured to the floor or secured to a drain
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pan. The detection shall use a microchip controlled energized probes. The detector shall operate on 24V or less. Provide a way to adjust the height of the leak probes. The SPDT contacts shall be inside a watertight enclosure.

M. Carbon Dioxide Sensors

1. Space or Zone Sensing
   a. One wall module in each zone shall take of each type of sensing called for in the sequences of operations. Separate wall devices in one zone for temperature, humidity and CO2 shall not be allowed.
   b. Provide a plain cover, no display, no setpoint change unless called for in the sequences of operations.
   c. CO2 Sensing specifications:
      1) Range: 0-2000ppm
      2) Signal: 4-20mA or digital
      3) Sensing element type: NDIR
      4) Response: < 3 min full scale
      5) CO2 Accuracy: Maximum +/- 50ppm + 2% of reading
      6) CO2 drift: Maximum +/- 5% of range over 5 years
      7) Calibration: Automatic comparison of dual elements
      8) Calibration adjustment: Adjustable bias set at the module
      9) Power: 24Vac or 24Vdc
   d. Where called for in the sequences of operation or shown on the drawings, provide a display on the face of the thermostat cover. The display shall normally show the current sensor readings. If more than one sensor is used, then rotate the display between the readings.
      1) The display shall be an LED, OLED or backlit LCD.
      2) The display shall show the value, units and the occupied/unoccupied status
   e. Where called for in the sequences of operations, provide setpoint adjustment. If not called for in the sequence, then provide a plain cover or lock out the adjustment through settings.
   f. Where called for in the sequences of operation, provide an occupancy override button to allow the user to switch the zone from unoccupied to occupied.
   g. Provide power for the sensor. If a special power module is required, then provide one for each sensor.
   h. Provide cables to run from the wall sensor to the zone controller
      1) Wall sensors shall have a communication plug to allow an operator to plug in a portable interface and communicate with the zone controller to adjust setpoints and settings.
   i. Installation:
1) All wall modules shall be mounted on an electrical wall box with wire connection in the box.
2) Mount wall modules according to the architectural and engineering plans.
3) If mounting locations are not given on the plans, then mount according to the following:
   a) Sensors with plain covers, no display or adjustments: 60”AFF
   b) Sensors with display and/or adjustments: 48” AFF
   c) Insulate between the sensing elements and the interior of the wall or junction box.
   d) Do not mount where sun can shine on the sensor through a window.
   e) Do not mount where airflow can be stagnant because of furniture or other obstructions.
   f) Do not mount above or near heat sources, such as appliances, PCs, AV equipment, copiers or baseboard heat.

2. Duct or Outside Air Intake Sensing
   a. Provide a duct probe sensing module for sensing CO2 levels. Outside air CO2 shall be sensed at an outside air intake duct so that air movement can be maintained over the sensing element.
   b. Electrical connections shall be enclosed in a Nema 1, UL listed enclosure. Connection boxes exposed to weather shall have a Nema 4 watertight junction box for connections.
   c. CO2 Sensing specifications:
      1) Range: 0-2000ppm
      2) Signal: 0-5V, 0-10V, 4-20mA
      3) Sensing element type: NDIR
      4) Response: < 3 min full scale
      5) CO2 Accuracy: Maximum +/- 50ppm + 2% of reading
      6) CO2 drift: Maximum +/- 5% of range over 5 years
      7) Calibration adjustment: Adjustable bias set at the module
      8) Ambient operating ranges: 0 to 100 Deg. F. and 10 to 95% RH noncondensing.
      9) Power: 24Vac or 24Vdc
   d. Provide power for the sensor. If a special power module is required, then provide one for each sensor.
   e. Installation
      1) Mount sensor in an accessible location for service and replacement.
      2) Probe shall be located where there is consistent, low turbulent airflow when the system is on.
      3) Do not locate probe where it can be exposed to moisture, such as at the outlet of a cooling coil, outlet of a humidifier, or in an intake plenum that is exposed to weather.

N. Air Flow Measuring Stations:
1. Provide airflow/temperature measurement devices (ATMD) where specified and/or indicated on the plans.
2. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices.
3. Each ATMD shall consist of one (1) or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.
4. Each sensor assembly shall contain 2 individually wired, hermetically sealed bead-in-glass thermistors.
5. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
6. The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.
7. The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.
8. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.
9. Devices using chip-in-glass or diode-case chip thermistors are not acceptable.
10. Devices using less than two (2) thermistors in each sensor assembly are not acceptable.
11. Devices using platinum wire RTDs are not acceptable.
12. Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
13. Pitot tubes and arrays are not acceptable.
14. Vortex shedding devices are not acceptable.
15. Sensor Probes
16. Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.
17. Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
18. Airflow accuracy shall be + 2% of reading over the entire operating airflow range.
19. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
20. Temperature accuracy shall be +0.15°F over the entire operating temperature range of -20°F to 160°F.
21. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
22. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
23. Each sensor assembly shall not require matching to the transmitter in the field.
24. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.
25. Duct and Plenum Probes
26. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
27. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using 1 of the following options:
28. Insertion mounted through the side or top of the duct.
29. Internally mounted inside the duct or plenum.
30. Standoff mounted inside the plenum.
31. The number of sensor housings provided for each location shall be as follows:

   a. Duct or Plenum Area (sq. ft)    Total # Sensors/Location
      <2            4
      >2 and <4          6
      >4 and <8          8
      >8 and <16         12
      >16            16

32. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.
33. Transmitters
34. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.
35. The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.
36. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).
37. The transmitter shall use a switching power supply fused and protected from transients and power surges.
38. The transmitter shall use "watch-dog" circuitry to assure reset after power disruption, transients and brown-outs.
39. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.
40. The operating temperature range for the transmitter shall be -20°F to 120°F. The transmitter shall be installed at a location that is protected from weather and water.
41. The transmitter shall be capable of communicating with other devices using the following:
42. Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10 VDC/4-20 mA (4-wire).
43. The ATMD shall be UL listed as an entire assembly.
44. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.
45. Integral sleeve for outside air measurement where applicable:

   a. Provide an extruded aluminum (6063T5) sleeve. Sleeve depth shall be 15" for ducted applications and 18" for un-ducted applications. Unducted applications shall include a 3" radius aluminum entry flair. Provide an additional 7" (10" for ducted applications) between the downstream edge of an intake louver and the leading edge of the entry flair for outside air intake applications that are close coupled to intake louvers.

46. Provide Ebtron Model GTx116-P or pre-approved equal.
2.15 ELECTRO-MECHANICAL THERMOSTATS

A. Fire-Protection Thermostats: UL listed with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, with the following:

1. Reset: Automatic with control circuit arranged to require manual reset at central control panel, with pilot light and reset switch on panel labeled to indicate operation.

B. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Setpoint shall be adjustable.

2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

C. Electric space thermostats: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

D. Aquastat: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V.

2.16 AUTOMATIC CONTROL VALVES

A. General:

1. All automatic control valves shall be fully proportioning, unless specified otherwise. The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of control air failure. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements. The valves shall be capable of operating in sequence with other valves and/or dampers when required by the sequence of operation. All control valves shall be sized by the control vendor and shall be guaranteed to accommodate the flow rates as scheduled. All control valves shall be suitable for the pressure conditions and shall close against the differential pressures involved. Body pressure rating and connection type construction shall conform to fitting and valve schedules. Control valve operators shall be sized to close against a differential pressure equal to the design pump heads plus 10 percent.
2. Cold water, hot water and steam valves, throttling type, and bypass valves shall have equal percentage flow characteristics.
3. Unless otherwise specified, control valves 2 inches and smaller shall have cast iron or bronze bodies with screwed NPT connections.
4. Valves between 2-1/2 inch and 4 inch shall have cast iron bodies with flanged connections.
5. All automatic control valves installed exposed to the elements shall be provided with electric actuators with operating characteristics and accessories as described in herein. Coordinate with electrical contractor for power availability and point of connection.
6. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless noted otherwise in these documents.
7. All automatic control valves shall be installed by the mechanical trade.
8. The controls contractor shall provide wiring as follows:
   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
   b. All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.
   c. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.
   d. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

B. Characterized Ball Valves
1. All control valves shall be sized by the control vendor. All control valve bodies shall be suitable for the static and dynamic pressures of the system. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
2. Body pressure rating and connection type construction shall conform to fitting and valve schedules.
   a. Design body pressure shall be determined by adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.
3. The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.
4. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless otherwise noted in these documents.
5. All automatic control valves shall be installed by the mechanical trade.
6. The controls contractor shall provide wiring as follows:
   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
   b. All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.
   c. All wiring between safeties and the valve actuator shall be wired by the controls contractor.
   d. All wiring shall comply with code requirements. Segregate high and low voltage wiring and circuits and segregate the Fire Alarm (FACS) and BAS controls wiring.

C. Manufacturer
1. Siemens 599 series valves bodies, SSD, SAX, SQV Actuators, Series 230, 231, 232, 233, 238, 239, 371, and 373 assemblies

D. Threaded Valves, line size ½” to 2”
1. Controlled Media Specific Items
   a. The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C). 3-way 1-1/2 inch and 2 inch valves shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 230°F (110°C).
   b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C). 3-way 1-1/2 inch and 2 inch valves shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 230°F (110°C).

2. General Construction Materials/Applicable Standards
   a. Control valve bodies shall be constructed of forged brass according to ASTM B283 (C37700, CuZn39Pb2 or equivalent), and shall meet requirements of ANSI 250 and 600WOG pressure classes.
   b. Inlets and outlets shall be clearly marked on the valve bodies.
   c. Valve ball shall consist of nickel-plated brass, chrome-plated brass or stainless steel.
   d. End connections shall be NPT internally threaded according to ANSI B1.20.1.
   e. The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.
   f. The control valve shall have an equal percentage flow characteristic, according to ANSI/ISA S75.11. A single glass filled PTFE V port insert shall provide both the ball seal and shall establish the flow coefficient of the valve. The V port insert shall be retained by the valve body itself, not requiring additional retaining components. Flow coefficient adapters requiring a retainer clip, or installed after final assembly of the valve or as inserts in the ball shall not be allowed.
   g. 2-way valves and the A-AB path on 3-way valves shall meet the requirements of ANSI Class IV (0.01% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2, at the specified close-off pressure. Bypass path (B-AB) on 3-way valves shall meet the requirements of ANSI Class III (0.1% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2.
   h. Chilled and Hot water valve shall have a blow-out proof stem with two EPDM (peroxide cured) O-rings. External stem retainers will not be allowed.
   i. Valve stem shall be made of brass or stainless steel.
   j. Valve shall have the ability to be manually operated in the event of a power failure.

E. Actuators - Electric
   1. The valves shall be provided with an actuator by the same manufacturer, factory installed.
   2. All actuators shall have visual position indication.
   3. No external programming device shall be required.
   4. Actuator shall be electric motor driving, microprocessor signal controlled.
   5. Modulating valves shall be positive positioning, responding to a 0-10VDC, 2-10VDC or 4-20mA signal. Floating modulating signals are acceptable for modulation on terminal units and radiation units. There shall be a visual valve position indicator.
6. Power: All actuators shall be 24VAC power and less than 100VA draw. Power shall be via Class 2 wiring. Actuators requiring more than 100VA shall have a dedicated conduit for power wiring, not mixed with the signal wiring.

7. Fail Safe: Valves actuators shall position the valve in a fail-safe position when the power supply is disrupted or the signal goes to 0. Fail-safe according to the following guidelines unless otherwise stated in the sequence of operations
   a. Power fail safe shall be via spring loaded mechanical means
   b. Any AHU hot water exposed to ventilation air shall fail open
   c. AHU Chilled water coils exposed to ventilation air in possible freezing conditions shall be fail open
   d. AHU Chilled water coils that are drained in winter months or are in climate zones without freezing conditions shall be fail-in-place
   e. Terminal unit valves shall fail-in-place

8. Fail in Safe valves on primary equipment such as chilled water systems, hot water systems and condenser water systems shall have a means to manually open the valve when power is not available, such as a hand wheel or a geared crank with a clutch.

9. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).

10. Actuator shall provide minimum torque required for proper valve close-off. The close-off differential pressure rating of the valve shall exceed the highest possible head pressure available at the pump plus 10%, and still be rated for a Class IV leakage.

11. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.

12. All automatic control valves installed in locations exposed to the elements shall be provided with weather resistant housings and heaters for climates that reach below freezing.

13. Actuators shall be UL and CSA listed.

F. Hot Water / Condenser Water / Control Valves

2. Fully proportioning with modulating plug or V-port inner valves.
3. Body pressure rating and connection type construction shall conform to fitting and valve schedules. The ANSI rating of the valve shall match the ANSI rating of the piping in which the valve is installed. Minimum ANSI rating shall be ANSI 125.
4. Stainless steel stems and trim.
5. Spring loaded Teflon packing
6. Quiet in operation.
7. Fail-safe in either normally open or normally closed position in the event of power failure.
8. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.
9. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.

G. Differential Pressure Control Valves:

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1. Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each closed loop water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

H. Steam Valves:

1. Steam control valves shall be of linear flow characteristics for modulating service.
2. Sizing Criteria:
   a. 15 psig or less; pressure drop 80% of inlet psig.
   b. 16 to 50 psig; pressure drop 50% of inlet psig.
   c. Over 50 psig; pressure drop as scheduled on plans.
   d. Steam valves shall fail normally open or closed, as scheduled on plans, or as follows:
      1) Heating coils in air handlers: normally open.
      2) Steam to hot water heat exchanger: normally closed.
      3) Other applications: as required by sequences of operation.

2.17 PRESSURE INDEPENDENT CONTROL VALVES (PICV)

A. General

1. All control valves shall be sized by the control vendor. All control valve bodies shall be suitable for the static and dynamic pressures of the system. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
   a. Body pressure rating and connection type construction shall conform to fitting and valve schedules. Design body pressure shall be determined by the adding the static pressure due to the height of the system plus the compression tank charge plus the maximum head of the system pump at cut off. Provide 10% design factor.

2. The valve seat differential pressure rating shall exceed the pump dynamic head design pressure.
3. All automatic control valves controlled by the BAS shall be furnished by the controls contractor unless otherwise noted in these documents.
4. All automatic control valves shall be installed by the mechanical trade.
5. The controls contractor shall provide wiring as follows:
   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.
   b. All low voltage wiring between the controller and the valve actuator shall be wired by the controls contractor.
   c. All wiring between safeties and the valve actuator shall be wired by the controls contractor.
d. All wiring shall comply with code requirements. Segregate high and low voltage wiring and circuits and segregate the Fire Alarm (FACS) and BAS controls wiring.

B. Manufacturer


C. Where to use PICVs

1. Provide PICVs where called for in the specifications, sequences of operations, or on the drawings.
2. If it is not stated elsewhere, PICV valves should be provided to meet the following guidelines:
   a. Provide in direct return, constant speed pumping systems.
   b. Provide in direct return, variable flow water systems where with the system at full flow the pressure differential between the supply connection and the return connection is more than double the pressure drop of the circuit or loop at design flow (including piping, fittings, devices, control valve and coil).
   c. Provide in reverse return, constant speed pumping systems where the circuits and loop pressure drops differ by more than 50%.
   d. Provide in reverse return, variable speed pumping systems where the differential pressure between the systems will vary more than the pressure drop of the circuit or loop.
   e. Provide in systems that have direct return headers and reverse return branch lines where with the system at full flow the pressure differential between the supply connection and the return connection is more than double the pressure drop of the branch at design flow (including piping, fittings, devices, control valve and coil).

D. Piping for circuits with PICVs

1. Systems installed with PICVs shall not require balancing valves.
2. Calibrated balancing valves shall not be required in branches or loops where PICV are installed.
3. Automatic flow control valves are strictly prohibited in branches or loops where PICVs are installed.
4. Circuit setters may be required for coils with multiple sections. Follow the piping details.
5. Install pressure ports on either side of the coil for the balancer to test the flow across the coil at different system flows.

E. Sizing Criteria (Pressure Independent):

1. Two-way modulating service:
   a. Determine the design GPM of the actual coil that is selected be used (may be different than the coil and GPM on the design coil schedule).
   b. Select the PICV valve with a GPM rating higher than the GPM required.
   c. If more than one valve fits the GPM rating, then pick the valve that matches or is
closest to the line size of the circuit piping.

d. If the maximum GPM of the valve exceeds the design GPM required, then adjust the Flow Limiter setting on the valve to the GPM required.

e. Traditional flow coefficient and pressure drop sizing is not applicable to PICV valves.

F. Flanged Valves, line size 2 ½" and larger

1. Controlled Media Specific Items

a. The control valve shall be suitable for chilled water to a minimum of 34°F (1°C) and hot water to a maximum temperature of 248°F (120°C).

b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 34°F (1°C) and hot glycol/water solutions to a maximum temperature of 248°F (120°C).

2. General Construction Materials/Applicable

a. Control valve bodies shall be constructed of cast iron and shall meet requirements of ANSI 125 or ANSI 250 pressure classes.

b. Inlets and outlets shall be clearly marked on the valve bodies.

c. Valves shall be constructed with a single chamber and multiple seats to provide flow limiting, pressure compensation and flow control.

d. Valves shall contain a mechanical, spring-loaded pressure independent regulator to maintain a consistent differential pressure across the control port of the valve.

e. Valves shall contain an actuated flow control portion that responds to the modulating signal from the controller. This control valve portion shall have a linear flow characteristic.

f. Valves shall contain a field adjustable flow limiter. The flow limiter shall be easily adjustable in the field without the use of special tools. The adjustment dial shall be set for and indicate maximum flow. It shall be possible to manually limit the flow to the required value with the flow limiter and then modulate the flow with the control valve and actuator.

1) A table shall be attached to each valve indicating GPM corresponding to each setting on the dial.

2) No mechanical devices besides the valve and actuator shall be permitted to adjust the maximum flow setting. Flow limiting port shall be integrated into the valve body.

3) The valve shall always maintain full nominal stroke regardless of the maximum flow setting of the flow limiter.

4) The flow limiter shall be lockable and tamper resistant when the actuator is installed correctly.

g. At any given actuator setting the flow accuracy across the entire pressure independent operating range of the automatic differential pressure regulator shall be ±10% or less.

h. Pressure ports shall be standard in the body of the valve for all flanged valves.

Pressure ports shall provide a means for a balancer to test the differential pressure.
across the valve control port to ensure the PICV is operating within the pressure independent range.

i. Valves 2-1/2 inch and larger shall be provided with ANSI 125 or ANSI 250 flanged connections.

j. Valves 2-1/2 inch and larger line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 100 psi close off.

k. The differential pressure range for effective pressure independent operation shall be 3.6 – 90 psi or 8 – 90 psi for 2-½ and 3 inch flanged valves and 5 – 90 psi or ≤ 10 – 90 psi for 4 to 6 inch flanged valves, depending on the maximum gpm flow range of the valve.

l. Valve materials shall meet or exceed the following:

1) Valve body: Cast iron
2) Stem, spring: Stainless steel
3) Seat: Stainless steel
4) Plug: Brass and EPDM
5) Seals: EPDM (peroxide cured)

G. Threaded Valves, line size ½” to 2”

1. Controlled Media Specific Items

a. The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C).

b. The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C).

2. General Construction Materials/Applicable Standards

a. Control valve bodies shall be constructed of forged DZR brass or ductile iron and shall meet requirements of ANSI 250 pressure class.

b. Inlets and outlets shall be clearly marked on the valve bodies.

c. Valves shall be constructed with a single chamber and multiple seats to provide flow limiting, pressure compensation and flow control.

d. Valves shall contain a mechanical, spring-loaded pressure independent regulator to maintain a consistent differential pressure across the control port of the valve.

e. Valves shall contain an actuated flow control portion that responds to the modulating signal from the controller. This control valve portion shall have a linear flow characteristic.

f. Valves shall contain a field adjustable flow limiter. The flow limiter shall be easily adjustable in the field without the use of special tools. The adjustment dial shall be set for and indicate maximum flow. It shall be possible to manually limit the flow to the required value with the flow limiter and then modulate the flow with the control valve and actuator.

1) The dial shall show settings in GPM.
2) No mechanical devices besides the valve and actuator shall be permitted to adjust the maximum flow setting. Flow limiting port shall be integrated into
3) The valve shall always maintain full nominal stroke regardless of the maximum flow setting of the flow limiter.
4) The flow limiter shall be lockable and tamper resistant when the actuator is installed correctly.

g. At any given actuator setting the flow accuracy across the entire pressure independent operating range of the automatic differential pressure regulator shall be +/- 5% from 5 to 58 psi and ≤-10% from Δp min. to 5 psi.
h. Pressure ports shall be an optional accessory that can be added to threaded valves. Pressure ports shall provide a means for a balancer to test the differential pressure across the valve control port to ensure the PICV is operating within the pressure independent range.
i. Valves 2 inch and smaller shall be provided female NPT piping connections.
j. Close-off and leakage

1) Normally open valves 1-1/4 inch and smaller line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 200 psi close off.
2) Normally closed valves 1-1/4 inch and smaller line size shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 45 psi close off.
3) Valves 1-1/2 and 2 inch line sizes shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 100 psi close off. Differential pressure ranges:
4) The start-up differential pressure of the automatic differential pressure regulator shall be between 2.3 and 5 psi, depending on valve size and flow rate for ½ to 2 inch valves.
5) The maximum operating differential pressure of the automatic differential pressure regulator shall be 58 psi for ½ to 2 inch valves.
6) In no instance shall the minimum effective pressure differential for effective pressure independent operation exceed 5 psi for valves less than or equal to 2 inch line size.

k. Valve materials shall meet or exceed the following:

1) Valve body: DZR brass or ductile iron
2) Stem, spring: Stainless steel
3) Seat: brass
4) Plug: Brass and EPDM
5) Seals: EPDM (peroxide cured)

2.18 ELECTRONIC ACTUATOR SPECIFICATION

A. ELECTRONIC VALVE ACTUATORS

1. Actuator shall be fully modulating, floating (tri-state), two position, and/or spring return as indicated in the control sequences. Specified fail safe actuators shall require
mechanical spring return.

2. Modulating valves shall be positive positioning, responding to a 2-10VDC or 4-20mA signal. There shall be a visual valve position indicator.

3. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.

4. Actuator shall provide minimum torque required for proper valve close-off. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).

5. Actuators shall be UL listed.

B. ELECTRONIC DAMPER ACTUATORS

1. Actuator shall be direct coupled (over the shaft), enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator-to-shaft clamp shall use a "V" bolt and "V" shaped, toothed cradle to attach to the damper shaft for maximum holding strength. Single bolt or set screw type fasteners are not acceptable.

2. Actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch are not acceptable.

3. For power-failure/safety applications, a mechanical, spring return mechanism shall be used.

4. Actuators with spring return mechanisms shall be capable of either clockwise or counterclockwise spring return operation by simply changing the mounting orientation.

5. Proportional actuators shall accept a 2-10VDC, 4-20mA signal, or be of the 2 point floating type and provide a 2-10VDC actuator position feedback signal.

6. All actuators shall have an external manual gear release (clutch) or manual crank to aid in installation and to allow proper control response.

7. All actuators shall have an external direction of rotation switch to aid in installation and to allow proper control response.

8. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box.

9. Actuators shall be listed under Underwriters Laboratories Standard 873 and Canadian Standards Association. They must be manufactured under ISO 9001.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.
C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor’s work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor’s work with the work of others.

3.2 INSTALLATION

A. Provide all relays, switches, and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified. All field wiring shall be by this contractor.

B. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

C. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.

D. Install equipment level and plumb.

E. Install control valves horizontally with the power unit up.

F. Unless otherwise noted, install wall mounted thermostats and humidistat 60” above the floor measured to the center line of the instrument, or as otherwise directed by the Architect.

G. Install averaging elements in ducts and plenums in horizontal crossing or zigzag pattern.

H. Install outdoor sensors in perforated tube and sunshield.

I. Install damper motors on outside of duct in protected areas, not in locations exposed to outdoor temperatures.

J. Install labels and nameplates on each control panel listing the name of the panel referenced in the graphics and a list of equipment numbers served by that panel.

K. Furnish hydronic instrument wells, valves, and other accessories to the mechanical contractor for installation.

L. Furnish automatic dampers to mechanical contractor for installation.

3.3 GRAPHIC DISPLAY GENERATION

A. All workstation(s) shall be provided with color graphics. All workstation(s) software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

B. Provide a main default screen showing the basic layout of the building. Each color graphic
screen shall have transfer links to allow the building operator to transfer between system associated screens (both forward and backward), as well as a transfer link back to the main default screen.

C. Basic CAD floor plans with layers for walls, windows, low pressure ductwork only, supply diffusers and room numbers shall be provided for all CV, VAV, and FPVAV terminal units. Floor plans shall show the location of each space temperature sensor with a dashed line to the associated terminal unit. Display in real time the difference between the space temperature and the current setpoint.

1. Display the
   a. cooling %,
   b. heating % (if applicable)
   c. current CFM of each terminal unit.

2. Provide a transfer link for each terminal unit to allow the operator to access the flow graphic for each individual terminal unit. Use a different color to shade the background area for each part of a floor plan graphic served by a different air handling unit.

D. Thermal floor plan graphics:

1. Show heating and cooling zones throughout the building in a range of colors (minimum 5) that provide a visual display of temperatures relative to their respective setpoints. The colors shall be updated dynamically as zones’ comfort conditions change. Locations of space sensors shall also be shown for each zone. Floor plan humidity’s shall be represented similarly to zone temperatures. Setpoint adjustment and color band displays shall be provided as a tool for user adjustment.

2. These full screen plans shall be accessible by rolling over the floor on the building elevation rendering. This will provide the viewer a quick and accurate overview of which zones are at setpoint, near setpoint, or need attention.

3. The viewer may then click on any zone to be brought to the terminal unit that is related to that zone. Rolling over any zone will bring up the zone description and temperature in a pop-up flag. Flags are used to keep the zone information legible regardless of how small the zone is depicted on the plan.

4. All floor plans shall be vector based to allow for zooming in and out of floor plans without pixelization.

5. If zone lighting controls are tied into the BAS, then produce the same floor viewing and control for lights.

6. If a Web-based graphical interface is specified, then the floor plan graphics shall be accessible through the Web Browser Interfaces.

E. All control set points shall be easily adjustable from the system’s color graphic screen by operators with the proper access level. Each controlled point on the BAS operator workstation color graphic screens shall have the set point indicated along with the actual controlled variable reading (preferred set point on top and actual reading on bottom). All points shall indicate the associated engineering unit. All analog outputs points shall indicate engineering units such as “%-open” or “%-closed” as required by the application. All normally-closed or normally-open points shall indicate the normal position (such as “N.C.” or “N.O.” next to the controlled
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Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS. Provide scaled floor plans indicating equipment location, service, and system data as required.

G. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water systems to optimize system performance analysis and speed alarm recognition.

H. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

I. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

J. The windowing environment of the PC operator workstation(s) shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

1. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays via an off the shelf graphics package similar to MicroGraphix Designer.

2. Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.

3. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.

K. Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers, PC workstation(s) and networks.

L. Provide a separate dynamic display page of each HVAC (AHU, AC, chiller, cooling tower, fuel oil, etc.), electrical, and/or plumbing system connected to the BMS.

M. Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

N. Provide an additional (10) separate dynamic, graphic display pages at each workstation as required by the operating staff to further assist in daily system operations.

O. Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

P. Each graphic shall have a “BACK” button and a “HOME” or “MAIN” button located in the
same location on all graphics.

Q. The operator shall be able to clearly distinguish the difference between the following types of points on a graphic either by color, shape, icon or text label:

1. Real-time sensor reading
2. Setpoint
3. Manually set vs. program set Setpoint
4. Real-time output reading
5. Manually Overridden or commanded output vs program set output
6. Status feedback from a piece of equipment vs the output command

R. When the operator selects a graphic from a menu or a hyperlink, the system shall also make the following adjustments for the operator:

1. Highlight the system name on the system tree
2. Highlight the controller name on the network tree
3. Make appear links to additional information associated with the data on the graphic, such as:
   a. Adjustable modes of operation
   b. Setpoints
   c. Alarm statuses
   d. Trend logs
4. Make appear links to additional information associated with the system on the graphic, such as:
   a. Controls as-built schematics and wiring diagrams
   b. As-built Sequence of Operation
   c. Mechanical drawings
   d. Electrical drawings

S. For control loops that have a 4-point setpoint reset schedule, the operator shall have access to adjust the 4 points in the graphics. Provide a separate graphic with the 4 adjustable data points and a line graph with labels vertices showing the scale of the reset ramp. Display the current calculated output setpoint.

T. Integration graphics shall be representative of personnel standing in front of equipment. The graphics for equipment specified in the Building Systems Integration paragraph shall be representative of the manufacturers’ local display panel and each shall be completely operable from the computer workstation.

U. Lighting Control System User Interface:

1. Floor plan Graphics: Provide interface for area-level lights status, level, occupancy mode, preset scene, and ability to override all.
2. Room Graphics: Provide interface for zone-level lights status, level, occupancy mode, preset scene, light level (photocell), light level setpoint, and ability to override all.
3. Schedule Interface: Time clock schedule commands to the Lighting Control System shall be managed by the BAS System. Provide interface for schedule mode input for each time clock area, with mode feedback.

4. Alarm Management: BAS System shall manage collection and distribution of alarms from Lighting Control System. Provide interface for any system or device alarm, including lamp or ballast failures (as available), panel failures, or network failures.

5. Trend/History Management: BAS System shall collect and manage historical trend logs for Lighting Control System points.

3.4 ELECTRICAL WIRING SCOPE

A. This contractor shall be responsible for power that is not shown on the electrical drawings, to controls furnished by this contractor. If power circuits are shown on the electrical drawings, this contractor shall continue the power run to the control device. If power circuits are not shown, this contractor shall coordinate with the electrical contractor to provide breakers at distribution panels for power to controls. This contractor is then responsible for power from the distribution panel.

1. Coordinate panel locations. If enclosures for panels are shown on the electrical drawings, furnish the enclosures according to the electrician’s installation schedule.

B. This contractor shall not be responsible for power to control panels and control devices that are furnished by others, unless it is part of the control interlock wiring.

C. Refer to Coordination section for what devices this contractor is responsible to mount and which are turned over to others to mount.

D. This contractor shall be responsible for wiring of any control device that is furnished as part of this section of specification.

E. Interlock wiring shall be run in separate conduits from BAS associated wiring.

F. Provide network wiring for equipment that is called to be integrated to the BAS.

3.5 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. All low voltage control wiring shall be class 2. Control wiring that is not class 2 shall be run in separate conduits from class 2 wiring.

B. Floor level network wiring between terminal units can be combined with thermostat and other low voltage wiring in the same conduit. All other network wiring shall be in dedicated conduits.

C. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes."

D. Install building wire and cable according to Division 26 Section "Conductors and Cables."
E. Installation shall meet the following requirements:

1. Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway or conduit.
3. Install concealed cable using plenum rated cable.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. All wiring in lab areas shall be in conduit.
8. All unsupported risers shall be rigid steel conduit. Supported risers shall be EMT.

F. Rigid conduit shall be steel, hot dip galvanized, threaded with couplings, ¾ inch minimum size, manufactured in accordance with ANSI C-80-1. Electrical metallic tubing (EMT) with compression fittings or intermediate metallic conduit (IMC) may be used as conduit or raceway where permitted by the NEC.

G. Concealed control conduit and wiring shall be provided in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

H. Install conduit adjacent to machine to allow service and maintenance.

I. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

J. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

K. Ground equipment.

3.6 COMMUNICATION WIRING

A. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer’s installation recommendations for all communication cabling.

B. Do not install communication wiring in raceway and enclosures containing Class 1 wiring.

C. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

D. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

E. Cable bundling:
1. RS485 cabling run open air in accessible areas can be bundled with other class 2 low voltage cabling.
2. RS485 cabling run between terminal units in conduits above ceilings or under floors or in inaccessible areas can be bundled with other class 2 low voltage cabling.
3. RS485 cabling run between floors shall be in a communication only conduit.
4. RS485 conduit run long distances between utility rooms or between buildings shall be in a communication only conduit.
5. Ethernet cabling shall be in a communication only conduit.
6. Ethernet and RS485 can be run together.
7. Fiber optics can be run with Ethernet and RS485 cabling as long as the conduit is bent to fiber optic standards and junction boxes are sized for fiber optic use.

F. RS485 Cabling
1. RS485 cabling shall be used for BACnet MS/TP networks.
2. RS485 shall use low capacitance, 20-24 gauge, twisted shielded pair.
3. The shields shall be tied together at each device.
4. The shield shall be grounded at one end only and capped at the other end.
5. Provide end of line (EOL) termination devices at each end of the RS485 network or subnetwork run, to match the impedance of the cable, 100 to 120ohm.

G. Ethernet Cabling
1. Ethernet shall not be run with any Class 1 or low voltage Class 2 wiring.
2. CAT6, unshielded twisted pair (UTP) cable shall be used for BAS Ethernet.
3. Solid wire shall be used for long runs, between mechanical rooms and between floors. Stranded cable can be used for patch cables and between panels in the same mechanical room up to 50 feet away.
4. When the BAS Ethernet connects to an Owner’s network switch, document the port number on the BAS As-builts.

H. Fiber-Optic Cabling
1. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer’s specifications.
2. All cabling and associated components shall be installed in accordance with manufacturers’ instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.
3. All terminations shall to be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

I. When a cable enters or exits a building, a lightning arrester must be installed between the lines and ground. The lightning arrester shall be installed according to the manufacturer’s instructions.

J. All runs of communication wiring shall be unspliced length when that length is commercially available.

K. All communication wiring shall be labeled to indicate origination and destination data.
L. Grounding of coaxial cable shall be in accordance with NEC regulations article on “Communications Circuits, Cable, and Protector Grounding.”

3.7 IDENTIFICATION

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows: C A U T I O N This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows: C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

C. Control Equipment and Device labeling:
   1. Labels and tags shall match the unique identifiers shown on the as-built drawings.
   2. All Enclosures shall be labeled to match the as-built drawing by either control panel name or the names of the DDC controllers inside.
   3. All sensors and actuators not in occupied areas shall be tagged.
   4. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.
   5. Duct static pressure taps shall be tagged at the location of the pressure tap.
   6. Each device inside enclosures shall be tagged.
   7. Terminal equipment need only have a tag for the unique terminal number, not for each device. Match the unique number on:
      a. First, the design drawings, or
      b. Second, the control as-builts, or
      c. Third, the DDC addressing scheme
   8. Tags on the terminal units shall be displayed on the Operator Workstation Graphics.

D. Tags shall be mechanically printed on permanent adhesive-backed labeling strips, 12 point height minimum.

E. Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

F. Identification of Wires
1. Tag each wire with a common identifier on each end of the wire, such as in the control panel and at the device termination.
2. Tag each network wire with a common identifier on each end.
3. Tag each 120V power source with the panel and breaker number it is fed by.

G. Identification of Conduits:
   1. Identify the low voltage conduit runs as BAS conduit, power feeds not included.
   2. Identify each electric box, junction box, utility box and wiring tray with a blue paint mark or blue permanent adhesive sticker.
   3. For conduit runs that run more than 8 ft between junction boxes in 1 room, place a blue identifier at least every 8 feet.
   4. Place a blue identifier on each side of where a conduit passed through a wall or other inaccessible path.
   5. Identify all BAS communication conduits the same as above.

3.8 FIELD QUALITY CONTROL

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

   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
   3. Calibration test controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.

   1. Start, test, and adjust control systems.
   2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
   3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

3.9 SYSTEM CHECKOUT AND STARTUP

A. Inspect each termination in the MER control panels and devices to make sure all wires are connected according to the wiring diagrams and all termination are tight.

B. After the controls devices and panels are installed and power is available to the controls, perform a static checkout of all the points, including the following:
1. Inspect the setup and reading on each temperature sensor against a thermometer to verify its accuracy.
2. Inspect the setup and reading on each humidity sensor against a hygrometer to verify its accuracy.
3. Inspect the reading on each CO2 sensor using a calibration kit to verify the sensor range accuracy matches the DDC setup.
4. Inspect the reading of each status switch to verify the DDC reads the open and close correctly.
5. Command each relay to open and close to verify its operation.
6. Command each 2-position damper actuator to open and close to verify operation.
7. Command each 2-position valve to open and close to verify operation.
8. Ramp each modulating actuator to 0%, 25%, 50%, 75% and 100% to verify its operation.
9. Ramp each modulating output signal, such as a VFD speed, to verify its operation.
10. Test each safety device with a real life simulation, for instance check freezestats with ice water, water detectors with water, etc.

C. Document that each point was verified and operating correctly. Correct each failed point before proceeding to the dynamic startup.

D. Verify that each DDC controller communicates on its respective network correctly.

E. After all of the points are verified, and power is available to the mechanical system, coordinate a startup of each system with the mechanical contractor. Include the following tests:

1. Start systems from DDC.
2. Verify that each setpoint can be met by the system.
3. Change setpoints and verify system response.
4. Change sensor readings to verify system response.
5. Test safety shutdowns.
6. Verify time delays.
7. Verify mode changes.
8. Adjust filter switches and current switches for proper reactions.
9. Adjust proportional bands and integration times to stabilize control loops.

F. Perform all program changes and debugging of the system for a fully operational system.

G. Verify that all graphics at the operator workstations correspond to the systems as installed. Verify that the points on the screens appear and react properly. Verify that all adjustable setpoints and manual commands operate from the operator workstations.

H. After the sequence of operation is verified, setup the trends that are listed in the sequence of operations for logging and archiving for the commissioning procedure.

3.10 SYSTEM COMMISSIONING, DEMONSTRATION AND TURNOVER

A. The BAS Contractor shall prepare and submit for approval a complete acceptance test procedure including submittal data relevant to point index, functions, sequence, inter-locks, and associated parameters, and other pertinent information for the operating system. Prior to
acceptance of the BAS by the Owner and Engineer, the BAS contractor shall completely test the BAS using the approved test procedure.

B. After the BAS contractor has completed the tests and certified the BAS is 100% complete, the Engineer shall be requested, in writing, to approve the satisfactory operation of the system, sub-systems and accessories. The BAS contractor shall submit Maintenance and Operating manuals at this time for approval. An acceptance test in the presence of the Engineer and Owner's representative shall be performed. The Owner will then shake down the system for a fixed period of time (30 days).

C. The BAS contractor shall fix punch list items within 30 days of acceptance.

D. When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

3.11 TRAINING

A. During System commissioning and at such time as acceptable performance of the Building Automation System hardware and software has been established, the BAS contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction during normal working hours shall be performed by a competent building automation contractor representative familiar with the Building Automation System's software, hardware and accessories.

B. At a time mutually agreed upon, during System commissioning as stated above, the BAS contractor shall give 40 hours of onsite training on the operation of all BAS equipment. Describe its intended use with respect to the programmed functions specified. Operator orientation of the automation system shall include, but not be limited to:

1. Explanation of drawings and operator’s maintenance manuals.
2. Walk-through of the job to locate all control components.
3. Operator workstation and peripherals.
4. DDC Controller and ASC operation/sequence.
5. Operator control functions including scheduling, alarming, and trending.
6. Explanation of adjustment, calibration and replacement procedures.

C. Additional 8-hours of training shall be given after the 30 day shakedown period.

D. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer’s standard pricing such as transportation, meals, etc.
## Points List

### Exhaust Fans

<table>
<thead>
<tr>
<th>Point Name</th>
<th>Description</th>
<th>Hardware Points</th>
<th>Software Points</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>AV   BV  Integ</td>
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**Points List**

**Exhaust Fans**

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<tr>
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**AHU**

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**Building Automation System**

230900 - 95
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**Boilers**

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## Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
RMF Engineering, Inc.
July 18, 2016

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<td>AV  BV  Integ</td>
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### Chilled Water

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Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
RMF Engineering, Inc.  July 18, 2016

END OF SECTION 230900
SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. Related Sections include the following:

1. Section 230900 "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. VAV: Variable air volume.

1.4 HEATING CONTROL SEQUENCES

A. Heating-Water Supply Temperature Control:

1. Input Device: [Thermostat] [Thermistor temperature sensor] [Resistance temperature sensor].
2. Output Device: Control valve.
3. Action: Modulate control valve to maintain heating-water supply temperature.
4. Display:
   a. Heating-water supply temperature.
   b. Heating-water supply temperature set point.
   c. Control-valve position.

B. Heating-Water Supply Temperature Reset:

1. Input Device: [Electric, outdoor-air-reset controller] [Outdoor-air sensor].
2. Output Device: [Unitary controller] [DDC system software].
3. **Action:** Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

   a. \([195 \text{ deg F}] <\text{Insert highest heating temperature}\) heating water when outdoor-air temperature is \([-30 \text{ deg F}] <\text{Insert lowest outdoor-air temperature}\).
   
   b. \([130 \text{ deg F}] <\text{Insert lowest heating temperature}\) heating water when outdoor-air temperature is 75 deg F.
   
   c. \([150 \text{ deg F}] <\text{Insert temperature}\) minimum, heating-water temperature.

4. **Display:**

   a. Outdoor-air temperature.
   b. Heating-water supply temperature.
   c. Heating-water supply temperature set point.

C. **Control Primary Circulating Pump(s):**

1. **Input Device:** [Thermostat] [DDC system].
2. **Output Device:** [Starter] [DDC system command to starter] relay.
3. **Action:** Energize pump(s) at outdoor-air temperatures below \([65 \text{ deg F}] <\text{Insert temperature}\).
4. **Display:**

   a. Outdoor-air temperature.
   b. Operating status of primary circulating pump(s).

1.5 **CENTRAL REFRIGERATION EQUIPMENT SEQUENCES**

A. **Start and Stop Condenser-Water Pump(s):**

1. **Enable:** Allow pump to start when water is in cooling tower:

   a. **Input Device:** Water pressure transducer.
   b. **Output Device:** Hard wired through motor starter[; DDC system binary output].
   c. **Action:** Confirm water in cooling-tower sump.

2. **Enable:** When outdoor-air temperature conditions are met:

   a. **Input Device:** [Space thermostat] [DDC system outdoor-air temperature].
   b. **Output Device:** Hard wired through motor starter[; DDC system binary output].
   c. **Action:** Confirm outdoor-air temperature is above 50 deg F.

3. **Enable:** When demand conditions are met:

   a. **Input Device:** DDC system software demand.
   b. **Action:** Confirm cooling demand from ventilation system(s).

4. **Initiate:**
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

a. Input Device: [Time clock] [DDC system time schedule].
b. Output Device: [Time clock] [Binary output].
c. Action: Energize pump(s).

5. Display:
   a. Low-level cooling-tower sump alarm.
   b. Outdoor-air temperature.
   c. Cooling (software) demand indication.
   d. Time and time schedule.
   e. Condenser-water pump(s) on-off status.
   f. Condenser-water pump(s) on-off indication.

B. Start and Stop Chilled-Water Pump(s):
   1. Input Device: Flow switch in condenser-water circuit.
   2. Output Device: [Starter] [DDC system command to starter] relay.
   3. Action: Energize pump(s).
   4. Display:
      a. Chilled-water flow indication.
      b. Chilled-water pump(s) on-off status.
      c. Chilled-water pump(s) on-off indication.

C. Start and Stop Cooling-Tower Fans(s):
   1. Input Device: Flow switch in condenser-water circuit.
   2. Output Device: [Starter] [DDC system command to starter] relay.
   3. Action: Energize fan(s).
   4. Display:
      a. Condenser-water flow indication.
      b. Cooling-tower fan(s) on-off indication.

D. Start and Stop Refrigeration Machine(s):
   1. Input Device: Flow switch in condenser-water circuit.[Flow switch in chilled-water circuit.]
   2. Output Device: [Refrigeration] [DDC system command to refrigeration] machine terminal strip.
   3. Action: Energize refrigeration machine(s) internal control circuit.
   4. Display:
      a. Condenser-water flow indication.
      b. Chilled-water flow indication.
      c. Refrigeration machine on-off indication.
      d. Chilled-water supply and return temperature.
      e. Chilled-water temperature control-point adjustment.
E. Start and Stop Chiller(s):
   1. Input Device: Flow switches in condenser-water and chilled-water circuit.
   2. Output Device: [Chiller] [DDC system command to chiller] terminal strip.
   3. Action: Energize chiller internal control circuit.
   4. Display:
      a. Condenser-water flow indication.
      b. Chilled-water flow indication.
      c. Chiller(s) on-off status.
      d. Chiller(s) on-off indication.
      e. Chilled-water supply and return temperature.
      f. Chilled-water temperature control-point adjustment.

F. Alternate Chiller(s):
   1. Input Device: [Electric alternator] [DDC system software].
   2. Output Device: [Chiller] [DDC system command to chiller] terminal strip.
   3. Action: Operate chiller(s) on lead-lag, alternating each startup.
   4. Action: Adding and dropping chiller(s) as follows: <Insert sequence and parameters.>
   5. Display: Chiller(s) on-off indication.

G. Alarm Chiller(s) Start Failure:
   1. Input Device: Chiller [control panel terminal strip contact] [software signal].
   2. Output Device: [Analog control panel] [DDC system alarm].
   3. Action: Signal alarm.

H. Chilled-Water Level:
   1. Input Device: Expansion tank [level switch] [liquid sensor].
   2. Output Device: [Electric relay signal to alarm panel] [DDC system alarm].
   3. Action: Signal alarm.

I. Chilled-Water Supply Temperature:
   1. Input Device: Temperature [sensor] [transmitter] in common chilled-water supply piping.
   2. Output Device: [Integral chiller controls] [DDC system signal to chiller control panel].
   3. Action: Maintain constant leaving chilled-water temperature [reset according to highest cooling demand].
      a. Display: Chilled-water supply temperature.

J. Condenser-Water Temperature:
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

1. Input Device: Temperature [sensor] [transmitter] in cooling-tower sump.
2. Output Device: [Bypass control valve] [Cooling-tower fan starter relay] [DDC system command to cooling-tower fan starter relay].
3. Action: Modulate control valve open to cooling tower and closed to bypass and cycle tower fan(s) [on and off][ and to low speed and then to high speed] to maintain [65 deg F] [70 deg F] sump temperature.[ Close valve when unoccupied.]
4. Display:
   a. Condenser-water sump (return) control-point temperature.
   b. Condenser-water sump (return) temperature.
   c. Control-valve position.
   d. Cooling-tower fan(s) on-off indication.
   e. Condenser-water supply temperature.

K. Cooling-Tower Sump Heater:

1. Input Device: Sump temperature [sensor] [transmitter].
2. Output Device: [Electric relay] [DDC system command to electric relay] [and solenoid valve].
3. Action: Energize sump heater[; drain sump on low temperature].
4. Display:
   a. Cooling-tower sump temperature.
   b. Cooling-tower sump heater on-off indication.
   c. Cooling-tower dump indication.

L. Operator Station Display: Indicate the following on operator workstation display terminal:

1. DDC system graphic.
2. DDC system status, on-off.
3. Low-level cooling-tower sump alarm.
4. Outdoor-air temperature.
5. Cooling (software) demand indication.
6. Time and time schedule.
7. Condenser-water pump(s) on-off status.
8. Condenser-water pump(s) on-off indication.
9. Condenser-water flow indication.
10. Chilled-water pump(s) on-off status.
11. Chilled-water pump(s) on-off indication.
12. Cooling-tower fan(s) on-off indication.
13. Chilled-water flow indication.
15. Chilled-water supply temperature.
17. Chilled-water temperature control-point adjustment.
18. Chiller(s) on-off status.
19. Chiller(s) on-off indication.
22. Condenser-water sump (return) control-point temperature.
23. Condenser-water sump (return) temperature.
24. Condenser-water control-valve position.
25. Cooling-tower fan(s) on-off indication.
26. Condenser-water supply temperature.
27. Cooling-tower sump temperature.
29. Cooling-tower dump indication.
30. Chilled-water pressure drop through chiller.
31. Entering condenser-water temperature.
32. Leaving condenser-water temperature.
33. Condenser-water pressure drop through chiller.
34. Chiller condenser-water supply and return temperature.
35. Chiller chilled-water supply and return temperature.
36. System capacity in tons.

1.6 AIR-HANDLING-UNIT CONTROL SEQUENCES

A. Start and Stop Supply Fan(s):
   1. Enable: Freeze Protection:
      a. Input Device: Duct-mounted averaging element thermostat, located before supply fan.
      b. Output Device: Hard wired through motor starter; [analog alarm panel] [DDC system alarm].
      c. Action: Allow start if duct temperature is above 37 deg F; signal alarm if fan fails to start as commanded.
   2. Enable: High-Temperature Protection:
      a. Input Device: Duct-mounted thermostat, located in return air.
      b. Output Device: Hard wired through motor starter; [analog alarm panel] [DDC system alarm].
      c. Action: Allow start if duct temperature is below 300 deg F.
   3. Enable: Smoke Control:
      a. Input Device: Duct-mounted smoke detector, located in [return] [supply] air.
      b. Output Device: Hard wired through motor starter; [analog alarm panel] [DDC system alarm].
      c. Action: Allow start if duct is free of products of combustion.
   4. Initiate: Occupied Time Schedule:
      a. Input Device: [Time clock] [DDC system time schedule].
      b. Output Device: [Time clock] [Binary output] to motor starter.
      c. Action: Energize fan(s).
5. Initiate: Unoccupied Time Schedule:
   a. Input Device: [Room thermostat] [DDC system demand].
   b. Output Device: [Room thermostat] [Binary output] to motor starter.
   c. Action: Energize fan(s).

6. Unoccupied Ventilation:
   a. Input Device: [Time clock and room thermostat] [DDC system time schedule and output].
   b. Output Device: [Room thermostat] [DDC system binary output] to motor starter.
   c. Action: Cycle fan(s) during unoccupied periods.


B. Supply Fan(s) Variable-Volume Control:

1. Occupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Time clock] [Binary output].
   c. Action: Enable control.

2. Volume Control:
   a. Input Device: [Static-pressure transmitter] [Differential-pressure switch] sensing supply-duct static pressure referenced to conditioned-space static pressure.
   b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] to modulating damper actuator. Set inlet guide vanes to [minimum] [closed] position when fan is stopped.
   c. Action: Maintain constant supply-duct static pressure.

3. Volume Control:
   a. Input Device: [Static-pressure transmitter] [Differential-pressure switch] sensing supply-duct static pressure referenced to conditioned-space static pressure.
   b. Output Device: [Receiver controller] [DDC system analog output] to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
   c. Action: Maintain constant supply-duct static pressure.

4. High Pressure:
   a. Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
   b. Output Device: [Receiver controller] [DDC system binary output] to [alarm panel] [motor starter].
SEQ 1: Action: Stop fan and signal alarm when static pressure rises above excessive-static-pressure set point.

5. Display:
   a. Supply-fan-discharge static-pressure indication.
   b. Supply-fan-discharge static-pressure set point.
   c. Supply-fan airflow rate.
   d. Supply-fan [inlet vane position] [speed].

C. Start and Stop Return Fan(s):
   1. Initiate: Occupied Time Schedule:
      a. Input Device: [Time clock] [DDC system time schedule].
      b. Output Device: [Time clock] [Binary output] to motor starter.
      c. Action: Energize fans when supply fans are energized.
   2. Initiate: Unoccupied Time Schedule:
      a. Input Device: [Room thermostat] [DDC system demand].
      b. Output Device: [Room thermostat] [Binary output] to motor starter.
      c. Action: Energize fans when supply fans are energized.
   3. Unoccupied Ventilation:
      a. Input Device: [Time clock and room thermostat] [DDC system time schedule and output].
      b. Output Device: [Room thermostat] [DDC system binary output] to motor starter.
      c. Action: Cycle fan(s) during unoccupied periods.

D. Return Fan(s) Variable-Volume Control:
   1. Occupied Time Schedule:
      a. Input Device: [Time clock] [DDC system time schedule].
      b. Output Device: [Time clock] [Binary output].
      c. Action: Enable control.
   2. Volume Control:
      a. Input Device: [Static-pressure transmitter] [Differential-pressure switch] sensing building static pressure referenced to outdoor static pressure.
      b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] to modulating
damper actuator. Set inlet guide vanes to [minimum] [closed] position when fan is stopped.

c. Action: Maintain constant building static pressure.

3. Volume Control:
   a. Input Device: [Static-pressure transmitter] [Differential-pressure switch] sensing building static pressure referenced to outdoor static pressure.
   b. Output Device: [Receiver controller] [DDC system analog output] to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
   c. Action: Maintain constant building static pressure.

4. Display:
   a. Return-air static-pressure indication.
   b. Return-air static-pressure set point.
   c. Return-fan airflow rate.
   d. Return-fan [inlet vane position] [speed].
   e. Building static-pressure indication.
   f. Building static-pressure set point.

E. Return Fan(s) Variable-Volume Control:

1. Occupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Time clock] [Binary output].
   c. Action: Enable control.

2. Volume Control:
   a. Input Device: [Static-pressure transmitter] [Differential-pressure switch] sensing building static pressure referenced to outdoor static pressure.
   b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] to modulating damper actuator. Set inlet guide vanes to [minimum] [closed] position when fan is stopped.
   c. Action: Maintain constant building static pressure.

3. Volume Control:
   a. Input Device: [Static-pressure transmitter] [Differential-pressure switch] sensing building static pressure referenced to outdoor static pressure.
   b. Output Device: [Receiver controller] [DDC system analog output] to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
   c. Action: Maintain constant building static pressure.

4. Display:
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Owner: City of Fayetteville
Fayetteville, North Carolina

AP#1515
RMF Engineering, Inc. July 18, 2016

F. Preheat Coil:

1. Freeze Protection:
   a. Input Device: Duct-mounted averaging element thermostat, located after preheat coil.
   b. Output Device: Hard wired through motor starter; [analog alarm panel] [DDC system alarm].
   c. Action: Allow start if duct temperature is above 33 deg F.

2. Occupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Time clock] [Binary output] to motor starter.
   c. Action: Energize coil circulating pump(s).

3. [Supply] [Discharge]-Air Temperature:
   a. Input Device: [Time clock and duct-mounted thermostat] [DDC system time schedule and electronic temperature sensor].
   b. Output Device: Modulating control valve.
   c. Action: Maintain air temperature set point of 55 deg F.

4. Unoccupied Time Schedule:
   a. Input Device: [Time clock and duct-mounted thermostat mounted in outdoor air] [DDC system time schedule and outdoor-air temperature].
   b. Output Device: [Time clock] [Binary output] to motor starter.
   c. Action: Energize coil circulating pump(s) when outdoor-air temperature falls below 35 deg F.

5. Display:
   a. Preheat-coil air-temperature indication.
   b. Preheat-coil air-temperature set point.
   c. Preheat-coil pump operation indication.
   d. Preheat-coil control-valve position.

G. Mixed-Air Control:

1. Occupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Pneumatic relay] [DDC system output].
c. Action: Enable control.

2. Minimum Position:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] to modulating damper actuator(s).
   c. Action: Open [minimum outdoor-air dampers] [outdoor-air dampers to minimum position].

3. Heating Reset:
   a. Input Device: [Room thermostat] [DDC system software].
   b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] to modulating damper actuator(s).
   c. Action: [Close minimum outdoor-air dampers] [Set outdoor-air dampers to minimum position].

4. [Supply] [Mixed]-Air Temperature:
   a. Input Device: [Duct-mounted thermostat] [Electronic temperature sensor].
   b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] to modulating damper actuator(s).
   c. Action: Modulate outdoor-, return-, and relief-air dampers to maintain air temperature set point of 55 deg F.

5. Cooling Reset:
   a. Input Device: Outdoor- and return-air, duct-mounted [thermostats] [electronic temperature sensors].
   b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] to damper actuator(s).
   c. Action: Set outdoor-air dampers to minimum position when outdoor-air [temperature exceeds return-air temperature] [enthalpy exceeds return-air enthalpy].

6. Unoccupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] to modulating damper actuator(s).
   c. Action: Position outdoor- and relief-air dampers closed and return-air dampers open.
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Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.
July 18, 2016

7. Display:
   b. Mixed-air-temperature set point.
   c. Mixed-air damper position.

H. Humidifier:
   1. Occupied Time Schedule:
      a. Input Device: [Time clock] [DDC system time schedule] and airflow switch
      b. Output Device: [Pneumatic relay] [DDC system output].
      c. Action: Enable control.
   2. Humidity:
      a. Input Device: [Room humidistat] [Return-air, duct-mounted humidistat] [DDC system].
      b. Output Device: [Receiver controller] [DDC system analog output] [DDC system analog output to digital-to-pneumatic transducer] [enables humidifier] [modulates control valve to maintain humidity] [cycles pump to maintain humidity] [cycles pump and modulates control valve to maintain humidity] in straight-line relationship for the following conditions:
         1) 20 percent when outdoor-air temperature is [minus 30 deg F] <Insert temperature>.
         2) 40 percent when outdoor-air temperature is [75 deg F] <Insert temperature>.
      c. Action: Modulate outdoor-, return-, and relief-air dampers to maintain air temperature set point of [55 deg F] <Insert temperature>.
   3. Display:
      a. Relative humidity indication.
      b. Relative humidity set point.
      c. Relative humidity control-valve position.

I. Filters: During occupied periods, when fan is running, differential air-pressure transmitters exist.
   1. Occupied Time Schedule:
      a. Input Device: [Time clock] [DDC system time schedule].
      b. Output Device: [Electric relay] [DDC system output].
      c. Action: Enable control.
   2. Differential Pressure:
a. Input Device: [Differential-pressure switches] [Pressure transmitter].
b. Output Device: [Analog alarm panel] [DDC system alarm].
c. Action: Signal alarm on low- and high-pressure conditions.

3. Display:
   a. Filter air-pressure-drop indication.
   b. Filter low-air-pressure set point.
   c. Filter high-air-pressure set point.

J. [Hydronic] [Steam] Heating Coil:

1. Occupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Time clock] [Binary output].
   c. Action: Enable control.

2. [Supply] [Discharge]-Air Temperature:
   a. Input Device: [Duct-mounted thermostat] [Electronic temperature sensor].
   c. Action: Maintain supply-air temperature set point of 55 deg F.

3. Temperature Reset:
   a. Input Device: [Duct-mounted thermostat] [Electronic temperature sensor] in return air.
   b. Output Device: [Direct to receiver controller] [DDC system] in straight-line relationship for the following conditions:
      1) [65 deg F] <Insert temperature> when return-air temperature is [70 deg F] <Insert temperature>.
      2) [55 deg F] <Insert temperature> when return-air temperature is [75 deg F] <Insert temperature>.
   c. Action: Reset supply-air temperature set point of 55 deg F.

4. Temperature Reset:
   a. Input Device: [Load analyzer] [DDC system] with input from room [thermostats] [temperature sensors].
   b. Output Device: [Direct to receiver controller] [DDC system].
   c. Action: Reset supply-air temperature in response to greatest heating demand.

5. Unoccupied Time Schedule:
   a. Input Device: [Time clock and room thermostat] [DDC system time schedule and output].
b. Output Device: [Room thermostat (cycling fan)] [DDC system binary output].
c. Action: [Enable normal control] [Return valve to normal position] when fan is cycled on.

6. Display:
   a. Fan-discharge air-temperature indication.
   b. Fan-discharge air-temperature set point.
   c. Heating-coil air-temperature indication.
   d. Heating-coil air-temperature set point.
   e. Heating-coil pump operation indication.
   f. Heating-coil control-valve position.
   g. Hot-deck air-temperature indication.
   h. Hot-deck air-temperature set point.

K. Hydronic Cooling Coil:

1. Occupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Time clock] [Binary output].
   c. Action: Enable control.

2. [Supply] [Discharge]-Air Temperature:
   a. Input Device: [Duct-mounted thermostat] [Electronic temperature sensor].
   c. Action: Maintain supply-air temperature set point of 55 deg F.

3. Temperature Reset:
   a. Input Device: [Duct-mounted thermostat] [Electronic temperature sensor] in return air.
   b. Output Device: [Direct to receiver controller] [DDC system] in straight-line relationship for the following conditions:
      1) [65 deg F] <Insert temperature> when return-air temperature is [70 deg F] <Insert temperature>.
      2) [55 deg F] <Insert temperature> when return-air temperature is [75 deg F] <Insert temperature>.
   c. Action: Reset supply-air temperature set point of 55 deg F.

4. Temperature Reset:
   a. Input Device: [Load analyzer] [DDC system] with input from room [thermostats] [temperature sensors].
   b. Output Device: [Direct to receiver controller] [DDC system].
   c. Action: Reset supply-air temperature in response to greatest heating demand.
5. Unoccupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Time clock] [Binary output].
   c. Action: Disable control.

6. Display:
   a. Fan-discharge air-temperature indication.
   b. Fan-discharge air-temperature set point.
   c. Cooling-coil air-temperature indication.
   d. Cooling-coil air-temperature set point.
   e. Cooling-coil control-valve position.
   f. Cold-deck air-temperature indication.
   g. Cold-deck air-temperature set point.

L. Multizone Damper Control:

1. Occupied Time Schedule:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Time clock] [Binary output].
   c. Action: Enable control.

2. Room Temperature:
   a. Input Device: [Room thermostat] [Electronic temperature sensor].
   b. Output Device: Damper actuator.
   c. Action: Maintain room temperature.

3. Display:
   a. Room temperature indication.
   b. Room temperature set point.
   c. Multizone damper position.

M. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.

N. Operator Station Display: Indicate the following on operator workstation display terminal:

1. DDC system graphic.
2. DDC system on-off indication.
3. DDC system occupied/unoccupied mode.
5. Supply-fan on-off indication.
7. Supply-fan-discharge static-pressure set point.
9. Supply-fan [inlet vane position] [speed].
11. Return-air static-pressure indication.
12. Return-air static-pressure set point.
14. Return-fan [inlet vane position] [speed].
15. Building static-pressure indication.
16. Building static-pressure set point.
17. Preheat-coil air-temperature indication.
18. Preheat-coil air-temperature set point.
19. Preheat-coil pump operation indication.
20. Preheat-coil control-valve position.
23. Mixed-air damper position.
25. Relative humidity set point.
27. Filter air-pressure-drop indication.
28. Filter low-air-pressure set point.
29. Filter high-air-pressure set point.
30. Fan-discharge air-temperature indication.
31. Fan-discharge air-temperature set point.
32. Heating-coil air-temperature indication.
33. Heating-coil air-temperature set point.
34. Heating-coil pump operation indication.
35. Heating-coil control-valve position.
37. Hot-deck air-temperature set point.
38. Cooling-coil air-temperature indication.
40. Cooling-coil control-valve position.
41. Cold-deck air-temperature indication.
42. Cold-deck air-temperature set point.
43. Room temperature indication.
44. Room temperature set point.
45. Multizone damper position.

1.7 TERMINAL UNIT OPERATING SEQUENCE

A. Cabinet Unit Heater, [Hydronic] [Steam]:

1. Room Temperature:
   a. Input Device: [Room thermostat] [Electronic temperature sensor].
   b. Output Device: [Room thermostat] [DDC system binary output].
   c. Action: Cycle fan to maintain temperature.
2. Low-Temperature Safety:
   c. Action: Stop fan when [return heating-water] [condensate] temperature falls below 35 deg F.

3. Display:
   a. Room temperature indication.
   b. Room temperature set point.

B. Cabinet Unit Heater, Electric: Room thermostat cycles fan and sequences stages of heating.

C. Unit Heater, [Hydronic] [Steam]:
   1. Room Temperature:
      a. Input Device: [Room thermostat] [Electronic temperature sensor].
      b. Output Device: [Room thermostat] [DDC system binary output].
      c. Action: Cycle fan to maintain temperature.
   2. Low-Temperature Safety:
      c. Action: Stop fan when [return heating-water] [condensate] temperature falls below 35 deg F.
   3. Display:
      a. Room temperature indication.
      b. Room temperature set point.

D. Unit Heater, Electric: Room thermostat cycles fan and sequences stages of heating.

E. Combustion-Air Unit Heaters:
   1. Room Temperature:
      a. Input Device: [Room thermostat] [Electronic temperature sensor].
      c. Action: Modulate valve to maintain temperature.
   2. Display:
      a. Room temperature indication.
      b. Room temperature set point.
      c. Control-valve position.
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F. Radiant Heating Cable, Electric: Room thermostat cycles power.

G. Radiant Heating Panel, Electric: Room thermostat cycles power.

H. Radiant Heating Panel, Hydronic:
   1. Room Temperature:
      a. Input Device: [Room thermostat] [Electronic temperature sensor].
      c. Action: Modulate valve to maintain temperature.

   2. Display:
      a. Room temperature indication.
      b. Room temperature set point.
      c. Control-valve position.

I. Two-Pipe, Single-Coil, Fan-Coil Unit:
   1. Occupied Time Schedule:
      a. Input Device: [Fan switch] [Time clock] [DDC system time schedule].
      b. Output Device: [Time clock] [Binary output].
      c. Action: Start and stop fan and enable control.

   2. Room Temperature:
      a. Input Device: [Room thermostat] [Electronic temperature sensor] in [room]
         [return air].
      c. Action: Modulate valve to maintain temperature.

   3. DDC System Changeover:
      a. Input Device: [Thermostat] [Electronic temperature sensor] [in supply-water]
         [on supply-water piping] [DDC system].
      b. Output Device: [Hard-wired relay] [DDC system software].
      c. Action: Reverse control-valve action to switch from heating to cooling.

   4. Display:
      a. DDC system graphic.
      b. DDC system on-off indication.
      c. DDC system occupied/unoccupied mode.
      d. Room temperature indication.
      e. Room temperature set point.
      f. Control-valve position.
      g. Supply-water temperature indication.
J. Four-Pipe, Hydronic Fan-Coil Unit:
   1. Occupied Time Schedule:
      a. Input Device: [Fan switch] [Time clock] [DDC system time schedule].
      b. Output Device: [Time clock] [Binary output].
      c. Action: Start and stop fan, and enable control.
   2. Room Temperature:
      a. Input Device: [Room thermostat] [Electronic temperature sensor].
      c. Action: Modulate multiport control valves to maintain temperature.
   3. Display:
      a. DDC system graphic.
      b. DDC system on-off indication.
      c. DDC system occupied/unoccupied mode.
      d. Room temperature indication.
      e. Room temperature set point.
      f. Control-valve position.

K. Unit Ventilator: Room thermostat modulates heating-and-cooling control valves; airstream thermostats modulate outdoor- and return-air dampers as follows:
   1. Occupied Time Schedule:
      a. Input Device: [Fan switch] [Time clock] [DDC system time schedule].
      b. Output Device: [Time clock] [Binary output].
      c. Action: Start and stop fan, move outdoor- and return-air dampers to [minimum]
         [maximum] outdoor-air position, and enable control.
   2. Room Temperature - Valves:
      a. Input Device: [Room thermostat] [Electronic temperature sensor].
      c. Action: Modulate heating-water supply control valve and chilled-water supply
         control valve in sequence to maintain temperature.
   3. Room Temperature - Dampers:
      a. Input Device: [Thermostat] [Electronic temperature sensor] in mixed air.
      c. Action: Modulate outdoor- and return-air dampers to maintain temperature.
   4. Supply-Air Temperature Limit:
      a. Input Device: [Thermostat] [Electronic temperature sensor] in discharge air.
b. Output Device: [Pneumatic] [Electronic] control-valve operators and control damper actuators.
c. Action: Override room thermostat to control valves and dampers to prevent discharge air from dropping below a minimum set point.

5. Warm-up Cycle:
   a. Input Device: [Time clock] [DDC system time schedule].
   b. Output Device: [Hard-wired relay] [DDC system binary output].
   c. Action: Open heating-water supply control valve, close outdoor-air damper, and open return-air damper.

6. Display:
   a. DDC system graphic.
   b. DDC system on-off indication.
   c. DDC system occupied/unoccupied mode.
   d. Room temperature indication.
   e. Room temperature set point.
   f. Control-valve position.
   g. Damper position.

L. Heating Coils, [Hydronic] [Steam]:

1. Room Temperature:
   a. Input Device: [Room thermostat] [Electronic temperature sensor].
   b. Output Device: [Pneumatic] [Electronic] [Electric] control-valve operators.
   c. Action: [Modulate] [Cycle] valve to maintain temperature.

2. Display:
   a. Room temperature indication.
   b. Room temperature set point.
   c. Control-valve position.

M. Heating Coils, Electric: Room thermostat [cycles coils] [sequences stages of heating].

N. Radiators and Convectors, [Hydronic] [Steam]:

1. Occupancy:
   a. Input Device: Occupancy sensor.
   b. Output Device: DDC system binary output.
   c. Action: Report occupancy and enable occupied temperature set point.

2. Room Temperature:
   a. Input Device: [Room thermostat] [Electronic temperature sensor].
b. Output Device: [Pneumatic] [Electronic] [Electric] control-valve operators.

c. Action: [Modulate] [Cycle] valve to maintain temperature.

1) Occupied Temperature: 75 deg F.
2) Unoccupied Temperature: 65 deg F.

3. Display:

a. Room/area served.
b. Room temperature indication.
c. Room temperature set point.
d. Room temperature set point, occupied.
e. Room temperature set point, occupied standby.
f. Room temperature set point, unoccupied.
g. Control-valve position as percent open.

O. Radiators and Convectors, Electric: Room thermostat [cycles coils] [sequences stages of heating].

P. Constant-Volume, Terminal Air Units, [Hydronic] [Steam]:

1. Occupancy:

a. Input Device: Occupancy sensor.
b. Output Device: DDC system binary output.
c. Action: Report occupancy and enable occupied temperature set point.

1) Occupied Temperature: 75 deg F.
2) Unoccupied Temperature: 65 deg F.

2. Room Temperature:

a. Input Device: [Room thermostat] [Electronic temperature sensor].
b. Output Device: [Pneumatic] [Electronic] [Electric] control-valve operators.
c. Action: [Modulate] [Cycle] valve to maintain temperature.

3. Display:

a. Room/area served.
b. Room occupied/unoccupied.
c. Room temperature indication.
d. Room temperature set point.
e. Room temperature set point, occupied.
f. Room temperature set point, unoccupied.
g. Control-valve position as percent open.

Q. VAV, Terminal Air Units with [Hydronic] [Steam] Coils:

1. Occupancy:
**SEQUENCE OF OPERATIONS FOR HVAC CONTROLS**

1. Input Device: Occupancy sensor.
   - Output Device: DDC system binary output.
   - Action: Report occupancy and enable occupied temperature set point.
     1) Occupied Temperature: 75 deg F.
     2) Unoccupied Temperature: 65 deg F.

2. Room Temperature:
   a. Input Device: [Room thermostat] [Electronic temperature sensor].
   b. Output Device: [Pneumatic] [Electronic] damper actuators and control-valve operators.
   c. Action: Modulate damper and valve to maintain temperature.
     1) Sequence damper from full open to minimum position, then valve from closed to fully open.

3. Display:
   a. Room/area served.
   b. Room occupied/unoccupied.
   c. Room temperature indication.
   d. Room temperature set point.
   e. Room temperature set point, occupied.
   f. Room temperature set point, unoccupied.
   g. Air-damper position as percent open.
   h. Control-valve position as percent open.

R. Dual-Duct, VAV, Terminal Air Units:

1. Occupancy:
   a. Input Device: Occupancy sensor.
   b. Output Device: DDC system binary output.
   c. Action: Report occupancy and enable occupied temperature set point.
     1) Occupied Temperature: 75 deg F.
     2) Unoccupied Temperature: 65 deg F.

2. Room Temperature:
   a. Input Device: [Room thermostat] [Electronic temperature sensor].
   b. Output Device: [Pneumatic] [Electronic] damper actuators.
   c. Action: Modulate dampers to maintain temperature.
     1) Sequence when space temperature is below set point: Close VAV damper to minimum position, open hot-deck dampers and close cold-deck dampers, then open VAV damper.
2) Sequence when space temperature is above set point: Close VAV damper to minimum position, close hot-deck dampers and open cold-deck dampers, then open VAV damper.

3. Display:
   a. Room/area served.
   b. Room occupied/unoccupied.
   c. Room temperature indication.
   d. Room temperature set point.
   e. Room temperature set point, occupied.
   f. Room temperature set point, unoccupied.
   g. VAV damper position as percent open.
   h. Hot-deck damper position as percent open.
   i. Cold-deck damper position as percent open.

1.8 VENTILATION SEQUENCES

A. Combustion-Air, Makeup Unit Control, Electric: Start fan when served appliance burner starts; room thermostat sequences stages of heating.

B. Combustion-Air, Makeup Unit Control, [Hydronic] [Steam]: Start fan when served appliance burner starts; room thermostat [cycles] [modulates] control valve.

C. Gravity Roof Ventilator: [Occupancy sensor] [Room thermostat] opens dampers.

D. Exhaust Fan: [Occupancy sensor] [Interlock with light switch] [Room thermostat] cycles fan.

E. Kitchen Exhaust Fan: Occupancy sensor starts fan and energizes makeup air unit.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230993
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SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
7. Concrete bases.

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, crawlspace, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 100 psig minimum unless otherwise indicated.
3. Minimum Operating Pressure of Service Meter: 2 psig.

B. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 2 psig.

C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: 1/4 inch per foot.
2. Detail mounting, supports, and valve arrangements for service meter assembly and pressure regulator assembly.

C. Delegated-Design Submittal: For natural-gas piping and equipment 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 seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Welding certificates.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators and meters to include in emergency, operation, and maintenance manuals.
1.8 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

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

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.10 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

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

1.11 COORDINATION

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

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."
PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Dresser Piping Specialties; Division of Dresser, Inc.
      2) Smith-Blair, Inc.
   b. Buna-nitrile seals.
   c. Stainless-Steel bolts, washers, and nuts.
   d. Coupling shall be capable of joining steel pipe to steel pipe.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
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8. Maximum Length: 36 inches

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. 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 and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.


2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125 psig.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flowserve.
   b. Homestead Valve; a division of Olson Technologies, Inc.
   d. Milliken Valve Company.
   e. Mueller Co.; Gas Products Div.

2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.5 MOTORIZED GAS VALVES


1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
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a. ASCO Power Technologies, LP; Division of Emerson.
b. Eaton Corporation; Controls Div.
c. Eclipse Combustion, Inc.
d. Honeywell International Inc.
e. Johnson Controls.

2. Body: Brass or aluminum.
5. Normally closed.
7. Electrical operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ASCO Power Technologies, LP; Division of Emerson.
   b. Goyen Valve Corp.; Tyco Environmental Systems.
   c. Magnatrol Valve Corporation.
   d. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.
   e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.

2. Pilot operated.
3. Body: Brass or aluminum.
5. Springs and Valve Trim: Stainless steel.
6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
7. NEMA ICS 6, Type 4, coil enclosure.

2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
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2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 100 psig.


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

   a. Actaris.
   b. American Meter Company.
   c. Eclipse Combustion, Inc.
   d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
   e. Invensys.
   f. Maxitrol Company.
   g. Richards Industries; Jordan Valve Div.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.


1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Canadian Meter Company Inc.
   b. Eaton Corporation; Controls Div.
   c. Harper Wyman Co.
   d. Maxitrol Company.
   e. SCP, Inc.

5. Seat Disc: Nitrile rubber.
8. Provide vent connection and vent to the exterior of the building.

2.7 DIELECTRIC FITTINGS

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

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Central Plastics Company.
   d.jomar International Ltd.
   e. Matco-Norca, Inc.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   h. Wilkins; a Zurn company.

2. Description:
   b. Pressure Rating: 150 psig minimum at 180 deg.
   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:
   b. Central Plastics Company.
   c. Matco-Norca, Inc.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. Wilkins; a Zurn company.

2. **Description:**
   b. Factory-fabricated, bolted, companion-flange assembly.
   c. Pressure Rating: 150 psig minimum at 180 deg.
   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. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. **Description:**
   a. Nonconducting materials for field assembly of companion flanges.
   b. Pressure Rating: 150 psig.
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

2.8 **LABELING AND IDENTIFYING**

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the 2012 North Carolina State Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.


3.3 OUTDOOR PIPING INSTALLATION


B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

   1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Steel Piping with Protective Coating:

   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
   3. Replace pipe having damaged PE coating with new pipe.

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

E. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION


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

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

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

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

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

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

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.

2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.

3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.

4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
   a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:
   a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
   b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."
3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAEJ513. Tighten finger tight, then use wrench. Do not overtighten.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 PAINTING

A. Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.
C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
   c. Topcoat: Interior latex flat.
   d. Color: By Architect.

2. Alkyd System: MPI INT 5.1E.
   c. Topcoat: Interior alkyd flat.
   d. Color: By Architect.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base 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. Use 3000-psig, 28-day, compressive-strength concrete and reinforcement as specified in Section 033053 "Miscellaneous Cast-in-Place Concrete."

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

2. Duke Engineering and Operations Representative shall witness all chemical flushing and hydronic pressurization tests.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.13 DEMONSTRATION

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

3.14 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be the following:
   1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas piping shall be the following:
   1. Steel pipe with wrought-steel fittings and welded joints.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 5 PSIG

A. Aboveground, branch piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be the following:
   1. Steel pipe with steel welding fittings and welded joints.

C. Underground, below building, piping shall be the following:
   1. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be the following:
   1. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be the following:
   1. Cast-iron, lubricated plug valve.

E. Valves in branch piping for single appliance shall be the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION 231123
SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Makeup-water piping.
4. Condensate-drain piping.
5. Air-vent piping.

B. Related Sections include the following:

1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.3 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

B. RTRF: Reinforced thermosetting resin (fiberglass) fittings.

C. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.4 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Chilled-Water Piping: 150 psig at 200 deg F.
3. Makeup-Water Piping: 80 psig at 150 deg F.
4. Condensate-Drain Piping: 150 deg F.
5. Blowdown-Drain Piping: 200 deg F.
6. Air-Vent Piping: 200 deg F.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.
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Fayetteville, North Carolina
RMF Engineering, Inc.
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1.5 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. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   5. Air control devices.

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding certificates.

D. Qualification Data: For Installer.

E. Field quality-control test reports.

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

G. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
   2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

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

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

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. 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 01.

1.7 EXTRA MATERIALS

A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

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

PART 2 - - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "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 Part 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings;
2. End Connections: Butt welding.
3. Facings: Raised face.

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

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

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:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Central Plastics Company.
      d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.
2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

   b. Central Plastics Company.
   c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

3. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:

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

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. 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.

3. 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:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Calpico, Inc.
   b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

G. Dielectric Nipples:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the
following:

a. Perfection Corporation; a subsidiary of American Meter Company.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Company, Inc.
d. Victaulic Company of America.

2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.5 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Building Automation System."

C. Bronze, Calibrated-Orifice, Balancing Valves:

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

   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Flow Design Inc.
   d. Gerand Engineering Co.
   e. Griswold Controls.
   f. Taco.

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.
8. Handle Style: Lever, with memory stop to retain set position.
10. Maximum Operating Temperature: 250 deg F.

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

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

   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Flow Design Inc.
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**Owner:** City of Fayetteville  
Fayetteville, North Carolina  
RMF Engineering, Inc.

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d. Gerand Engineering Co.  
e. Griswold Controls.  
f. Taco.  
g. Tour & Andersson; available through Victaulic Company of America.

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.  
11. **Maximum Operating Temperature:** 250 deg F.

**E. Diaphragm-Operated, Pressure-Reducing Valves:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:  
   a. Amtrol, Inc.  
   b. Armstrong Pumps, Inc.  
   c. Bell & Gossett Domestic Pump; a division of ITT Industries.  
   d. Conbraco Industries, Inc.  
   e. Spence Engineering Company, Inc.  
   f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. **Body:** Bronze or brass.  
3. **Disc:** Glass and carbon-filled PTFE.  
4. **Seat:** Brass.  
5. **Stem Seals:** EPDM O-rings.  
6. **Diaphragm:** EPT.  
7. **Low inlet-pressure check valve.**  
8. **Inlet Strainer:** stainless steel, removable without system shutdown.  
9. **Valve Seat and Stem:** Noncorrosive.  
10. **Valve Size, Capacity, and Operating Pressure:** Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

**F. Diaphragm-Operated Safety Valves:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:  
   a. Amtrol, Inc.  
   b. Armstrong Pumps, Inc.  
   c. Bell & Gossett Domestic Pump; a division of ITT Industries.  
   d. Conbraco Industries, Inc.
e. Spence Engineering Company, Inc.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
8. Inlet Strainer: stainless steel, removable without system shutdown.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Flow Design Inc.
   b. Griswold Controls.
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.
9. Maximum Operating Temperature: 250 deg F.

2.6 AIR CONTROL DEVICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
4. Inlet Connection: NPS 1/2.
7. Maximum Operating Temperature: 240 deg F.

D. Bladder-Type Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.

E. Tangential-Type Air Separators:
1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
5. Size: Match system flow capacity.

F. In-Line Air Separators:
1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Operating Temperature: Up to 300 deg F.

2.7 CHEMICAL TREATMENT

A. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
1. **Chemicals:** Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

B. **Ethylene and Propylene Glycol:** Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions.

### 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 and smaller; flanged ends for NPS 2-1/2 and larger.
3. **Strainer Screen:** 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. **CWP Rating:** 125 psig.

#### B. 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 misalignment.
4. **CWP Rating:** 150 psig.
5. **Maximum Operating Temperature:** 250 deg F.

#### C. 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.
5. **Maximum Operating Temperature:** 250 deg F.

### PART 3 - - EXECUTION

#### 3.1 PIPING APPLICATIONS

**A.** Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

**B.** Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and
C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

E. Makeup-water piping installed aboveground shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

F. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

G. Air-Vent Piping:
   1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
   2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

H. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.2 CHILLED WATER PIPING BELOW GRADE

A. Piping shall be factory fabricated and insulated by Rovanco, Perma-pipe or Thermacor.

B. Carrier Pipe: Carrier Pipe will be black carbon steel pipe conforming to ASTM A-53 Grade B schedule 40. Pipe will be joined by welding to ANSI B.31.1 Code for Pressure Piping.

C. All pipe and fittings will be insulated with polyurethane foam.

D. All fittings will be factory prefabricated and insulated at pre-insulators plant.

E. Jacketing Material shall be extruded black high density polyethylene (HDPE). The jacket throughout the entire system shall incorporate electric fusion, butt fusion or extrusion welding at all fittings, joint closures or other points of connection prohibiting the ingress of water.

F. Moisture Barrier End Seals shall be factory applied, sealed to the jacket and carrier pipe. End seals shall be certified as having passed a 20 foot head pressure test. End seals shall be high temperature mastic completely sealing the exposed end of the insulation. Field applied ends seals
shall be installed at any field cut to the piping before continuing with the installation.

G. All underground piping shall have a separate copper tracer wire and non-metallic warning tape installed above the pipe.

H. The tracer wire shall be traced for continuity prior to backfill, immediately upon completion of backfill and compaction and once again during final utility location/as-built at the end of the project.

I. Identification Tape: The 1st stage of identification shall be a buried warning tape. This tape shall provide an early warning at shallow depth excavation. The tape shall be 6” wide, and buried approximately 18” to 30” above the service pipe, but a minimum of 10” below finished grade. It shall consist of multiple layers of polyethylene with an overall thickness of 3 to 5 mils. It shall be installed continuous from valve box to valve box or manhole to manhole, and shall terminate just outside of valve box or manhole wall. The black colored lettering on the warning tape shall be abrasion resistant and be imprinted on a color-coded background that conforms to APWA color code standards. The lettering on the tape should name the utility it is protecting. (i.e. Caution Buried Chilled Water Line Below).

J. TRACER WIRE: The 2nd stage of identification shall be a buried tracer wire. This tracer wire shall provide pipeline identification, be fully detectable from above grade utility locators, and be able to provide a depth reference point to top of pipe.

K. All pipe, including lawn irrigation lines, and metallic pipe with compression gasket fittings installed underground shall have a tracer wire installed along the length of the pipe. The wire shall be taped to the bottom of the pipe at a maximum of 10’ intervals and not allowed to "float freely" within the backfill.

L. Tracer wire shall be single-conductor, 12 gauge minimum, copper single-conductor wire with type "UF" (Underground Feeder) insulation, and shall be continuous along the pipeline passing through the inside of each valve box. A #12 AWG or heavier (smaller AWG number), solid, insulated (RHW, THW, or polyethylene insulation is recommended), copper wire shall be taped to pipe at 10 foot intervals. Do not wrap wire around pipe. The wire must be one continuous, unbroken length.

M. Piping shall meet H-20 Highway loading with 24” of backfill is provided on top of pipe.

3.3 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 balancing valves at each branch connection to return main.

C. Install automatic, 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; and 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.

3.4 PIPING INSTALLATIONS

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

B. 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 Division 23 Section "General-Duty 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 strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

T. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

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.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 3/8 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 1/2 inch.
7. NPS 3: Maximum span, 12 feet; minimum rod size, 1/2 inch.
8. NPS 3-1/2: Maximum span, 13 feet; minimum rod size, 1/2 inch.
9. NPS 4: Maximum span, 14 feet; minimum rod size, 5/8 inch.

E. Install hangers for drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 3/8 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 3/8 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, 1/2 inch.
7. NPS 3: Maximum span, 10 feet; minimum rod size, 1/2 inch.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.6 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 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. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.


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

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from air separator to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

F. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above the floor. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

G. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.8 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 bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.9 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum 100 ppm. Modify this value if closed system contains glycol.
5. Corrosion Inhibitor:
   a. Sodium Nitrate: 1000 to 1500 ppm.
   b. Molybdate: 200 to 300 ppm.
   c. Chromate: 200 to 300 ppm.
   d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
   e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum 0.20 ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
8. Total Suspended Solids: Maximum 10 ppm.
10. Free Caustic Alkalinity: Maximum 20 ppm.
11. Microbiological Limits:
    a. Total Aerobic Plate Count: Maximum 1000 organisms/ml.
    b. Total Anaerobic Plate Count: Maximum 100 organisms/ml.
    c. Nitrate Reducers: 100 organisms/ml.
    d. Sulfate Reducers: Maximum 0 organisms/ml.
    e. Iron Bacteria: Maximum 0 organisms/ml.

B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.10 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
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 100 psi. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Once all leaks have been repaired, repeat the test in the presence of the designer.
7. 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 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   2. Separately coupled, base-mounted, end-suction centrifugal pumps.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.4 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.7 COORDINATION

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

1.8 EXTRA MATERIALS

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

1. Mechanical Seals: One mechanical seal for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

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

2.2 CLOSE-COUPLLED, IN-LINE CENTRIFUGAL PUMPS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Bell & Gossett Series 80 Pumps or a comparable product by one of the following.

1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. Patterson.
4. Taco, Inc.
5. Weinman; Div. of Crane Pumps & Systems.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 200 deg F.

C. Pump Construction:
   1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, and threaded companion-flange or union end connections.
   2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
   4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
   5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

D. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

E. Capacities and Characteristics: (See schedule on drawings.)

2.3 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers:
   1. Armstrong Pumps Inc.
   2. Aurora Pump; Division of Pentair Pump Group.
   3. Bell & Gossett; Div. of ITT Industries.
   4. PACO Pumps.
   5. Thrush Company Inc.
   6. Weinman; Div. of Crane Pumps & Systems.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.

C. Pump Construction:
   1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged
connections. Provide integral mount on volute to support the casing, and attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.


4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket.

5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

6. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.

D. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. EPDM coupling sleeve for variable-speed applications.

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for pumps and controllers.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete
3.3 PUMP INSTALLATION

A. Comply with HI 1.4.

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

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.

   1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.

   2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and spring hangers of sufficient size to support pump weight. Vibration isolation devices are specified in Division 21 Section "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment." Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment/Hangers and Supports for HVAC Piping and Equipment."

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.
3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check valve and throttling valve on discharge side of pumps.

F. Install Y-type strainer and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

I. Install electrical connections for power, controls, and devices.

J. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:
   a. Verify bearing lubrication.
   b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Open discharge valve slowly.
3.7 DEMONSTRATION

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

END OF SECTION 23 2123
SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 RELATED SECTIONS

A. Refrigerant piping sleeves, hangers, and supports are specified in Division 23 - Hangers and Supports for HVAC Piping and Equipment.

B. Pipe and valve identification is specified in Division 23 - Identification for HVAC Piping and Equipment.

C. Pipe insulation is specified in Division 23 – HVAC Piping Insulation.

1.4 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:


1.5 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
1. Shop Drawing Scale: 1/4 inch equals 1 foot.
2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Welding certificates.
D. Field quality-control test reports.
E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.8 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.
B. Wrought-Copper Fittings: ASME B16.22.
C. Wrought-Copper Unions: ASME B16.22.
D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
E. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (Silver)
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F. Flexible Connectors:

2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
5. Maximum Operating Temperature: 250 deg F.

G. Flexible Connectors:

2. End Connections:
   a. NPS 2 and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Operator: Rising stem and hand wheel.
5. End Connections: Socket, union, or flanged.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
8. Maximum Operating Temperature: 275 deg F.
C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
4. End Connections: Copper spring.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
7. Maximum Operating Temperature: 240 deg F.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
4. End Connections: Threaded.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
5. Seat: Polytetrafluoroethylene.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
11. Maximum Operating Temperature: 240 deg F.

I. Straight-Type Strainers:
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
5. End Connections: Socket or flare.
7. Maximum Operating Temperature: 240 deg F.
**L. Sight Glasses:**

1. **Body:** Forged brass or bronze,
2. **Fittings:** Flanged as specified for piping.
3. **Test Pressure Rating:** 350 psi
4. **Provide double-port, see-through type**
5. **Two bull’s-eyes of nonferrous material.**

**M. Vibration Eliminators: Flexible bellows tube type**

1. **Body:** Seamless tin bronze or stainless steel core with high tensile bronze braid covering.
2. **Connections:** Soldered
3. **Minimum Working Pressure:** 500 psig (3450 kPa)
4. **UL-labeled, minimum 7 inches in length.**

### 2.3 REFRIGERANTS

**A. Available Manufacturers:** Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

**C. ASHRAE 34, R-410A:** Pentafluoroethane/Difluoromethane.

**PART 3 - EXECUTION**

### 3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

**A. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:** Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

**B. Safety-Relief-Valve Discharge Piping:** Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

### 3.2 VALVE AND SPECIALTY APPLICATIONS

**A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor.**

**B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.**

**C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor**
suction connection.

D. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

E. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

F. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

G. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

H. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Hot-gas bypass valves.
   4. Compressor.

3.3 PIPING INSTALLATION

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

B. Install refrigerant piping according to ASHRAE 15.

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

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

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

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.
H. Install fittings for changes in direction and branch connections.

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

J. Refer to Division 23 Section "Building Automation System."

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:
   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   2. Install horizontal suction lines with a uniform slope downward to compressor.
   3. Install traps and double risers to entrain oil in vertical runs.
   4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
   2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
   3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
   6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements
for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 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. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

a. Fill system with nitrogen to the required test pressure.
b. System shall maintain test pressure at the manifold gage throughout duration of test.
c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

END OF SECTION 232300
SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes the following HVAC water-treatment systems:
      1. Bypass chemical-feed equipment and controls.

1.3 DEFINITIONS
   A. EEPROM: Electrically erasable, programmable read-only memory.
   B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
   C. RO: Reverse osmosis.
   D. TDS: Total dissolved solids.
   E. UV: Ultraviolet.

1.4 PERFORMANCE REQUIREMENTS
   A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
   B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
   C. Closed hydronic systems, including [hot-water heating] [chilled water] [dual-temperature water] [and] [glycol cooling], shall have the following water qualities:
      1. pH: Maintain a value within [9.0 to 10.5] <Insert range>.
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2. "P" Alkalinity: Maintain a value within [100 to 500] <Insert range> ppm.
3. Boron: Maintain a value within [100 to 200] <Insert range> ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of [100] <Insert number> ppm.
5. Soluble Copper: Maintain a maximum value of [0.20] <Insert number> ppm.
6. TDS: Maintain a maximum value of [10] <Insert number> ppm.
9. Microbiological Limits:
   a. Total Aerobic Plate Count: Maintain a maximum value of [1000] <Insert number> organisms/ml.
   b. Total Anaerobic Plate Count: Maintain a maximum value of [100] <Insert number> organisms/ml.
   c. Nitrate Reducers: Maintain a maximum value of [100] <Insert number> organisms/ml.
   d. Sulfate Reducers: Maintain a maximum value of [0] <Insert number> organisms/ml.
   e. Iron Bacteria: Maintain a maximum value of [0] <Insert number> organisms/ml.
10. <Insert other requirements if necessary.>

D. Steam Boiler and Steam Condensate:

1. Steam Condensate:
   a. pH: Maintain a value within [7.8 to 8.4] <Insert range>.
   b. Total Alkalinity: Maintain a value within [5 to 50] <Insert range> ppm.
   d. Soluble Copper: Maintain a maximum value of [0.20] <Insert number> ppm.
   e. TDS: Maintain a maximum value of [10] <Insert number> ppm.
   g. Total Hardness: Maintain a maximum value of [2] <Insert number> ppm.
   h. <Insert other requirements if necessary.>

2. Steam boiler operating at 15 psig and less shall have the following water qualities:
   a. "OH" Alkalinity: Maintain a value within [200 to 400] <Insert range> ppm.
   b. TDS: Maintain a value within [600 to 3000] <Insert range> ppm.
   c. <Insert other requirements if necessary.>

3. Steam boiler operating at more than 15 psig shall have the following water qualities:
   a. "OH" Alkalinity: [200 to 400] <Insert range> ppm.
   b. TDS: Maintain a value within [600 to 1200] <Insert range> ppm to maximum 30 times RO water TDS.
   c. <Insert other requirements if necessary.>

E. Open hydronic systems, including [condenser] [fluid-cooler spray] water, shall have the
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following water qualities:

1. pH: Maintain a value within [8.0 to 9.1] <Insert range>.
2. "P" Alkalinity: Maintain a maximum value of [100] <Insert number> ppm.
3. Chemical Oxygen Demand: Maintain a maximum value of [100] <Insert number> ppm.
4. Soluble Copper: Maintain a maximum value of [0.20] <Insert number> ppm.
5. TDS: Maintain a maximum value of [10] <Insert number> ppm.
7. Free "OH" Alkalinity: Maintain a maximum value of [0] <Insert number> ppm
8. Microbiological Limits:
   a. Total Aerobic Plate Count: Maintain a maximum value of [10,000] <Insert number> organisms/ml.
   b. Total Anaerobic Plate Count: Maintain a maximum value of [1000] <Insert number> organisms/ml.
   c. Nitrate Reducers: Maintain a maximum value of [100] <Insert number> organisms/ml.
   d. Sulfate Reducers: Maintain a maximum value of [0] <Insert number> organisms/ml.
   e. Iron Bacteria: Maintain a maximum value of [0] <Insert number> organisms/ml.
9. Polymer Testable: Maintain a minimum value within [10 to 40] <Insert range>.
10. <Insert other requirements if necessary:>

F. Passivation for Galvanized Steel: For the first 60 days of operation.

1. pH: Maintain a value within [7 to 8] <Insert range>.
2. Calcium Carbonate Hardness: Maintain a value within [100 to 300] <Insert range> ppm.
3. Calcium Carbonate Alkalinity: Maintain a value within [100 to 300] <Insert range> ppm.

1.5 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. TDS controllers.
7. Chemical solution tanks.
8. Injection pumps.
9. Ozone generators.
10. UV-irradiation units.
11. Chemical test equipment.
12. Chemical material safety data sheets.
14. RO units.
15. Multimedia filters.
17. Bag- or cartridge-type filters.
18. Centrifugal separators.

B. Shop Drawings: Pretreatment and chemical, and ozone-generator biocide, and UV-irradiation biocide treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.


C. Field quality-control test reports.

D. Manufacturer Seismic Qualification Certification: Submit certification that water softeners, RO equipment, water filtration units, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Operation and Maintenance Data: For sensors, injection pumps, water softeners, RO equipment, water filtration units, and controllers to include in emergency, operation, and maintenance manuals.

F. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for [cooling, chilled-water piping] [heating, hot-water piping] [heating, steam and condensate piping] [steam and condensate system for humidifier and cooking appliance applications] [condenser-water piping] and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Ampion Corp.
2. Anderson Chemical Co, Inc.
4. Barclay Chemical Co.; Water Management, Inc.
5. Boland Trane Services
6. GE Betz.
7. GE Osmonics.
2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.


2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
5. Registration: Gallons or cubic feet.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.

B. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
5. Registration: Gallons or cubic feet.
7. Control: Low-voltage signal capable of transmitting 1000 feet.

C. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: [Bronze] [Epoxy-coated cast iron].
5. Registration: Gallons or cubic feet.
D. Inhibitor Injection Timers:

1. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."]**

2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.

3. Test switch.


5. Illuminated legend to indicate feed when pump is activated.

6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.

7. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

E. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."]**

2. Digital display and touch pad for input.

3. Sensor probe adaptable to sample stream manifold.

4. High, low, and normal pH indication.

5. High or low pH alarm light, trip points field adjustable; with silence switch.


7. Internal adjustable hysteresis or deadband.

F. TDS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. **[Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."]**

2. Digital display and touch pad for input.

3. Sensor probe adaptable to sample stream manifold.

4. High, low, and normal conductance indication.

5. High or low conductance alarm light, trip points field adjustable; with silence switch.


8. Internal adjustable hysteresis or deadband.

9. Bleed Valves:
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a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.

b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

G. Biocide Feeder Timer:

1. Microprocessor-based controller with digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. [Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."

2. 24-hour timer with 14-day skip feature to permit activation any hour of day.

3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer.

4. Solid-state alternator to enable use of two different formulations.

5. 24-hour display of time of day.

6. 14-day display of day of week.

7. Battery backup so clock is not disturbed by power outages.


H. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.

2. Molded cover with recess for mounting pump.


I. Chemical Solution Injection Pumps:

1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.

2. Adjustable flow rate.

3. Metal and thermoplastic construction.


5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

J. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

K. Injection Assembly:

1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.

2. Ball Valve: [Three] [Two]-piece, stainless steel as described in "Stainless-Steel Pipes and Fittings" Article below; and selected to fit quill.

3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.

4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.
2.4 OZONE-GENERATOR BIOCIDE EQUIPMENT

A. Corona discharge generator with stainless-steel generating cells, and transformer housed in a NEMA 250, Type 4 enclosure. Assembly shall be suitable for continuous duty. Provide site glasses to verify proper operation of generator.

B. Water-cooled generators shall be provided with cooling water at maximum $[70 \text{ deg F}] <\text{Insert value}>$ and $[35 \text{ psig}] <\text{Insert value}>$.

C. Generator vessels exposed to system pressure shall be constructed according to ASME Boiler and Pressure Vessel Code and be equipped with pressure relief valve.

D. External air compressor or induced airflow through a cleanable prefilter supplies concentrated oxygen through a molecular sieve with minus 62 deg F dew point to avoid the formation of nitric acid.

E. Microprocessor-based control with software in EEPROM, surge protection, high-temperature cutout, and operational status lights. [Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation and Control for HVAC."]

F. Ozone Contactors:
   1. Bubble diffusers.
   2. Induction injection nozzle.
   3. Injectors with static mixers.

G. Ozone Detector and Alarm Devices:
   1. Detector:
      a. Sensor: Metal dioxide semiconductor.
      b. Concentration Range: $[0.01 \text{ to } 0.14] <\text{Insert range}>$ ppm.
      c. Accuracy: Plus or minus 20 percent of range.
      d. Sensitivity: 0.01 ppm.
      e. Response Time: Maximum 10 seconds.
      f. Operating Temperature: 50 to 100 deg F.
      g. Relatively Humidity: 20 to 95 percent, noncondensing over the operating temperature range.
   2. Horns:
      b. 24-V dc; with provision for housing the operating mechanism behind a grille.
      c. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn.
   3. Visible Alarm Devices:
Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.
July 18, 2016

HVAC WATER TREATMENT

232500-10

a. Xenon strobe lights listed in UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate.

b. Rated Light Output: \[75 \leq \text{Insert number} \leq 110\] candelas.

c. Strobe Leads: Factory connected to screw terminals.

H. Self-Contained Breathing Apparatus: Open-circuit, pressure-demand, compressed air includes completely assembled, portable, self-contained devices designed for hazardous breathing environment application.

1. Face Piece: EPDM or silicone rubber construction material, one-size-fits-all with double-sealing edge, stainless-steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in mask, close-fitting nose piece to ensure no CO\textsubscript{2} buildup, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.

2. Backplate: Orthopedically designed of [chemical and impact-resistant, glass-fiber composite] [aluminum].

3. Harness and Carrier Assembly: Large triangular back pad, backplate, and adjustable waist and shoulder straps. Modular in design, detachable components, and easy to clean and maintain. Shoulder straps padded with flame-resistant material, reinforced with stainless-steel cable, and attached with T-nuts, washers, and screws.

4. Air Cylinder: \[30 \leq \text{Insert number} \leq 45 \leq 60\]-minute, low-pressure, air-supply-loaded [fiberglass] [aluminum] [steel] cylinders fitted with quick-fill assembly for refilling and air transfer.

5. Wall-Mounting Cabinet: Leakproof, corrosion-resistant, clear, plastic case.

6. Tested and Certified: By the National Institute for Occupational Safety and Health and by the Mine Safety and Health Administration, according to 42 CFR 84, Subpart H.

2.5 STAINLESS-STEEL PIPES AND FITTINGS

A. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.

B. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.

C. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig SWP and 600-psig CWP ratings.

D. Three-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, threaded body design with adjustable stem packing, threaded ends, and 150-psig SWP and 600-psig CWP rating.

2.6 UV BIOCIDE EQUIPMENT

A. Target Irradiation: Minimum 30,000 microwatts x s/sq. cm.

B. Light Source Vessels:
1. ASTM A 666, Type 304 stainless steel.
2. Construct for minimum [150 psig] <Insert value> at [150 deg F] <Insert value>
according to ASME Boiler and Pressure Vessel Code, and equipped with pressure relief
valve.
3. Light Source Sleeve: Quartz, with EPDM O-ring seals.
4. Light Source: Replaceable UV lamp producing minimum target irradiation of 254-nm
wavelength light.

C. Controls: Interlock with pumps to operate when water is circulating.

2.7 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for
testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for
high-pressure boilers, and oxidizing biocide test for open cooling systems.

B. Sample Cooler:

1. Tube: Sample.
   a. Size: NPS 1/4 tubing.
   b. Material: ASTM A 666, Type 316 stainless steel.
   d. Temperature Rating: Minimum 850 deg F.

2. Shell: Cooling water.
   a. Material: ASTM A 666, Type 304 stainless steel.
   c. Temperature Rating: Minimum 450 deg F.

3. Capacities and Characteristics:
   a. Tube: Sample.
      1) Flow Rate: [0.25 gpm] <Insert value>.
      2) Entering Temperature: [400 deg F] <Insert value>.
      3) Leaving Temperature: [88 deg F] <Insert value>.
      4) Pressure Loss: [6.5 psig] <Insert value>.
   b. Shell: Cooling water.
      1) Flow Rate: [3 gpm] <Insert value>.
      2) Entering Temperature: [70 deg F] <Insert value>.
      3) Pressure Loss: [1.0 psig] <Insert value>.

C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with
piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild
steel coupon in the test-coupon assembly.
1. [Two] <Insert number>-station rack for closed-loop systems.
2. [Four] <Insert number>-station rack for open systems.

2.8 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

B. Water Softener Chemicals:

   1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. of calcium carbonate of resin when regenerated with 15 lb of salt.
   2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

2.9 HVAC MAKEUP WATER SOFTENER

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:

   1. Alamo Water Treatment; Ecodyne Water Treatment, Inc.
   3. CSI; a division of Chandler Systems, Inc.
   5. CUNO Incorporated.
   8. Environmental Dynamics Corporation.
   9. Hungerford & Terry, Inc.
   11. Marlo Incorporated.
   13. Plymouth Products, Inc.
   14. Rainsoft Div.; Aquion Partners L. P.
   15. Water King.
   16. <Insert manufacturer's name>.
D. Description: Twin mineral tanks and one brine tank, factory mounted on skid.

E. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.

F. Mineral Tanks:

1. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
3. Pressure Rating: \[100 \text{ psig} [125 \text{ psig} [150 \text{ psig}] <\text{Insert value}>\] minimum.
4. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F \(<\text{Insert range}>>.
5. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
6. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
7. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
9. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even-flow distribution through resin bed.

G. Controls: Automatic; factory mounted on mineral tanks and factory wired.

1. Adjustable duration of regeneration steps.
2. Push-button start and complete manual operation override.
3. Pointer on pilot-control valve shall indicate cycle of operation.
5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
   a. Slow opening and closing, nonslam operation.
   b. Diaphragm guiding on full perimeter from fully open to fully closed.
   c. Isolated dissimilar metals within valve.
   d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
   e. Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
   f. Sampling cocks for soft water.

6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons, and automatically resets after regeneration to preset total in gallons for next service run. Include alternator to regenerate one mineral tank with the other in
H. Brine Tank: Combination measuring and wet-salt storing system.
   1. Tank and Cover Material: Fiberglass a minimum of 3/16 inch thick; or molded PE a minimum of 3/8 inch thick.
   2. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
   3. Size: Large enough for at least four regenerations at full salting.

I. Factory-Installed Accessories:
   1. Piping, valves, tubing, and drains.
   2. Sampling cocks.
   3. Main-operating-valve position indicators.

J. Water Test Kit: Include water test kit in wall-mounting enclosure for water softener.

K. Capacities and Characteristics:
   2. Peak Service Flow Rate: <Insert gpm> at 25-psig pressure loss.
   3. Water Consumption: <Insert gal./day>.
   4. Water Demand: <Insert number> hours/day.
   5. Electrical Characteristics:
      a. Volts: <Insert value>.
      b. Phase: <Insert value>.
      c. Hertz: <Insert value>.
      d. Full-Load Amperes: <Insert value>.
      e. Minimum Circuit Ampacity: <Insert value>.
      f. Maximum Overcurrent Protection: <Insert amperage>.
      g. Interrupting Capacity: <Insert amperage>.

2.10 RO EQUIPMENT FOR HVAC MAKEUP WATER

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:
   1. Alamo Water Treatment; Ecodyne Water Treatment, Inc.
D. Description: Factory fabricated and tested with RO membrane elements in housings, high-pressure pumps and motors, controls, valves, and prefilter; mounted on skid.

E. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.

F. Skid Assembly: Welded-steel frame coated with epoxy protective finish.

G. RO Membrane and Housing:

1. Element: Thin-film composite with U-cup brine seal with minimum 98 percent salt rejection based on 2000-ppm water supplied at 225 psig and 77 deg F.
2. Housing: ASTM A 666, Type 304 stainless steel with PVC end caps held in place with stainless-steel straps.

H. High-Pressure Pumps and Motors:

1. Pump:
   a. Vertical, multistage centrifugal operating at 3500 rpm with ASTM A 666, Type 304 stainless-steel casing, shaft, impellers, and inlet and discharge casting.
   b. Bearings shall be tungsten carbide and ceramic.
   c. Cast-iron frame and flanged suction and discharge connections.

2. Motor: NEMA-standard, C-faced TEFC motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

I. Controls:

1. Microprocessor-based controller with LCD display.
2. Interlock for remote start/stop control.
3. Membrane flush sequence when pumps shut down.
4. Run time indicator.
5. Low-pressure safety cutoff.
6. Panel-mounted gages as follows:
   a. Product and concentrate.
   b. Inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product pressures.
   c. Product conductivity monitor.

J. Valves:
   1. Stainless-steel pump, concentrate, and recycle throttling valves rated for minimum 300 psig.
   2. Automatic inlet shutoff valve, diaphragm type; solenoid actuated, normally closed, and constructed of glass-reinforced noryl thermoplastic.
   3. PVC valves with EPDM seats and seals for isolation at inlet, and check and sample valves at product and concentrate. Sample valves at cartridge filter outlet, concentrate, and product outlet.

K. Prefilter:
   1. Housing: Polypropylene with built-in relief or vent valve.
   2. Element: Spun-wound polypropylene.

L. Inlet Water Tempering Valve: Thermostatic water-tempering valve to maintain [77 deg F] <Insert value> inlet water temperature to RO unit.

M. Activated Carbon Filter:
   1. Media Tank: Fiberglass-reinforced polyester rated for minimum 150 psig with internal backwash distributor and filtered water collector.
   4. Backwash Control: Seven-day time clock.

N. Atmospheric Storage Tank:
   1. Tank: Polyethylene single piece with closed top and flat bottom with manway in top, 0.2-micron filter vent, inlet, discharge, and drain piping connections, and bulkhead fittings for level controls.
   2. Control: Level switches start and stop RO unit. Low-level limit shall stop repressurization pumps, and signal an alarm.

O. Repressurization Pumps:
   1. Pumps: Two close-coupled, single-stage centrifugal pumps, with mechanical seals. Wetted components ASTM A 666, Type 316 stainless steel.
   2. Controls: NEMA-4X pump control panel constructed of fiberglass to control pumps, one operating, one standby, with automatic alternator and fail-over control.
motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

P. Water Test Kit: Include water test kit in wall-mounting cabinet for RO unit.

Q. Capacities and Characteristics:

1. RO Product Flow Rate: <Insert gpm.>
2. Total Water Flow Rate: <Insert gpm.>
3. Daily Water Consumption: <Insert gal./day.>
4. Water Demand: <Insert number> gpm.
5. Storage Tank Size: <Insert gal.>
6. RO Inlet Operating Temperature: [77 deg F] <Insert value>.
7. High-Pressure Pump:
   a. Discharge Pressure: <Insert psig.>
   b. Flow Rate: <Insert gpm.>
   c. Horsepower: <Insert value.>
   d. Motor Speed: [3500] <Insert number> rpm.
8. Repressure Pumps:
   a. Discharge Pressure: <Insert psig.>
   b. Flow Rate: <Insert gpm.>
   c. Horsepower: <Insert value.>
   d. Motor Speed: [3500] <Insert number> rpm.
9. Prefilter Design (at Total Water Flow Rate):
   a. Filter Efficiency: [98] <Insert number> percent.
   b. Particle Size: [5] <Insert number> microns and larger.
   d. Replacement Pressure Loss: [6 psig] <Insert value>.

10. Electrical Characteristics (Single-Point Connection):
   a. Volts: <Insert value.>
   b. Phase: <Insert value.>
   c. Hertz: <Insert value.>
   d. Full-Load Amperes: <Insert value.>
   e. Minimum Circuit Ampacity: <Insert value.>
   f. Maximum Overcurrent Protection: <Insert amperage.>
   g. Interrupting Capacity: <Insert amperage.>

2.11 FILTRATION EQUIPMENT

A. Multimedia Filters:
Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:

b. Everfilt.
c. LAKOS; a div. of Claude Laval Corporation.
d. Miami Filter LLC.
e. PEP Filters, Inc.
f. Puroflux Corporation.
g. United Industries, Inc.
h. <Insert manufacturer's name.>

Description: Factory-fabricated and -tested, simplex, multimedia filter system of filter tank, media, strainer, circulating pump, piping, and controls for removing particles from water.

a. Filter Tank: Corrosion resistant with distribution system and media.

1) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
3) Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.
4) Steel Tank Pipe Connections NPS 2-1/2 and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
5) FRP Tank Pipe Connections NPS 2-1/2 and Larger: Type A, integral; Designation [E, 125-psig] or [F, 150-psig] pressure category flanges of grade same as tank material according to ASTM D 5421.

b. Motorized Valves: Flanged or grooved-end, ductile-iron butterfly type with [EPDM] <Insert material> valve seat and stem seal; with ASTM B 148 aluminum bronze disc.

c. Strainer: Basket type mounted on pump suction.

d. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.

e. Piping: ASTM B 88, Type L copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.


g. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
1) Casing: Radially split, cast iron.
2) Pressure Rating: [125 psig] [150 psig] minimum.
3) Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
4) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
5) Seal: Mechanical.
6) Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

h. Controls: Automatic control of circulating pump and tank backwash; factory wired for single electrical connection.

2) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
3) Backwash: Automatic; with time clock and differential pressure switch.
4) Backwash Valve: Tank mounted with valves interlocked to single actuator.

i. Support: Skid mounting. [Fabricate supports and base and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.]

5. Capacities and Characteristics:

a. Filter Design:

2) Clean Pressure Loss: [5 psig] <Insert value>.
3) Maximum Media Flow Rate: [15 gpm/sq. ft.] <Insert value>.
4) Filtration Efficiency: [98] <Insert number> percent.
5) Particle Specific Gravity: [1.8] <Insert number>.
6) Particle Size: [5] [10] [20] [45] <Insert number> microns.

b. Filter Tank: With internal distribution piping.

1) Pressure Rating: <Insert psig.>
2) Diameter: <Insert inches.>
3) Inlet and Outlet Size: <Insert NPS.>
4) Blowdown Piping Outlet Size: <Insert NPS.>

c. Filter Media: <Insert material.>


e. Backwash Period: [10] <Insert number> minutes.

f. Circulating Pump:

1) Capacity: <Insert gpm.>
2) Total Dynamic Head: <Insert feet.>
3) Motor Speed: <Insert number> rpm.
g. Pump Motor Size and Electrical Characteristics:
   1) Horsepower: <Insert value.>
   2) Volts: [120] [208] [240] [277] [480] <Insert number> V.
   3) Phase: [Single] [Three].
   4) Hertz: [60] <Insert number> Hz.

h. Unit Electrical Characteristics:
   1) Full-Load Amperes: <Insert value.>
   2) Minimum Circuit Ampacity: <Insert value.>
   3) Maximum Overcurrent Protection: <Insert amperage.>
   4) Interrupting Capacity: <Insert amperage.>

B. Self-Cleaning Strainers:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:
      a. Everfilt.
      b. Hayward Industrial Products, Inc.
      c. Islip Flow Controls Inc.
      d. Orival, Inc.
      e. Sure Flow Equipment, Inc.
      f. <Insert manufacturer's name.>
   4. Description: Factory-fabricated and -tested, ASTM A 126, Class B, cast-iron or steel, self-cleaning strainer system of tank, strainer, backwash arm or cleaning spiral, drive and motor, piping, and controls for removing particles from water.
      a. Fabricate and label ASTM A 126, Class B, cast-iron or steel strainer tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
      b. Pipe Connections:
         1) NPS 2 and Smaller: Threaded according to ASME B1.20.1.
         2) NPS 2-1/2 and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
   5. Motorized Valves: Flanged or grooved-end, ductile-iron angle type with [EPDM] <Insert material> valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
7. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
9. Backwash Arm Drive:
   a. Drive Casing: Cast iron.
   b. Worm Gears: Immered in oil.
   c. Motor: ODP motor supported on the strainer-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
10. Controls: Automatic control of backwash; factory wired for single electrical connection.
   c. Backwash: Automatic; with time clock and differential pressure switch.
   d. Backwash Valve: Electric actuator.
11. Support: Skid mounting. [Fabricate supports and base and attachment to tank with reinforcement strong enough to resist strainer movement during a seismic event when strainer base is anchored to building structure.]
12. Capacities and Characteristics:
   a. Strainer Design:
      2) Clean Pressure Loss: [5 psig] <Insert value>.
      3) Strainer Mesh: [40] [60] [80] <Insert number>.
   b. Strainer Tank: With internal distribution piping.
      1) Material: [Cast iron] [Steel] <Insert material>.
      2) Pressure Rating: [150 psig] <Insert value>.
      3) Inlet and Outlet Size: <Insert NPS>.
      4) Backwash Piping Outlet Size: <Insert NPS>.
   c. Start Backwash: [10 psig] <Insert value>.
   e. Drive Motor Size and Electrical Characteristics:
      1) Horsepower: <Insert value>.
      2) Volts: [120] [208] [240] [277] [480] <Insert number> V.
      3) Phase: [Single] [Three].
      4) Hertz: [60] <Insert number> Hz.
   f. Unit Electrical Characteristics:
1) Full-Load Amperes: <Insert value.>
2) Minimum Circuit Ampacity: <Insert value.>
3) Maximum Overcurrent Protection: <Insert amperage.>
4) Interrupting Capacity: <Insert amperage.>

C. [Bag] [Cartridge]-Type Filters:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:
   a. Cycron Corporation.
   c. Filter Specialists, Inc.
   e. Hayward Industrial Products, Inc.
   g. Parker Hannifin Corp.; Process Filtration Div.
   h. PEP Filters, Inc.
   i. Plymouth Products, Inc.
   j. RainSoft Div.; Aquion Partners L. P.
   k. Rosedale Products, Inc.
   l. RPA Process Technologies.
   m. Shelco Filters; division of Tinny Corp.
   n. USFilter.
   o. <Insert manufacturer's name.>

4. Description: Floor-mounting housing with filter [bags] [cartridges] for removing particles from water.
   a. Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through [bag] [cartridge]-type water filter; with [bag support and ] base, feet, or skirt.
      1) Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.
      2) Steel Housing Pipe Connections NPS 2-1/2 and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
      3) Plastic Housing Pipe Connections NPS 2-1/2 and Larger: 150-psig plastic flanges.
   b. [Bag] [Cartridge]: Replaceable; of shape to fit housing.

5. Capacities and Characteristics:
a. Filter Design:
   1) Water Flow Rate: <Insert gpm.>
   2) Filtration Efficiency: [98] <Insert number%> percent.
   3) Particle Size: [10] [20] <Insert number> microns and larger.
   4) Clean Pressure Loss: [2 psig] <Insert value>.
   5) Pressure Loss at Replacement: [6 psig] <Insert value>.

b. Housing:
   1) Material: [Carbon steel] [Plastic].
   2) Pressure Rating: <Insert psig>.
   3) Seal Material: [NBR] <Insert material>.
   4) Diameter: <Insert inches>.
   5) Height or Length: <Insert inches>.
   6) Inlet and Outlet Size: <Insert NPS>.
   7) Drain Size: [Not applicable] <Insert NPS>.
   8) Bag Support Basket Material: [Stainless steel] <Insert material>.

c. [Bag] [Cartridge]:
   1) Number Required: <Insert number>.
   2) Nominal Diameter: <Insert inches>.
   3) Nominal Length: <Insert inches>.
   4) Media Material: [Cotton] [Polyester] [Polypropylene] <Insert material>.

D. Centrifugal Separators:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   3. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:
      a. Alamo Water Treatment; Ecodyne Water Treatment, Inc.
      b. Culligan International.
      c. Griswold Controls.
      d. LAKOS; a div. of Claude Laval Corporation.
      e. PEP Filters, Inc.
      f. Puroflux Corporation.
      g. Rosedale Products, Inc.
      h. USFilter.
      i. <Insert manufacturer's name.>
   4. Description: Simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity.
5. Housing: With manufacturer's proprietary system of baffles and chambers.
   a. Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   b. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
   c. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
   d. Collection Chamber: Designed to hold separated particles.
   e. Outlet: Near top of unit.
   f. Purge: At bottom of collection chamber.
   g. Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.
   h. Pipe Connections NPS 2-1/2 and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if tank is stainless steel.

6. Motorized Purge Valve: Gate or plug pattern valve.
   a. Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with [EPDM] <Insert material> valve seat and stem seal; with ASTM B 148 aluminum bronze disc.

7. Strainer: Stainless-steel basket type mounted on pump suction.

8. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.

9. Piping: ASTM B 88, Type L copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.

10. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
    a. Casing: Radially split, cast iron.
    b. Pressure Rating: [125 psig] [150 psig] minimum.
    c. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
    d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
    e. Seal: Mechanical.
    f. Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

11. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.
    d. TDS Controller Interlock: Open separator purge valve with bleed-off control.

12. Support: Skid mounting.[Fabricate supports and base and attachment to separator]
housing with reinforcement strong enough to resist separator movement during a seismic event when separator base is anchored to building structure.

13. Capacities and Characteristics:

a. Separator Design:

1) Water Flow Rate: <Insert gpm.> 
2) Pressure Loss: [5 psig] <Insert value>. 
3) Separator Efficiency: [98] <Insert number> percent. 
4) Particle Specific Gravity: [1.8] <Insert number>. 
5) Particle Size: [5] [10] [20] [45] <Insert number> microns.

b. Housing:

1) Material: [Steel] [Stainless steel] [Plastic] [Fiberglass] <Insert material>. 
2) Pressure Rating: <Insert psig>. 
3) Diameter: <Insert inches>. 
4) Height: <Insert inches>. 
5) Inlet and Outlet Size: <Insert NPS>. 
6) Purge Size: <Insert NPS>. 

$c. Circulating Pump:

1) Capacity: <Insert gpm>. 
2) Total Dynamic Head: <Insert feet>. 
3) Motor Speed: <Insert rpm>. 
4) Inlet Size: <Insert NPS>. 
5) Outlet Size: <Insert NPS>. 

d. Pump Motor Size and Electrical Characteristics:

1) Horsepower: <Insert value>. 
2) Volts: [120] [208] [240] [277] [480] <Insert number> V. 
3) Phase: [Single] [Three]. 
4) Hertz: [60] <Insert number> Hz. 
5) Full-Load Amperes: <Insert value>. 
6) Minimum Circuit Ampacity: <Insert value>. 
7) Maximum Overcurrent Protection: <Insert amperage>. 
8) Interrupting Capacity: <Insert amperage>. 

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.
3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including [hot-water heating] [chilled water] [dual-temperature water] [and] [glycol cooling], and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
2. Install water meter in makeup water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

G. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:

1. Install makeup water softener.
2. Install water meter in makeup water supply.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
   a. Pumps shall operate for timed interval when contacts close at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
4. Install test equipment and furnish test-kit to Owner.
5. Install RO unit for makeup water.
6. Install TDS controller with sensor and bleed valves.
   a. Bleed valves shall cycle to maintain maximum TDS concentration.
7. Install inhibitor injection timer with injection pumps and solution tanks.
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RMF Engineering, Inc.
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a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into main steam supply header.

H. Install automatic chemical-feed equipment for [condenser] [fluid-cooler spray] water and include the following:

1. Install makeup water softener.
2. Install water meter in makeup water supply.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
   a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

4. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
5. Install TDS controller with sensor and bleed valves.
   a. Bleed valves shall cycle to maintain maximum TDS concentration.

6. Install pH sensor and controller with injection pumps and solution tanks.
   a. Injector pumps shall operate to maintain required pH.

7. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
   a. Injection pumps shall operate to feed biocide on an alternating basis.

8. Install ozone generator with diffusers in condenser-water piping.
   a. Ozone generator shall operate continuously with condenser-water flow.

9. Install UV-irradiation lamps in condenser-water piping.
   a. UV lights shall operate continuously with condenser-water flow.

3.3 OZONE-GENERATOR INSTALLATION

A. Install ozone generator and equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.
C. Pipe ozone from ozone generator to condenser water with stainless-steel pipe and fittings with welded joints.

D. Install [two] [three]-piece, stainless-steel ball valve in ozone supply to condenser water.

E. Pipe cooling water to ozone generator, and to air-gap drain fitting with stainless-steel pipe and fittings with welded joints where enclosed in ozone-generator room.

F. Install [two] [three]-piece, stainless-steel ball valve in cooling water supply to ozone generator.

G. Mounting supports for ozone generator shall be ASTM A 666, Type 316 stainless steel.

H. Mount breathing apparatus outside ozone-generator room.

I. Mount and install ozone detector, warning lights, and audible alarm inside ozone-generator room. Mount another set of warning lights and audible alarm just outside the main entrance to ozone-generator room.

3.4 UV-IRRADIATION UNIT INSTALLATION

A. Install UV-irradiation units on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for UV-irradiation units and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

3.5 WATER SOFTENER INSTALLATION

A. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.

D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

E. Install water-testing sets on wall adjacent to water softeners.
3.6 RO UNIT INSTALLATION

A. Install RO unit and storage tank on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.

B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.

D. Install water testing sets on wall adjacent to RO unit.

3.7 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 23 Section "Common Work Results for HVAC."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section "General-Duty Valves for HVAC Piping."

E. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.

G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
B. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
   7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
   8. Repair leaks and defects with new materials and retest piping until no leaks exist.

D. Remove and replace malfunctioning units and retest as specified above.

E. Sample boiler water at [four] [six] [eight]-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at <Insert number>-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

F. At [four] [six] [eight]-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

G. Comply with ASTM D 3370 and with the following standards:

3.9 DEMONSTRATION

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

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 23 2500
SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.
   3. Double-wall round ducts and fittings.
   4. Sheet metal materials.
   5. Sealants and gaskets.
   6. Hangers and supports.
B. Related Sections:
   1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
   2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS
A. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
   1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
   2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
   3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.4 SUBMITTALS
A. Product Data: For each type of the following products:
1. Liners and adhesives.
2. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

D. Welding certificates.

E. Field quality-control reports.
2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Eastern Sheet Metal
   b. Lindab Inc.
   c. McGill AirFlow LLC.
   d. SEMCO Incorporated.
   e. Sheet Metal Connectors, Inc.
   f. Spiral Manufacturing Co., Inc.
   g. Hamlin Sheet Metal

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

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

1. Eastern Sheet Metal
2. Lindab, Inc.
3. McGill AirFlow LLC.
4. SEMCO Incorporated.
5. Sheet Metal Connectors, Inc.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

   a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Inner Duct: Minimum 0.028-inch solid sheet steel.

D. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   3. Coat insulation with antimicrobial coating.
   4. Cover insulation with polyester film complying with UL 181, Class 1.

E. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
   1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch
minimum diameter for lengths longer than 36 inches.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 4 inches.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Base: Synthetic rubber resin.
   4. Solids Content: Minimum 60 percent.
   5. Shore A Hardness: Minimum 60.
   7. Mold and mildew resistant.
   8. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.
   2. Type: S.
   3. Grade: NS.
   5. Use: O.
   6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:
   1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
3.2 INSTALLATION OF EXPOSED DUCTWORK

A. All exposed ductwork shall be round double wall spiral duct with a paint grip finish.

B. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

C. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

D. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

E. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

F. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4,
"Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakge Tests:
2. Test the following systems:
   a. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   b. Return Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   c. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   d. Outdoor Air Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.
E. Prepare test and inspection reports.

3.8 DUCT CLEANING
A. Clean existing duct systems before testing, adjusting, and balancing.
B. Use service openings for entry and inspection.
   1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23
Section "Air Duct Accessories" for access panels and doors.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.
3.9 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Heat Pumps, and Terminal Units (downstream):
   a. Pressure Class: Positive 1-inch wg.
   b. Minimum SMACNA Seal Class: B.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Constant-Volume Air-Handling Units:
   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
   a. Pressure Class: Positive 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 3.

B. Return Ducts:

1. Ducts Connected to Fan Coil Units:
   a. Pressure Class: Positive or negative 1-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 12.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
METAL DUCTS

Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina

AP#1515
RMF Engineering, Inc.
May 17, 2017

a. Pressure Class: Negative 2-inch wg.
b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
   1. Ducts Connected to Air-Handling Units:
      a. Pressure Class: Positive or negative 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round and Flat Oval: 6.
   2. Ducts Connected to Equipment Not Listed Above:
      a. Pressure Class: Positive or negative 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Intermediate Reinforcement:

F. Elbow Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
      a. Velocity 1000 fpm or Lower:
         1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         2) Mitered Type RE 4 without vanes.
      b. Velocity 1000 to 1500 fpm:
         1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
         3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vaners and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
c. Velocity 1500 fpm or Higher:
   1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   3) Mitered Type RE 2 with vanes complying with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
   
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   
   c. Mitered Type RE 2 with vanes complying with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
   
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      
      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      
      4) Radius-to Diameter Ratio: 1.5.

   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   
   c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
   
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   
   b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
   
   a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION
SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Backdraft and pressure relief dampers.
   3. Control dampers.
   4. Fire dampers.
   5. Smoke dampers.
   6. Combination fire and smoke dampers.
   7. Flange connectors.
   8. Turning vanes.
  10. Duct-mounted access doors.
  11. Flexible connectors.
  12. Flexible ducts.

B. Related Sections:
   1. Division 28 Section "Digital Addressable Fire Alarm" for duct-mounted smoke detectors.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      a. Special fittings.
      c. Control damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

e. Duct security bars.

f. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

D. Source quality-control reports.

E. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with AMCA 500-D testing for damper rating.

1.5 EXTRA MATERIALS

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

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.


2. Exposed-Surface Finish: Mill phosphatized.

C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.
2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. American Warming and Ventilating; a division of Mestek, Inc.
   3. Cesco Products; a division of Mestek, Inc.
   4. Duro Dyne Inc.
   5. Greenheck Fan Corporation.
   6. Lloyd Industries, Inc.
   7. Nailor Industries Inc.
   8. NCA Manufacturing, Inc.
   9. Pottorff; a division of PCI Industries, Inc.
  10. Ruskin Company.
  11. SEMCO Incorporated.

B. Description: Gravity balanced.


D. Maximum System Pressure: 2-inch wg.

E. Frame: 0.052-inch thick, galvanized sheet steel, with welded corners and mounting flange.

F. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inch width, 0.050-inch thick aluminum sheet with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:
   2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball.

M. Accessories:
   1. Adjustment device to permit setting for varying differential static pressure.
   2. Counterweights and spring-assist kits for vertical airflow installations.
   3. Electric actuators.
AIR DUCT ACCESSORIES  233300-4

4. Chain pulls.
5. Front of rear screens.
6. 90-degree stops.

N. Sleeve: Minimum 20-gage thickness.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Air Balance Inc.; a division of Mestek, Inc.
      b. American Warming and Ventilating; a division of Mestek, Inc.
      c. Flexmaster U.S.A., Inc.
      d. McGill AirFlow LLC.
      e. METALAIRE, Inc.
      f. Nailor Industries Inc.
      g. Pottorff; a division of PCI Industries, Inc.
      h. Ruskin Company.
      i. Trox USA Inc.
      j. Vent Products Company, Inc.
   2. Standard leakage rating, with linkage outside airstream.
   3. Suitable for horizontal or vertical applications.
   4. Frames:
      a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   5. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized-steel, 0.064 inch thick.
   7. Bearings:
      a. Stainless-steel sleeve.
      b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   8. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:
   2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
   3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Warming and Ventilating; a division of Mestek, Inc.
   2. Arrow United Industries; a division of Mestek, Inc.
   3. Cesco Products; a division of Mestek, Inc.
   4. Duro Dyne Inc.
   5. Flexmaster U.S.A., Inc.
   7. Lloyd Industries, Inc.
   8. M&I Air Systems Engineering; Division of M&I Heat Transfer Products Ltd.
   9. McGill AirFlow LLC.
  10. METALAIRE, Inc.
  11. Metal Form Manufacturing, Inc.
  12. Nailor Industries Inc.
  13. NCA Manufacturing, Inc.
  15. Vent Products Company, Inc.

B. Low-leakage rating and bearing AMCA’s Certified Ratings Seal for both air performance and air leakage.

C. Frames:
   1. Hat shaped.
   2. Galvanized-steel channels, 0.064 inch thick.
   3. Mitered and welded corners.

D. Blades:
   1. Multiple blade with maximum blade width of 8 inches.
   2. Parallel- and opposed-blade design.
   4. 0.064 inch thick.

E. Blade Axles: 1/2-inch-diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
   1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:
1. Stainless-steel sleeve.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.5 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. Cesco Products; a division of Mestek, Inc.
   4. McGill AirFlow LLC.
   5. METALAIRE, Inc.
   6. Nailor Industries Inc.
   7. NCA Manufacturing, Inc.
   8. Pottorff; a division of PCI Industries, Inc.
   9. Prefco; Perfect Air Control, Inc.
   10. Ruskin Company.
   11. United Enertech

B. Type: Static; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours. 3 hour damper shall be installed where required by the wall or floor rating.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
   2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.


2.6 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. Cesco Products; a division of Mestek, Inc.
   4. Nailor Industries Inc.
   5. PHL, Inc.
   6. Ruskin Company.
   7. United Enertech

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: See Division 28.

D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

F. Leakage: Class II.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.

I. Damper Motors: two-position action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
   3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:
1. Auxiliary switches for position indication.
2. Test and reset switches, remote mounted.

2.7 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
4. Nailor Industries Inc.
5. Ruskin Company.
6. United Enertech

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.

G. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

H. Leakage: Class II.

I. Rated pressure and velocity to exceed design airflow conditions.

J. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall
or floor application with factory-furnished silicone caulking.

K. Master control panel for use in dynamic smoke-management systems.

L. Damper Motors: two-position action.

M. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section “Common Motor Requirements for HVAC Equipment.”
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
   3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
   5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
   6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
   7. Electrical Connection: 115 V, single phase, 60 Hz.

N. Accessories:
   1. Auxiliary switches for position indication.
   2. Test and reset switches, remote mounted.

2.8 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Ductmate Industries, Inc.
   2. Nexus PDQ; Division of Shilco Holdings Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.
2.9 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. METALAIRE, Inc.
   4. SEMCO Incorporated.

B. Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.10 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Potterff; a division of PCI Industries, Inc.
   2. Ventfabrics, Inc.
   3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass.

D. Cable: Stainless steel.

E. Wall-Box Mounting: Recessed, 3/4 inches deep.

F. Wall-Box Cover-Plate Material: Stainless steel.
2.11 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
5. Greenheck Fan Corporation.
6. McGill Airflow LLC.
7. Nailor Industries Inc.
8. Pottorff; a division of PCI Industries, Inc.
9. Ventfabrics, Inc.


1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.12 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.
D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

   1. Minimum Weight: 26 oz./sq. yd.
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
   1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
   2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: Not less than 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.13 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Flexmaster U.S.A., Inc.
   2. McGill AirFlow LLC.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 10 to plus 160 deg F.

C. Flexible Duct Connectors:
   1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.14 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and
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gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
   1. Coordinate subparagraphs below with Division 23 Section "Metal Ducts." Install steel volume dampers in steel ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Downstream from manual volume dampers, control dampers and equipment.
   3. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   4. At each change in direction and at maximum 50-foot spacing.
   5. Upstream of turning vanes.
   6. Elsewhere as indicated.
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I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.

K. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

O. Connect diffusers to low-pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with draw bands.

Q. Install duct test holes where required for testing and balancing purposes.

R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.
   5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300
SECTION 233413 - AXIAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Vaneaxial fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight.
on each support. Indicate and certify field measurements.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For axial fans to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
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PART 2 - PRODUCTS

2.1 VANEAXIAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Greenheck.
   2. Loren Cook Company.
   3. Twin City Fan and Blower.

B. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.

C. Housings: Steel.
   1. Inlet and Outlet Connections: Flanges.
   2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.

D. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

E. Wheel Assemblies: Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, cast-aluminum blades; factory mounted and balanced.

F. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor Based on Fan Motor Size: 1.3.
   2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
   3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
   4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   8. Shaft Bearings: Radial, self-aligning ball or roller bearings.
      a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
      b. Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
      c. Extend lubrication lines to outside of casing and terminate with grease fittings.

G. Accessories:
   1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
6. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
7. Flow Measurement Port: Pressure measurement taps installed in the inlet of fan to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
8. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F.
9. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
10. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
11. Inlet Cones: Round-to-round transition of same material as housing.
12. Outlet Cones: Round-to-round transition of same material as housing.

H. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Enclosure Type: Totally enclosed, air over.

I. Factory Finishes:
   1. Sheet Metal Parts: Prime coat before final assembly.
   2. Exterior Surfaces: Baked-enamel finish coat after assembly.

J. Capacities and Characteristics: As indicated on Schedules.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install axial fans level and plumb.

B. Support suspended units from structure using threaded steel rods and vibration isolation indicated below. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
   1. Suspended Units, 4” total static pressure and under: Hanger spring neoprene, with static deflection as indicated below.
      a. 500 FRPM and up: 0.75 inches
      b. 375-499 FRPM: 1.5 inches
      c. 300-374 FRPM: 2.5 inches
      d. 175-299 FRPM: 3.5 inches
2. Suspended Units, above 4” total static pressure: Hanger spring neoprene with horizontal thrust restraints, with static deflection as indicated below.
   a. 500 FRPM and up: 0.75 inches
   b. 375-499 FRPM: 1.5 inches
   c. 300-374 FRPM: 2.5 inches

C. Install units with clearances for service and maintenance.

D. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
   8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
  10. Shut unit down and reconnect automatic temperature-control operators.
  11. Remove and replace malfunctioning units and retest as specified above.
B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. The total fan assembly after installation shall be checked for balance. Fans are to be statically and dynamically balanced to American National Standard Institute (ANSI) balancing tolerance of Grade G6.3 or as per AMCA Standard 204-96 - Balance Quality & Vibration Level for Fans.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

END OF SECTION 233413
SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Airfoil centrifugal fans.
2. Backward-inclined centrifugal fans.
3. Forward-curved centrifugal fans.
4. Plenum fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan performance ratings on sea level.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base
C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 EXTRA MATERIALS

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

1. Belts: [One] set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 AIRFOIL CENTRIFUGAL FANS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

1. Twin City.
2. Aerovent.
4. Bayley Fans; a division of Lau Industries, Inc.
5. Chicago Blower Corporation.
6. CML Northern Blower Inc.
7. Howden Fan Co.
8. Industrial Air; a division of Lau Industries, Inc.
9. Loren Cook Company.
11. Coolair/ILG.
12. <Insert manufacturer's name.>

D. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

E. Housings: Formed panels to make curved-scroll housings with shaped cutoff, with doors or panels to allow access to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Continuously welded, horizontally split, bolted-flange housing.
3. Spun inlet cone with flange.
4. Outlet flange.
5. Housing material will be reinforced steel.
6. Fun shall be minimum Class II unless noted otherwise.

F. Airfoil Wheels: Single-width-single-inlet and double-width-double-inlet steel construction with curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and
fastened to shaft with set screws; and special coating [add special coatings if desired].

G. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

H. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, L10 at [120,000 hours] <Insert hours>.
2. Roller-Bearing Rating Life: ABMA 11, L10 at [120,000 hours] <Insert hours>.

I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

J. Accessories:

1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
2. Cleanout Door: Bolted gasketed door allowing access to fan scroll, of same material as housing.
3. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Spark-Resistant Construction: AMCA 99 [specify A, B or C].

K. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Enclosure Type: Totally enclosed, fan cooled.

L. Capacities And Characteristics: (As indicated on Schedules)

2.2 BACKWARD-INCLINED CENTRIFUGAL FANS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

1. Twin City.
2. Aerovent.
4. Bayley Fans; a division of Lau Industries, Inc.
5. Chicago Blower Corporation.
6. CML Northern Blower Inc.
7. Howden Fan Co.
8. Industrial Air; a division of Lau Industries, Inc.
9. Loren Cook Company.
10. Coolair/ILG.

D. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

E. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Continuously welded, horizontally split, bolted-flange housing.
3. Spun inlet cone with flange.
4. Outlet flange.
5. Housing material will be reinforced steel.
6. Fan shall be minimum Class II unless noted otherwise.

F. Backward-Inclined Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded to flange and backplate; and fastened to shaft with set screws.

G. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

H. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, L10 at [50,000 hours] [120,000 hours] <Insert hours>.
2. Roller-Bearing Rating Life: ABMA 11, L10 at [50,000 hours] [120,000 hours] <Insert hours>.

I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

J. Accessories:

1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
2. Cleanout Door: Bolted gasketed door allowing access to fan scroll, of same material as housing.
3. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Spark-Resistant Construction: AMCA 99 [specify A, B, or C].

K. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.

L. Capacities And Characteristics: (As indicated on Schedules)
FORWARD-CURVED CENTRIFUGAL FANS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

   1. Twin City.
   2. Aerovent.
   3. Bayley Fans; a division of Lau Industries, Inc.
   5. CML Northern Blower Inc.
   6. Howden Fan Co.
   7. Industrial Air; a division of Lau Industries, Inc.
   8. Loren Cook Company.
   9. Coolair/ILG.

D. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor [and disconnect switch], drive assembly, and support structure.

E. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.

   1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   2. Horizontally split, bolted-flange housing.
   3. Spun inlet cone with flange.
   4. Outlet flange.

F. Forward-Curved Wheels: Black-enameled or galvanized steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

G. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

   1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
   2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
H. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   1. Ball-Bearing Rating Life: ABMA 9, L10 at $[50,000 \text{ hours}] [120,000 \text{ hours}] <\text{Insert hours}>.
   2. Roller-Bearing Rating Life: ABMA 11, L10 at $[50,000 \text{ hours}] [120,000 \text{ hours}] <\text{Insert hours}>.

I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   1. Service Factor Based on Fan Motor Size: 1.5.
   2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

J. Accessories:
   1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
   2. Cleanout Door: Quick-opening, latch-type gasketed door allowing access to fan scroll, of same material as housing.
   3. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
   4. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   5. Inlet Screens: Grid screen of same material as housing.
   6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
   7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
   8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

K. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Enclosure Type: Totally enclosed, fan cooled.

L. Capacities And Characteristics: (As indicated on Schedules)
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

C. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

1. Twin City.
2. Aerovent.
4. Bayley Fans; a division of Lau Industries, Inc.
5. Chicago Blower Corporation.
6. CML Northern Blower Inc.
7. Howden Fan Co.
8. Industrial Air; a division of Lau Industries, Inc.
9. Loren Cook Company.
10. Coolair/ILG.

D. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure. Fan shall be minimum Class II.

E. Airfoil Wheels: Single-width-single-inlet steel construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

F. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

G. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, L10 at $[50,000 \text{ hours}]$ $[120,000 \text{ hours}] < \text{Insert hours}>$.
2. Roller-Bearing Rating Life: ABMA 11, L10 at $[50,000 \text{ hours}]$ $[120,000 \text{ hours}] < \text{Insert hours}>$.

H. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: 1.5.
2. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
5. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

I. Accessories:
1. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
2. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

J. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Enclosure Type: Totally enclosed, fan cooled.

K. Capacities And Characteristics: (As indicated on Schedules)

2.5 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Support floor-mounting units using [spring isolators] [restrained spring isolators] <Insert device> having a static deflection of [1 inch] <Insert deflection>. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

E. Support suspended units from structure using threaded steel rods and [elastomeric hangers] [spring hangers] [spring hangers with vertical-limit stops] <Insert device> having a static deflection of [1 inch] <Insert deflection>. Vibration-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Install units with clearances for service and maintenance.

G. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Verify lubrication for bearings and other moving parts.
7. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
8. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
9. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 DEMONSTRATION

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

END OF SECTION 233416
SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of
   product indicated and include the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound-power ratings.
   3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   4. Material thickness and finishes, including color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Roof curbs.
   7. Fan speed controllers.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required
   clearances, method of field assembly, components, and location and size of each field connection.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic
      restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments
      to structure and to supported equipment. Include auxiliary motor slides and rails, and base
      weights.

C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the
following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL FANS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Greenheck BSQ or a comparable product by one of the following:
   2. American Coolair Corp.
   3. Breidert Air Products.
   4. Carnes Company HVAC.
   5. Coolair/ILG.
   7. Penn Ventilation.
   8. Twin City an and Blower.

B. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:
   1. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
   2. Companion Flanges: For inlet and outlet duct connections.
   3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
HVAC POWER VENTILATORS

G. Capacities and Characteristics: As indicated on Schedules.

2.2 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Enclosure Type: Totally enclosed, fan cooled.

2.3 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support suspended units from structure using threaded steel rods and vibration isolation indicated below. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

   1. Suspended Units, 4” total static pressure and under: Hanger spring neoprene, with static deflection as indicated below.
      a. 500 FRPM and up: 0.75 inches
      b. 375-499 FRPM: 1.5 inches
      c. 300-374 FRPM: 2.5 inches
      d. 175-299 FRPM: 3.5 inches

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."
3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
   8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
   10. Shut unit down and reconnect automatic temperature-control operators.
   11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. The total fan assembly after installation shall be checked for balance. Fans are to be statically and dynamically balanced to American National Standard Institute (ANSI) balancing tolerance of Grade G6.3 or as per AMCA Standard 204-96 - Balance Quality & Vibration Level for Fans.
3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 233423
SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Shutoff, single-duct air terminal units.

B. Terminal units utilized in laboratory containment exhaust applications or wet applications shall be stainless steel or have a baked phenolic coating.

1.3 SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.
   1. Air terminal units.
   2. Sealants and gaskets.

B. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.
   3. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustic tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field quality-control reports.

E. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and
maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

D. Units shall be certified under ARI Standard 880-94.

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 7 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

A. Basis-of-Design Product: Subject to compliance with requirements, provide Titus DESV or comparable product by one of the following:
   1. Krueger.
   2. METALAIRE, Inc.
   3. Nailor Industries Inc.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: minimum 22 gauge, double wall.
   1. Casing Lining: Adhesive attached, 1-inch-thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from 0 to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

F. Hydronic Coils: 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 valve.

G. Direct Digital Controls: Single-package unitary controller and actuator specified in Division 23 Section "Building Automation System."

H. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Building Automation System" and shall have the following features:
   1. Damper Actuator: 24 V, powered closed.
   2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated.
AIR TERMINAL UNITS  233600-4

to minimum and maximum air volumes, and having the following features:
a. Occupied and unoccupied operating mode.
b. Remote reset of airflow or temperature set points.
c. Adjusting and monitoring with portable terminal.
d. Communication with temperature-control system specified in Division 23 Section "Building Automation System."

3. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

I. Control Sequence:
1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
2. System-powered, wall-mounted thermostat.

2.3 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Steel Cables: Galvanized steel complying with ASTM A 603.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.
1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and
maintenance. Mount no more than 24 inches above the ceiling.

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

D. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."

E. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
H. Make connections to air terminal units with flexible connectors complying with requirements in Division 23 Section "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

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

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

C. Perform the following field tests and inspections and prepare test reports:
   1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
   2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Air terminal unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
   3. Verify that controls and control enclosure are accessible.
   4. Verify that control connections are complete.
   5. Verify that nameplate and identification tag are visible.
   6. Verify that controls respond to inputs as specified.
3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600
SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

C. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

D. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 GRILLES AND REGISTERS

A. Adjustable Bar Grille:
1. Manufacturers:
   a. Carnes.
   b. Krueger.
   c. METALAIRE, Inc.; Metal Industries Inc.
   d. Price
   e. Titus.
   f. Tuttle and Bailey
3. Finish: Baked enamel, white.
7. Damper Type: Adjustable opposed-blade assembly.

B. Fixed Face Grille:
1. Manufacturers:
   a. Carnes.
   b. Krueger.
   c. Price
   d. Titus.
   e. Tuttle and Bailey
3. Finish: Baked enamel, white.
5. Frame: 1 inch wide.
7. Damper Type: Adjustable opposed-blade assembly.
2.3 LINEAR SLOT OUTLETS

A. Linear Bar Grille or Diffuser:
   1. Manufacturers:
      a. Carnes.
      b. Krueger.
      c. METALAIRE, Inc.; Metal Industries Inc.
      d. Price
      e. Titus.
      f. Tuttle and Bailey
   3. Finish: Baked enamel, white.
   4. Narrow Core Spacing Arrangement: 1/8-inch thick blades spaced 1/4 inch apart, 15-degree deflection.
   5. Two-Way Deflection Vanes: Extruded construction fixed louvers with removable core.
   6. Frame: 1 inch wide.
   7. Mounting: Concealed bracket.
   8. Damper Type: Adjustable opposed-blade assembly.

B. Linear Slot Diffuser:
   1. Manufacturers:
      a. Carnes.
      b. Krueger.
      c. METALAIRE, Inc.; Metal Industries Inc.
      d. Price
      e. Titus.
      f. Tuttle and Bailey
   4. Finish - Face and Shell: Baked enamel, black.
   5. Finish - Pattern Controller: Baked enamel, black.
   7. Slot Width: See air device schedule on drawings.
   8. Number of Slots: See air device schedule on drawings.
   10. Accessories: Plaster frame, insulated inlet plenum.

2.4 CEILING DIFFUSER OUTLETS

A. Rectangular and Square Ceiling Diffusers:
   1. Manufacturers:
      a. Carnes.
      b. Krueger.
      c. METALAIRE, Inc.; Metal Industries Inc.
      d. Price
      e. Titus.
f. Tuttle and Bailey  
3. Finish: Baked enamel, white.  
4. Face Size: See air device schedule on drawings.  
5. Face Style: Three cone.  
6. Mounting: As required by ceiling type.  
9. Accessories:  
   a. Equaling grid.  
   b. Plaster ring.  

B. Louver Face Diffuser:  
1. Manufacturers:  
   a. Carnes.  
   b. METALAIRE, Inc.; Metal Industries Inc.  
   c. Price  
   d. Titus.  
   e. Tuttle and Bailey  
3. Finish: Baked enamel, white.  
4. Face Size: See air device schedule on drawings.  
5. Mounting: As required by ceiling type.  
6. Pattern: See air device schedule on drawings.  
7. Dampers: Radial opposed blade.  
8. Accessories:  
   a. Square to round neck adaptor.  
   b. Adjustable pattern vanes.  
   c. Throw reducing vanes.  
   d. Equaling grid.  
   e. Plaster ring.  

C. Type K: Aluminum supply grilles shall be TITUS direct spiral duct-mounted supply grilles model S301F, single deflection or equal by manufacturers listed, for the sizes and mounting types as shown on the plans and outlet schedule. The deflection blades shall be available parallel to the long or short dimension of the grille.  
1. Air supply grilles shall be constructed with radius end caps and foam gaskets for a tight seal to the duct diameter. All supply grilles shall be constructed with a 1 3/8-inch wide border.  
2. Blades shall be constructed of heavy duty extruded aluminum and shall be spaced 3/4-inch apart. Blades shall extend completely through the side frame on each side to ensure stability throughout the complete cfm operating range of the grille. Blades shall be individually adjustable without loosening or rattling and shall be securely held in place with tension wire.  
3. Air scoop damper/extractor (ASD) shall be constructed of heavy duty aluminum. The ASD must be operable from the face with a screwdriver.  
4. The grille finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-
hour ATM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied. The manufacturer shall provide published performance data for the grille. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

D. Type L: Turbofuser panel mounted nozzle diffusers shall be TITUS model. TBF (steel) or equal by manufacturers listed for the sizes and mounting types as shown on the plans and outlet schedule. Diffuser shall be of heavy duty construction with one, two, three or four nozzles. The TBF model will be constructed of 22-gauge steel nozzles with miscellaneous aluminum components.

1. Each nozzle shall have concentric deep deflection individually adjustable rings, heavy duty pivot bars will maintain numerous deflection settings for rated airflows up to 30° in any direction.
2. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ATM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied. The manufacturer shall provide published performance data for the grille. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

2.5 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements.
for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Air devices shall be selected to provide draft-free air distribution over entire area served and sound rating shall not exceed Noise Criteria (NC) 35.

D. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

E. All devices shall have plaster frames when installed in plaster or drywall construction. Margins shall be as indicated or directed to suit field conditions.

F. Provide an opposed blade volume damper for all diffusers and registers.

G. Align exposed butt edges of linear diffusers using slots and keys or with other concealed means.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713
SECTION 234100 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.3 DEFINITIONS
   A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.
   B. HEPA: High-efficiency particulate air.
   C. ULPA: Ultra low penetration air.

1.4 SUBMITTALS
   A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
   B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.
      1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
      2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
   C. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.
1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ARI 850.

D. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.

E. Comply with NFPA 70 for installing electrical components.

1.6 COORDINATION

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

1.7 EXTRA MATERIALS

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

1. Provide one complete set of filters for each filter bank. If system includes prefilters, provide only prefilters.

2. Provide one container of red oil for inclined manometer filter gage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Air Filters, Electrostatic Air Cleaners, and Filter-Holding Systems:
   a. AAF International.
   b. Farr Co.
   c. Flanders Filters, Inc.
   d. International Air Filtration Corporation.
2. Filter Gages:
   a. Airguard Industries, Inc.
   b. Dwyer Instruments, Inc.

2.2 PRE FILTERS (TYPE “A”)
   A. Pre filters shall consist of pleated media; media support grid, and enclosing frame. The filters shall be labeled by Underwriters Laboratories as Class 2.
   B. Filters shall have a nominal depth of 4" and initial pressure drop at 500 FPM filter velocity shall not exceed 0.3". Pre-filters shall be rated for a maximum final resistance of 0.90".
   C. The media shall be non-woven cotton fabric and shall have a minimum efficiency of 25-30%, MERV 7 with minimum arrestance of 90-92%. The media support shall be a welded wire grid with an effective open area of not less than 96%. The grid shall be bonded to the filter media to eliminate media oscillation and pull away. The enclosing frame shall be constructed of rigid, heavy duty, high wet strength beverage board.
   D. Filters shall be Camfil Farr 30/30, or approved equal.

2.3 FINAL FILTERS (TYPE “B”)
   A. Secondary and final filters shall be of the high performance, deep pleated, totally rigid cartridge type and shall consist of a filter media, media support grid, contour stabilizers, diagonal support bracing, and enclosing frame. The filters shall have a nominal depth of 12" and minimum efficiency of 90%, MEV 13. The filter shall be Underwriters Laboratories Listed as Class 2. The filter shall be capable of withstanding 10" W.G. pressure drop without noticeable distortion of the media pack.
   B. The filter media shall be a high-density micro-fine glass fiber laminated to a reinforcing backing to form a lofted filter blanket. Initial pressure drop at 500 FPM filter velocity shall not exceed . All filters shall be rated for a maximum final resistance of 1.50".
   C. Filters shall be Camfil Farr Riga-Flo or approved equal.

2.4 ACTIVATED-CARBON FILTERS (TYPE “E”)
   A. Rechargeable activated carbon adsorbers shall be the full flow high velocity type. Each 24" x 24" x 29" deep adsorber housing shall contain twelve (12) removable carbon panels and a total of 90 pounds of activated carbon, and shall be rated for a flow rate of 2000 CFM. The housing shall be constructed of galvanized steel, with provision for dust filters on both entering and leaving airsides, and shall be suitable for upstream or down-stream service.
B. The adsorber shall have a single pass average efficiency of 95% on ozone and a maximum pressure drop of 0.50” at 500 FPM velocity. The activated carbon shall be contained in removable panels constructed of high heat, medium impact polystyrene plastic to withstand corrosion, and so installed as to preclude the possibility of air bypass. The panels shall contain internal separators to minimize the settling of the carbon and shall be capable of being refilled. The activated carbon shall have an activity rating of at least 50 minutes by the Standard Government Accelerated Chloropicrin Test. Filters shall be Camfil Farr Model CF-4, or approved equal.

2.5 OPTIONAL - DISPOSABLE CARBON FILTERS

A. Disposable activated carbon panels shall be of the total detention disposable type with not less 12 pounds of 60% activity coconut shell carbon. A fully welded 28” deep steel housing with Grey enamel finish shall accommodate the disposable carbon panels and 1” deep medium efficiency disposable after-filters in a "V" configuration.

B. The 24” x 24” housing shall contain four (4) disposable panels with a total of 48 pounds of activated carbon and four (4) after-filters. The adsorber shall have a single pass average efficiency of 80% on ozone and a maximum pressure drop of 0.32” at 500 FPM velocity.

2.6 FRONT- AND REAR-ACCESS FILTER FRAMES

A. Filter frames shall be installed within a framework of 1” wide X 2” deep tubular steel. This framework shall provide openings no greater than 48” x 48” into which a maximum of (4) 24” X 24” filter frames shall be installed.

B. Holding frames shall be 16-ga. galvanized steel construction with a 3/4” flange and closed cell polyurethane foam gasket seal.

C. Filter retainer hardware shall be manufactured and catalogued for use with the specific filters provided. Cartridge filters shall have spring fasteners capable of withstanding 25 lbs. pressure without deflection.

D. Framing System: Aluminum framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters prevent deflection of horizontal members without interfering with either filter installation or operation.

E. Prefilters: Incorporate a separate track, removable from front or back.

F. Sealing: Factory-installed, positive-sealing device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.

G. Filter frames shall be Camfil Farr Type 8, or approved equal.
2.7 SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of galvanized steel, with flanges to connect to duct system.

B. Prefilters: Integral tracks to accommodate 2-inch disposable or washable filters.

C. Access Doors: Continuous gaskets on perimeter and positive-locking devices. Arrange so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.8 FILTER GAGES

A. Air filter gauges shall be provided for each bank of filters and mounted flush with unit casing.

B. Each gauge shall be a diaphragm actuated, dial type gauge with zero adjustment, 3-way vent valves, static pressure tips, integral compression fittings on both valves and tips, and aluminum surface mounting bracket with screws. Gauge shall be Dwyer Instruments, Inc., Series 2000 Magnehelic differential pressure gauge.

C. Gauges shall have a range of 0 to 1.0" for pre-filter banks, 0 to 2.0" for ASHRAE cartridge filter banks, 0 to 3.0" for two stage banks and 0 to 3.0" for HEPA filter banks.

D. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
   1. Diameter: 4-1/2 inches.
   2. Range: 0- to 2.0-inch wg.

E. Manometer-Type Filter Gage: Molded plastic with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within 3 percent of full scale range.

F. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gage for each filter bank.

E. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling unit installations.

G. Electrical wiring and connections are specified in Division 26 Sections.

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

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components, filter and filter-frame installation, and electrical wiring and to assist in field testing. Report results in writing.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234100
SECTION 235100 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes the following:
      1. Listed double-wall vents.
   B. Related Sections include the following:
      1. Division 23 Section "Draft Control Devices" for induced-draft and mechanical fans and for motorized and barometric dampers.

1.3 SUBMITTALS
   A. Product Data: For the following:
      1. Special gas vents.
      2. Guy wires and connectors.
   B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
      1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
      2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   C. Welding certificates.
   D. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:
      1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Breeching, Chimneys, and Stacks: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of anchorage devices on which the certification is based and their installation requirements.

E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.


C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: 15 years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Heat-Fab, Inc.
   2. Metal-Fab, Inc.
   3. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
   4. Van Packer.
   5. Z-Flex; Flexmaster Canada Limited.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.

D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

E. Outer Jacket: Stainless steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 APPLICATION

A. Listed Special Gas Vent: Condensing gas appliances.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

G. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

H. Erect stacks plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 235100
SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, water-tube condensing boilers, trim, and accessories for generating hot water.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
   1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
      a. Design Calculations: Calculate requirements for selecting vibration isolators for designing vibration isolation bases.
      b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
   2. Wiring Diagrams: Power, signal, and control wiring.

C. Source quality-control test reports.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

F. Warranty: Special warranty specified in this Section.

G. Other Informational Submittals:
   1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic
testing of piping external to boiler.

1.4 QUALITY ASSURANCE

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

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."


E. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.5 COORDINATION

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

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers:
   a. Leakage and Materials: 10 years from date of Substantial Completion.
   b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Non-prorated for five years from date of Substantial Completion.

2. Warranty Period for Water-Tube Condensing Boilers: 20 years from date of Substantial Completion.

3. Warranty Period for Water-Jacketed Condensing Boilers:
   a. Leakage and Materials: Eight years from date of Substantial Completion.
   b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Non-prorated for five years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Aerco Benchmark Series or a comparable product by one of the following:
   1. Fulton Boiler Works, Inc.
   2. Hydrotherm, Inc.; a division of Mestek, Inc.
   3. Heat Transfer Products, Inc.
   4. Lochinvar Corporation.

2.2 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, and -tested, water-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

B. Heat Exchanger: Cast aluminum.

C. Combustion Chamber: Stainless steel, sealed.

D. Burner: Natural gas, forced draft drawing from gas premixing valve.

E. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
   1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
      a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

G. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.

H. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.

I. Casing:
   1. Jacket: Sheet metal, with snap-in or interlocking closures.
   2. Control Compartment Enclosures: NEMA 250, Type 1A.
   4. Insulation: Minimum 2-inch-thick, mineral-fiber insulation surrounding the heat exchanger.
6. Mounting base to secure boiler.

J. Characteristics and Capacities: See schedule on drawings.

2.3 TRIM
A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch-diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.


G. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

2.4 CONTROLS
A. Refer to Division 23 Section "Instrumentation and Control for HVAC."

B. Boiler operating controls shall include the following devices and features:
1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Operating Pressure Control: Factory wired and mounted to cycle burner.
4. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
5. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
6. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F outside-air temperature, set supply-water temperature at 140 deg F; at 60 deg F outside-air temperature, set supply-water temperature at 120 deg F.
7. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
CONDENSING BOILERS

Fayetteville Regional Airport – Airline Terminal Improvements – Part 1
Owner: City of Fayetteville
Fayetteville, North Carolina
AP#1515
RMF Engineering, Inc.
July 18, 2016

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

2.6 VENTING KITS

A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
B. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
   1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

B. Vibration Isolation: Elastomeric isolation pads with a minimum static deflection of 0.25 inch. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install gas-fired boilers according to NFPA 54.

D. Assemble and install boiler trim.
E. Install electrical devices furnished with boiler but not specified to be factory mounted.

F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "Common Work Results for HVAC."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

I. Boiler Venting:
   1. Install flue venting kit and combustion-air intake.
   2. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, and Stacks."

J. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist
B. Tests and Inspections:
1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
   b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests:
1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.
   a. Test for full capacity.
   b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.

3.5 DEMONSTRATION

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

END OF SECTION 235216
SECTION 236426 - ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged, air-cooled, electric-motor-driven, rotary-screw water chillers with the following features:
   1. Motor controller.

1.3 DEFINITIONS

A. EER: Energy-efficiency ratio.

B. IPLV: Integrated part-load value.

1.4 SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Complete set of manufacturer's certified prints of water chiller assemblies, control panels, sections, and elevations, and unit isolation. Include the following:
   1. Assembled unit dimensions.
   2. Operating weight and load distribution.
   3. Required clearances for maintenance and operation.
   4. Size and location of piping and wiring connections.
   5. Vibration Isolation Calculations and Details: Signed and sealed by a qualified professional engineer.
      a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
      b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
C. Coordination Drawings: Floor plans drawn to scale and coordinated with the following:
   1. Structural supports.
   2. Piping roughing-in requirements.
   3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
   4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

D. Certificates: For certification required in "Quality Assurance" Article.

E. Manufacturer Seismic Qualification Certification: Submit certification that water chillers, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Source quality-control test reports.

G. Startup service reports.

H. Operation and Maintenance Data: For each water chiller to include in emergency, operation and maintenance manual.

I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. ARI Certification: Signed by manufacturer certifying compliance with requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

B. ASHRAE Certification: Signed by manufacturer certifying compliance with ASHRAE 15 for safety code for mechanical refrigeration. Comply with ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.

C. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
D. Comply with NFPA 70.

E. Comply with UL 1995.

F. Green Seal Certification: Signed by manufacturer certifying compliance with Green Seal's GS-31.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant or nitrogen.

1.7 COORDINATION

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

B. Coordinate installation of roof curbs and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Carrier; a United Technologies Company.
2. Dunham-Bush.
4. Trane Company (The).
5. YORK International Corporation.
2.2 PACKAGED WATER CHILLERS

A. Description: Factory-assembled and -tested water chiller complete with casing, compressor, heat exchanger, condenser coils and fans, and controls integrated with compressor operation.
   2. Fans: Propeller type, statically and dynamically balanced, with vertical air discharge for high efficiency and low sound; located in its own compartment to eliminate cross flow of condenser air during fan cycling; and equipped with heavy-gage, weather-protected fan guard.
   3. Fan Motor: Direct drive, weatherproof, with bearings permanently lubricated, and having built-in current- and thermal-overload protection.

B. Fabricate water chiller mounting frame and attachment to the pressure vessel with reinforcement strong enough to resist water chiller movement during a seismic event when the water chiller mounting frame is anchored to the building structure.

C. Water Chiller Characteristics and Capacities: Refer to Schedule.

2.3 COMPRESSORS

A. Description: Positive displacement, oil injected with direct-drive, [open] [hermetically sealed] motor.
   1. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
   2. Rotors: Screw.

B. Capacity Control: Hydraulically operated, modulating or stepped sliding valve to maintain chilled-water temperature set point without hunting within throttling range. Throttling range shall be from 100 to 20 percent of full load.

C. Oil Lubrication System: Positive-displacement submersible pump with heater, oil filter, and sight glass.

D. Refrigerant and Oil: HFC-134a.

E. Refrigerant Compatibility: Seals, O-rings, motor windings and internal water chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

F. Refrigerant Circuit: Two independent circuits. Each circuit shall include an electronic expansion valve, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter drier, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
2.4 HEAT EXCHANGERS

A. Evaporator:
   1. Description: Shell-and-tube design, ASME labeled.
   3. Tube Construction: Individually replaceable, expanded into tube sheets.
      a. Material: Copper.
   4. Water Box: Standard, with design working pressure of 150 psig (1035 kPa), and having
      grooved mechanical-joint coupling water-nozzle connections with a thermistor-type
      temperature sensor factory installed in each nozzle.

B. Air-Cooled Condenser: Copper tubes with mechanically bonded aluminum fins with corrosion-
   resistant coating] integral subcooling circuit, leak tested at 450 psig (3105 kPa).
   1. Safety and Operating Options: Low-ambient controls for operation down to 25 °C

2.5 INSULATION

A. Cold Surfaces: Closed-cell, flexible elastomeric, thermal insulation complying with
   ASTM C 534, Type II, for sheet materials.
   1. Thickness: 1-1/2 inches (38 mm).
   2. Adhesive: As recommended by insulation manufacturer.
   3. Factory apply insulation over entire surfaces of water chiller components.
      a. Apply adhesive to 100 percent of insulation contact surface.
      b. Seal seams and joints.
      c. After adhesive has fully cured, apply two coats of protective coating to insulation.

2.6 ACCESSORIES

A. Pressure Relief Valve: Single- or multiple-seating-type, spring-loaded relief valve.

2.7 CONTROLS

A. Control Panel: Stand-alone, microprocessor based.

B. Enclosure: Unit-mounted, NEMA 250, Weather tight enclosure, hinged or lockable; factory
   wired with a single-point power connection and a separate control circuit.

C. Status Display: Multiple-character liquid-crystal display or light-emitting diodes and keypad.
   Display the following conditions:
   1. Date and time.
   2. Operating or alarm status.
   3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Entering and leaving temperatures of chilled water.
7. Entering and leaving temperatures of condenser water (for water-cooled water chillers only).
8. Refrigerant pressures in evaporator and condenser.
9. Saturation temperature in evaporator and condenser.
10. Oil temperature and pressure.
13. Number of compressor starts.

D. Control Functions:
1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water temperature shall be reset based on return-water temperature.
3. Current limit and demand limit.
4. External water chiller emergency stop.

E. Manually Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
1. Low evaporator pressure; high condenser pressure.
2. Low chilled-water temperature.
3. Low oil differential pressure.
4. High or low oil pressure.
5. High oil temperature.
6. High compressor-discharge temperature.
7. Loss of chilled-water flow.
8. Electrical overload.
9. Sensor- or detection-circuit fault.
11. Starter fault.

F. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control chilled-water set point and chiller-control displays and alarms.

2.8 MOTORS

A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Open-drive motors shall have flanged or flexible coupling suitable for direct connection to compressor.
2.9 MAGNETIC ENCLOSED CONTROLLERS

A. Enclosure: Unit mounted, NEMA 250 Type 3R, with hinged access door with lock and key or padlock and key.

B. Control Circuit: 120 V; obtained from integral control power transformer with a control power source of enough capacity to operate connected pilot and indicating and control devices.

C. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of water chiller control microprocessor.

D. Star-Delta Controller: NEMA ICS 2, closed transition.

E. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
   1. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   2. Light-emitting-diode indicators showing motor and control status, including the following conditions:
      a. Controller on.
      b. Overload trip.
      c. Loss of phase.
      d. Starter fault.

F. Accessories: Devices shall be factory installed in controller enclosure, unless otherwise indicated.
   1. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
      a. Selectable, digital display of the following:
         1) Phase Currents, Each Phase: Plus or minus 1 percent.
         2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
         3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
         4) Three-Phase Real Power: Plus or minus 2 percent.
         5) Three-Phase Reactive Power: Plus or minus 2 percent.
         6) Power Factor: Plus or minus 2 percent.
         7) Frequency: Plus or minus 0.5 percent.
         8) Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
         9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
      b. Mounting: Display and control unit flush or semirecessed in instrument compartment door.
   2. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hard-wired connections.
2.10 SOURCE QUALITY CONTROL

A. Factory test and rate water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle." Stamp with ARI label.

B. Factory test heat exchangers hydrostatically at 1.50 times the design pressure.

C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. Factory test and inspect water boxes at 150 percent of working pressure.

E. Rate sound power level according to ARI 575 procedure.

F. Rate sound power level according to ARI 370 procedure.

G. Allow Owner access to places where water chillers are being source quality-control tested. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping, and electrical to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
   1. Final water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

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

3.2 WATER CHILLER INSTALLATION

A. Install water chillers on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

B. Concrete Bases: Anchor chiller mounting frame to concrete base.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams,
instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Cast-in-place concrete materials and placement requirements are specified in Division 03.

C. Vibration Isolation: Rubber pads with a minimum deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Vibration Isolation: Mount water chiller on vibration isolation equipment base as specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Charge water chiller with refrigerant if not factory charged.

G. Install separate devices furnished by manufacturer.

3.3 CONNECTIONS

A. Chilled-water piping installation requirements are specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Evaporator Connections: Connect inlet to evaporator with controller-bulb well, shutoff valve, thermometer, strainer, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, flow switch, balancing valve, thermometer, pressure gage, and union or flange.

D. Refrigerant Pressure Relief Valve Connections: Extend vent piping to the outside without valves or restrictions.

E. Ground water chillers according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

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

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
   2. Verify that pumps are installed and functional.
   3. Verify that thermometers and gages are installed.
   4. Operate water chiller for run-in period according to manufacturer's written instructions.
   5. Check bearing lubrication and oil levels.
   6. Verify that refrigerant pressure relief is vented outside (for water-cooled water chillers).
   7. Verify proper motor rotation.
   8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
  11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

3.5 DEMONSTRATION

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

END OF SECTION 236426
SECTION 237313 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Variable-air-volume, single-zone air-handling units.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/200 where "L" is the unsupported span length within completed casings.

1.4 SUBMITTALS

A. Product Data: For each air-handling unit indicated.
   1. Unit dimensions and weight.
   2. Cabinet material, metal thickness, finishes, insulation, and accessories.
   3. Fans:
      a. Certified fan-performance curves with system operating conditions indicated.
      b. Certified fan-sound power ratings.
      c. Fan construction and accessories.
      d. Motor ratings, electrical characteristics, and motor accessories.
   4. Certified coil-performance ratings with system operating conditions indicated.
   5. Dampers, including housings, linkages, and operators.
   6. Filters with performance characteristics.

B. LEED Submittals:
   2. Product Data for Credit EA 5: For continuous metering equipment for outdoor airflow and energy consumption.

C. 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. Attic layout and relationships between components and adjacent structural and mechanical elements.
2. Support location, type, and weight.
3. Field measurements.

D. Source quality-control reports.

E. Field quality-control reports.

F. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

D. Comply with NFPA 70.

1.6 COORDINATION

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

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set for each air-handling unit.
   2. Gaskets: One set for each access door.
   3. Fan Belts: One set for each air-handling unit fan.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Buffalo Air Handling Model K
   2. CES Group
   3. Carrier Corporation; a member of the United Technologies Corporation Family.
   4. Mammoth Inc.
   5. Daikin
   6. Trane; American Standard Inc.
   7. YORK International Corporation.

2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:
   1. Two (2) inch panelized or post/sheeting construction for walls, roofs and floors.
   2. Casing Joints: Sheet metal screws with gasketing.
   3. Sealing: Seal all joints with water-resistant sealant.

B. Factory Finish for Steel and galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.

C. Casing Insulation and Adhesive:

D. Materials: ASTM C 1071, Board Type or polyurethane foam.
   1. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of all section panels.
      a. Liner Adhesive: Comply with ASTM C 916, Type I.
      b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
   2. Location and Application: Encased between outside and inside casing.

E. Inspection and Access Panels and Access Doors:
   1. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
   2. Inspection and Access Panels:
      a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
      b. Gasket: Neoprene, applied around entire perimeters of panel frames.
      c. Size: Full height of unit and minimum of 24 inches wide.
3. Access Doors:
   a. Hinges: Continuous stainless steel hinges and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.
   c. Fabricate windows in doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
   d. Size: At least 18 by 60 inches.

4. Locations and Applications:
   a. Fan Section: Doors.
   b. Access Section: Doors.
   c. Coil Section: Inspection and access panel.
   d. Damper Section: Doors.
   e. Filter Section: Doors large enough to allow periodic removal and installation of filters.

5. Service Light: 100-W vaporproof fixture in each section accessed with door, with switched junction box located outside adjacent to door.

F. Condensate Drain Pans:
   1. Fabricated with slopes in at least 2 planes to collect condensate from cooling coils (including coil piping connections, coil headers and return bends.
   2. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
   3. A minimum of 2 inches deep, and complying with requirements in ASHRAE 62.1.
   4. Drain Connections: Both ends of pan with NPS 1 threaded nipple.
   5. Pan-Top Surface Coating: Asphaltic waterproofing compound.
   6. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

G. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

2.3 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
   1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
      a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
      b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
   1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
4. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch- wide, 0.028-inch-thick, galvanized-steel sheet or 0.032-inch-thick aluminum sheets; select metal compatible with casing.
      1) Fabric Minimum Weight: 26 oz./sq. yd..
      2) Fabric Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
      3) Fabric Service Temperature: Minus 40 to plus 200 deg F.
C. Plug Fans Housings: Steel cabinet; fabricated without fan scroll and volute housing.
D. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
E. Fan Shaft Bearings:
   1. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and 2-piece, cast-iron housing with grease lines extended to outside unit and a rated life of 50,000 hours according to ABMA 11.
F. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
   1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
   4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch-thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.
G. Discharge Dampers: Heavy-duty steel assembly with channel frame and sealed ball bearings, and opposed blades constructed of two plates formed around and welded to shaft, with blades linked out of air stream to single control lever.
H. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 2 inches.
   1. Enclosure Type: Totally enclosed, fan cooled.
   2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
4. Mount unit-mounted disconnect switches on exterior of unit.

I. Variable Frequency Controllers: (Refer to Section 262923)

2.4 COIL SECTION

A. General Requirements for Coil Section:
   1. Comply with ARI 410.
   2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
   3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
   4. Coils shall not act as structural component of unit.

2.5 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:
   1. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   2. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

B. Disposable Panel Filters: (Type “A”)
   2. Thickness: 2 inches.
   3. Initial Resistance: 0.25 inches at 500 FPM.
   4. Recommended Final Resistance: 0.75 inches at 500 FPM.
   5. Arrestance (ASHRAE 52.1): >90.
   6. Dust Spot Efficiency: 30 – 35%
   9. Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

C. Extended-Surface, Nonsupported-Media Filters:
   2. Initial Resistance: 0.7 inch at 500 FPM.
   3. Recommended Final Resistance: 1.5 inch at 500 FPM.
   6. Media: Fibrous material with antimicrobial agent constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions.
   8. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter.
D. Filter Gage:
1. 3-1/2-inch-diameter, diaphragm-actuated dial in metal case.
2. Vent valves.
3. Black figures on white background.
4. Front recalibration adjustment.
5. 2 percent of full-scale accuracy.
6. Range: 0- to 2.0-inch wg.
7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch aluminum tubing, and 2- or 3-way vent valves.

2.6 DAMPERS

A. Retain this article to require that dampers be provided by air-handling unit manufacturer; delete if dampers are specified in Division 23 Section "Instrumentation and Control for HVAC." General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.

B. Electronic Damper Operators:
1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and premium efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC."
   b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
   c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers for running torque calculated as follows:
   b. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
   c. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
   d. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
10. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
11. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
12. Temperature Rating: Minus 22 to plus 122 deg F.
13. Run Time: 12 seconds open, 5 seconds closed.

2.7 CHARACTERISTICS

A. Casing:
   1. Outside Casing: Galvanized steel, minimum 18 gauge thick.
   2. Inside Casing: Galvanized steel, solid, minimum 0.036 inches, 20 gauge thick.
   3. Inside Cooling coil Section Casing: Stainless steel, solid, minimum 0.036, 20 gauge thick.
   4. Floor Plate: Galvanized steel, minimum 0.064 inch 14 gauge thick.
   5. Insulation Thickness: 2 inches.
   6. Static-Pressure Classifications for Unit Sections before Fans: 4-inch wg.
   7. Static-Pressure Classifications for Unit Sections after Fans: 4-inch wg.

B. Supply Fan:
   2. Drive: V-belt.
   3. Type: Steel, airfoil centrifugal.
   5. Total Static Pressure: Refer to Schedule.
   6. External Static Pressure: Refer to Schedule.
   7. Maximum Fan Discharge Sound Power:
      a. 1st Octave: 98 db.
      b. 2nd Octave: 102 db.
      c. 3rd Octave: 104 db.
      d. 4th Octave: 97 db.
      e. 5th Octave: 94 db.
      f. 6th Octave: 86 db.
      g. 7th Octave: 83 db.
      h. 8th Octave: 79 db.

C. Preheat Coil: Refer to Section 238216

D. Cooling Coil: Refer to Section 238216

E. Prefilters:
   1. Type: MERV 8.

F. Filters:
   1. Type: MERV 13.
2.8 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Equipment Mounting: Install air-handling units on concrete bases using elastomeric pads. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
   1. Minimum Deflection: 2 inches.
   2. Install galvanized-steel plate to equally distribute weight over elastomeric pad.
   3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
   4. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   6. Install anchor bolts to elevations required for proper attachment to supported equipment.
B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

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

C. Tests and Inspections:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.

2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm
3. Proper motor rotation and unit operation.

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

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
7. Comb coil fins for parallel orientation.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

A. After startup service, clean air-handling units internally on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and
construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, clean filter housings and install new, clean filters.

C. Replace filters immediately prior to occupancy according to the LEED EQ Credit 3.1, "Construction IAQ Management Plan."

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.
SECTION 238121 - PRECONDITIONED AIR UNIT AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. The City of Fayetteville, North Carolina (Owner) proposes to add two (2) new Passenger Boarding Bridges (PBB’s) and associated equipment for the new “A” terminal at the Fayetteville Regional Airport (FAY).

B. The Owner also wishes to receive bids for two (2) Add Alternates.

1. Add Alternate 1 - The Contractor shall supply and install one (1) new PBB, GPU and PCAir at new “A” terminal Gate A1, as indicated on the Drawings and in these Specifications, including all structural, support, mechanical, electrical, and finish requirements to serve the aircraft mix indicated on the Drawings and in these Specifications.

2. Add Alternate 2 - The Contractor shall supply and install one (1) new PBB, GPU and PCAir at new “A” terminal Gate A2, as indicated on the Drawings and in these Specifications, including all structural, support, mechanical, electrical, and finish requirements to serve the aircraft mix indicated on the Drawings and in these Specifications.

C. The Contractor and PCAir manufacturer shall provide the necessary information, product data, project management, coordination and installation support to the PBB manufacturer so that the PCAir supplied fully integrates and functions with the PBB and meets all of the PCAir requirements of Section 347713 – PASSENGER BOARDING BRIDGES.

D. The PCAir manufacturer shall also be required to fully coordinate with the Contractor performing the other parts of this Project.

E. Related Work Specified Elsewhere:

1. GENERAL PROVISIONS
2. DIVISION 01 – GENERAL REQUIREMENTS
3. SECTION 238121 - PRECONDITIONED AIR UNIT AND ACCESSORIES
4. SECTION 347713 – PASSENGER BOARDING BRIDGES

1.1 REFERENCES

A. The PCAir shall be designed and manufactured to meet U.S. Codes and Regulations that have been adopted by the Aircraft Preconditioned Air and Passenger Boarding Bridge industry. Portions or all of certain recognized industry or association standards referred to herein as being a requirement of these Specifications shall be considered as binding as though the reproduced in full herein unless supplemented and/or modified by more stringent requirements in this Specification. Unless otherwise stated, the reference standard shall be the standard which is
B. Applicable Standards:

1. American Bearing Manufacturers Association (ABMA).
   a. 9 - Load Rating and Fatigue Life for Ball Bearings.
   b. 11 - Load Rating and Fatigue Life for Roller Bearings.

2. Air-Conditioning and Refrigeration Institute (ARI):
   b. 850 - Commercial and Industrial Filter Equipment.

3. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

4. Canadian Standards Association (CSA):
   a. C22.2.107.1 - General Use Power Supplies.
   b. C22.2,236 – Heating and Cooling Equipment

5. International Air Transport Association (IATA) – Airport Handling Manual (AHM)
   a. 973 & 974 – Air Conditioning and Heating

6. Institute of Electrical and Electronic Engineers (IEEE)

   a. 70 - National Electrical Code.
   b. 79 – Electrical Standard for Industrial Machinery
   c. 90A - Standard for Installation of Air Conditioning and Ventilation Systems.

8. National Electrical Manufacturer's Association (NEMA):
   a. MG1 - Motors and Generators.

9. Society of Automotive Engineers (SAE):
   b. ARP 5374 - Method of Testing Preconditioned Air Equipment.

10. Underwriters Laboratories (UL):
    a. 1012 - Power Units Other than Class 2.
    b. 268A - Smoke Detectors for Duct Application.
    c. 1995 – Heating and Cooling Equipment

11. Applicable state, county and local construction and electrical codes

1.2 DEFINITIONS
A. The City of Fayetteville, North Carolina is the Owner and contracting entity for this project.

B. The Owner shall appoint a Project Manager (Owner PM) as the Owner representative for this Project. All project correspondence, submittals, RFI’s, questions, etc. shall be directed to the Owner PM. The Owner shall notify the Contractor of the Owner PM’s contact information when the contract is awarded.

C. The term “Day” or “Days” shall refer to work days not calendar days.

D. The terms "Preconditioned Air Unit", or “PCAir” and specified components of these, whether referred to in singular or plural form, apply to each unit provided for this Project.

E. PBB Tunnels "A," "B," and "C", if referred to, are referred to in the order from closest to the terminal to closest to the aircraft.

F. The terms "right" and "left" refer to directions looking down the PBB tunnels toward the aircraft.

G. The term “Manufacturer” shall mean the PCAir and / or PCAir accessory manufacturer(s).

H. Any Specification language that is lined through shall not be considered requirements for this Project.

1.3 SUBMITTALS

A. Shop Drawings, Samples and Required Documentation (Submittals) shall be supplied in accordance with the requirements of this Specification and of DIVISION 01 – GENERAL REQUIREMENTS.

1. All Shop Drawings, Samples and Required Documentation submitted in English language and in Inch-Pound units, including dimensions, volumes, weights, and forces.

2. The Owner’s review, comment, approval or rejection of the Contractor’s Submittals shall not be considered a prerequisite for the Contractor to undertake the design, procurement of materials and manufacturing of the PCAir and accessories.
   a. If the Contractor is required to undertake the design, procurement of materials and manufacturing of the PCAir and accessories prior to the Owner’s review and approval of the Contractor’s submittals, the Contractor shall undertake these activities at its own risk and shall modify the design, material procurement and manufacturing based on the Owner’s review, comment, approval or rejection of the Contractor’s Submittals.
   b. Any such modification shall be at the cost of the Contractor and shall not impact the
Project schedule.

B. **Shop Drawings** - All drawings, diagrams, illustrations, schedules, test reports, certifications, cut sheets, calculations and other data or information which are specifically prepared and submitted by the Contractor to demonstrate that the Contractor will provide a PCAir and accessories which meets the requirements of the Project Specifications and Drawings.

1. Shop Drawing submittals shall show sufficient detail to indicate conformance to the requirements of the Project Specifications and Drawings.

2. Shop Drawing submittals shall be organized in a manner so that compliance to Project Specifications and Drawings can be easily determined by the Owner.

3. Before submitting each Shop Drawing package, the Contractor shall have determined and verified that the Shop Drawing submittal does in fact demonstrate compliance to the Project Specifications and Drawings.
   a. Shop Drawing packages that contain information that is not in compliance with the Project Specifications and Drawings will be rejected and will require re-submittal.

4. Manufacturer's assembly or fabrication drawings that do not provide information needed to determine compliance with requirements of the Project Specifications and Drawings are not acceptable and shall not be submitted.

C. **Samples** - Physical examples of materials, equipment, or workmanship that are representative of some portion or all of the PCAir or its components and accessories and which establish the standards by which certain portions of the PCAir, its components, accessories or installation will be judged.

D. Contractor shall submit Shop Drawings, Samples and Required Other Documentation for Owner’s review and approval in accordance with the schedule required in approved Progress Schedule and **APPENDIX I – SUBMITTAL SCHEDULE**.

1. All submittals will be identified as required and furnished in the number of copies specified in the Contract Documents.

2. The data shown on the Shop Drawings and Required Documentation will be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Owner the services, materials, and equipment Contractor proposes to provide.

E. Shop Drawings and Samples shall include but not be limited to the following:

1. An index prepared in sequential order listing all drawings, sketches, details, and material submitted.

2. Product Data: Manufacturer's technical product data, including specifications. Include data substantiating that materials comply with requirements.
3. PCAir Unit Data: Manufacturer's technical product data, including but not limited to the following:
   a. Fan performance curves with system operating conditions indicated.
   b. Motor ratings and electrical characteristics plus motor and fan accessories.
   c. Blower motor manufacturer specifications.
   d. Materials, gauges, and finishes.
   e. Filters
   f. Condensate pump and system
   g. Compressor data.
   h. Data on coil design, construction, coating, etc.
   i. Refrigerant line routing, installation and supports
   j. Refrigerant line dryers and mounting
   k. Access doors and panels
   l. Temperature Probe
   m. Pendant Control
   n. Electrical / Controls schematics.
   o. Wiring diagrams detailing wiring for power, signal, and control systems and differentiate between portions of wiring that are factory-installed and portions to be field-installed.
   p. Insulation details
   q. Interface details / information to PBB HMI display
   r. Methods of field assembly, components, and locations and size of each field connection. Detail mounting and securing to passenger boarding bridges, including brackets.

4. Accessory Product Data: Submit manufacturer's technical data for each type of ductwork, support straps, support elbows, fitting, flexible connection, aircraft adaptor nozzle, and hose basket reel, including dimensions, capacities, and materials of construction; and installation instructions.

5. Provide drawings and procedures that will be provided to installation subcontractor the required details and information for the removal, scrap or storage of PCAir and ancillary equipment and the installation of the new or existing PCAir and new ancillary equipment.
   a. Drawings and procedures shall provide sufficient detail so that the installation subcontractor can successfully complete the removal, scrap or storage of the existing PCAir and ancillary equipment and install the new or existing PCAir and new ancillary equipment.

6. Contractor shall provide within 30 days of Contract Award, all technical data and calculations to demonstrate that the offered 6030-ton PCAir units shall have the capability to provide the Steady State cooling and heating performance at the specified design day conditions for each of the largest RJ, NB and WB aircraft in the aircraft mix.
   a. Calculations shall identify the required volume, pressure and temperature of the air AT THE AIRCRAFT CONNECTION to meet these cooling and heating requirements.
   b. Air temperature, volume and pressure loss assumptions for the greatest length of PCAir hose required by the aircraft mix and any Telescoping Air Duct (TAD) shall be shown and be taken into consideration when determining the air temperature, pressure and volume are
delivered at the aircraft connection.

c. The PCAir manufacturer shall NOT rely solely on supplying calculations based on air
temperature, pressure and volume at the discharge of the unit.

d. Calculations shall be based on and reference the requirements defined in the specified
Aircraft Planning Manuals or other information provided by the aircraft manufacturer.

e. Calculations shall reflect the temperature rise that occurs during any compressor defrost
cycle. The amount and duration of such temperature rise shall not impact the ability of
the PCAir unit to provide the required air temperature at the aircraft connection required
to maintain the Steady State cooling performance at the specified design day conditions
of the largest RJ, NB and WB aircraft in the aircraft mix.

7. Contractor shall provide a Description of Operation that defines the method of capacity
control for refrigeration (i.e., cylinder unloading, hot-gas bypass) and heating systems,
defrost cycle, air volume control, and overload protection.

a. Include the number of tubes and fin spacing for coil selection.

F. The Contractor shall not be relieved of responsibility for compliance to the requirements of the
Project Drawings and Specifications by the Owner’s approval of Shop or working drawings,
product data, samples or similar submittals. Deviations from the requirements of the Project
Drawings and Specifications shall not be approved unless:

1. the Contractor has specifically submitted a formal deviation or substitution request to the
Owner in writing, per the requirements of the Contract Documents. This DOES NOT
include information in the submittal document or making notes on submittal documents that
such deviation is included within the Contractor’s submittal, and;

2. the Owner has given written approval of each such deviation by specific written response to
the Contractor.

G. If deviations from the Project Drawings and Specification requirements are included in approved
Shop Drawings or other submittals documents and they are NOT identified and approved per
paragraph F above, these deviations shall NOT be considered approved

H. Certifications

1. The PCAir shall be certified by an NRTL for compliance to UL-1995 and CSA-C22.22 No.
236. Evidence of such certification from the NRTL (e.g. the Authorization to Mark) must be
supplied with the Contractor’s Proposal OR prior to Contract award.

2. Independent 3rd Party Labeling from an NRTL, such as UL or ETL, shall be affixed to the
name plate of the PCAir prior to shipment, either by permission or by inspection of the
Independent 3rd Party NRTL. This labeling shall indicate compliance to the requirements of
UL-1995 and CSA-C22.22 No. 236.

3. Components shall be certified by an NRTL for compliance with UL 1012 and CSA
C22.2.107.1-M91. Provide documentation of certifications to the Owner PM for review and
approval.
I. Contractor shall supply documentation of coordination with the PBB manufacturer indicating coordination efforts, including mounting requirements, loads, power, communication, control, interlock, precool control, and condensate coordination.

J. Spare Parts: In addition to the manufacturer’s complete illustrated parts manual, the Contractor shall supply a list of the PCAir manufacturer’s recommended stocking levels of critical repair parts to include the manufacturer’s item description, part number, assemblies per unit, the recommended on-hand stocking level, and a firm list price for a period of two (2) years from the date of Final Acceptance of the PCAir by the Owner.

1. The total value of this recommended spare parts list shall be equal to the PCAir Spare Parts Allowance in the Bid Documents.

K. Operation and Maintenance Manuals:

1. Proposed format and content of the O&M manuals shall be submitted to the Owner for review and approval thirty (30) days prior to shipment of the first PCAir.

2. Supply, upon delivery of the first PCAir unit, ten (10) copies of the PCAir Operations and Maintenance (O&M) Manuals for the PCAir units.

3. O&M Manuals shall not be generic in nature and shall reflect the exact construction of the PCAir units furnished.

4. Non-applicable items and drawings shall not be included in the manuals.

5. Manuals may have descriptive type photographs.

6. Pages shall have reinforced edges.

7. Manuals shall be compact in size and bound.

8. Manufacturer shall also provide three (3) CD-ROM copies of the O&M Manual. Each section of this electronic O&M manual shall be directly accessible via an index provided with the electronic O&M manual.

8. O&M manuals shall contain the following information:
   a. Description and operation of all systems and components.
   b. Electrical drawings specific for each unit furnished. Provide two sets of bound, laminated electrical drawings for each unit, to be placed inside an access door to the unit controls.
   c. Copies of any component layout documentation that is provided in any cabinet doors of the unit.
   d. Maintenance instructions including troubleshooting/diagnostics guidelines.
   e. PCAir PLC Control Documentation
   f. Instructions for software access, programming upload and download and system diagnostics.
   g. Overhaul instructions.
h. List of parts and part numbers.
i. Illustrated parts list of all components.
j. Recommended spare parts list and sources.
k. Complete and detailed Preventive Maintenance Program for each type of PCAir furnished under this Contract.

L. Quality Assurance, Inspections, Testing and Commissioning – See APPENDIX I – SUBMITTAL SCHEDULE.

M. Training: See APPENDIX I – SUBMITTAL SCHEDULE.

N. Other Documentation: See APPENDIX I – SUBMITTAL SCHEDULE.

O. As Built Drawings: The Contractor shall supply the Owner with an As Built set of Shop Drawings within thirty (30) days of Final Acceptance by the Owner of the work at the first gate.

1. Quantity and submittal of the As Built drawings shall be per the requirements of the Contract Documents.

P. Project Schedule: Contractor shall develop and submit a Project Schedule, per the Contract Requirements, within thirty (30) days of the NTP.

1. Project Schedule shall include, but is not limited to the following:
   a. Complete list and schedule for of all required submittal documentation
   b. Contract Review activities
   c. Design and Engineering activities
   d. Material Procurement activities
   e. Manufacturing activities
   f. Shipment activities
   g. Installation activities
   h. Quality Assurance activities, included all inspection and hold points, factory inspections and testing, onsite inspections and testing, substantial completion and final acceptance.
   i. Training activities

2. Schedule should be on a gate by gate basis

3. Schedule should include activities for PCAir design, manufacturing, factory testing, installation and field testing and commission.

4. Schedule should include a one (1) week for tenant Airline “familiarization period” Airline employees to become familiar with the equipment at each gate. This familiarization process will utilize aircraft to “test” all equipment.

5. Schedule shall be coordinated with PBB manufacturer and the overall Project schedule.

Q. Software and Laptop: Contractor will supply at Substantial Completion of the first gate, copies of any and all software and the required interface cables so that the Authorities maintenance personnel can reload the PCAir’s control software and make any necessary adjustments, as
allowed by the manufacturer, to the PCAir control software.

1. If any software licenses are required to use this software, the Contractor shall supply any and all required licenses.

2. PCAir manufacturer shall coordinated with the PBB Contractor, who is to supply one (1) laptop computer for the Project with the latest Windows Operating System and all of the necessary software that would be required to access and use the PCAir software.

1.4 QUALITY ASSURANCE

A. PCAir units shall be products of a single manufacturer.

B. PCAir Unit Manufacturer's Qualifications: The PCAir manufacturer shall be in the specific business to design and manufacture the specially constructed PCAir required by this Specification.

1. The PCAir manufacturer must have a minimum of ten (10) years’ experience in producing the PCAir design proposed.

2. The PCAir design being proposed MUST have been in continuous use for a minimum of five (5) years.

3. Specific design features included in this ten (5) year requirement shall be the:
   a. Refrigeration circuit, system and component design, including the use of hot gas bypass or other defrost technology
   b. Heating system and components
   c. Blower system design and components
   d. Evaporator and condenser coil design and construction
   e. PCAir electronic controls system.

C. Accessory Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork and equipment, of types and sizes required, whose products have been in satisfactory use for not less than five (5) years. Ductwork and accessories must have demonstrated successful operation with the submitted and approved PCAir unit. Refer to 2.1 Manufacturers for additional information.

D. ARI Compliance: Coils shall comply with ARI 410; Air filter equipment shall comply with ARI 850.

E. ASHRAE Compliance: Air filters shall comply with ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates. Comply with ASHRAE recommendations pertaining to construction of ductwork.

F. NFPA Compliance: Comply with applicable portions of NFPA 70 and 79, for components and installation of PCAir units.
G. NEMA Compliance: Motors shall comply with NEMA standards. Electrical accessories shall comply with NEMA or IEC standards.

H. Factory and On-Site functional testing shall be conducted as Specified in Section 4 of this Specification and in SECTION 347713 – PASSENGER BOARDING BRIDGES.

I. Certifications

1. The PCAir shall be certified by a nationally recognized testing laboratory (NRTL) for compliance to UL-1995 and CSA-C22.2 No. 236.

2. The PCAir shall also have an NRTL certification name plate affixed to the PCAir.

3. Components shall be certified by an NRTL for compliance with UL 1012 and CSA C22.2.107.1-M91.

J. Prior to the Owner and their designated representatives scheduling the first Factory Inspection visit, the PCAir manufacture shall submit a Certificate of Compliance that the equipment supplied under this contract fully comply with the Contract Specifications and Drawings.

1. This Certificate of Compliance shall be signed by the PCAir manufacturer’s Engineering Manager, Quality Assurance Manager and General Manager.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Factory and Field Storage.

1. Store PCAir units at the factory and on site during installation process, and protect equipment and material against rust, debris, water and other damage, including the covering of all openings.

2. The Contractor shall have the flexibility to produce the PCAir units to facilitate their production schedule if the production schedule does not match the requirements for the PCAir units to be in FAY for installation.

3. The on-site installation schedule shall be coordinated with the Owner PM.
   a. The two (2) A gates should be able to be installed at the same time.
   b. Only one (1) of the B2 or B3 gates shall be taken out of service at any one time.
   c. Therefore, the Contractor shall make the necessary provisions to store the PCAir units and accessories at the manufacturing location and deliver the PCAir units and accessories to meet the on-site installation schedule.

4. The Contractor shall coordinate all deliveries with the Owner PM so that the PCAir units and accessories are delivered to FAY to correspond to their scheduled installation.
   a. It is the objective of the delivery and installation process to NOT have any PCAir units stored on-site at FAY.
B. Lift and support PCAir units with the manufacturer's designated lifting brackets or supporting points on the units frame.

C. Deliver PCAir units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

D. Deliver and store flexible aircraft ducts (hose), aircraft adapter nozzles, baskets, and "across the-bridge" devices to the jobsite in original unopened containers with labels informing about manufacturer, product name, and other pertinent information.

E. The shipment, unloading and checking of equipment shall be coordinated with the Owner PM. Under no circumstances will the equipment be released for shipment or delivered to jobsite without prior approval.

F. Examine all equipment and material delivered to the jobsite for concealed damage. The Contractor shall be responsible for loss or damage until equipment is off loaded at FAY. Report any damage to the Owner PM.

1.6 SEQUENCING AND SCHEDULING

A. Working Area: Coordinate location of PCAir staging area, storage area and erection area with the Owner PM.

B. Coordinate with the Contractor performing the installation of the PBB, 400 Hz GPU, PCAir units and bag slides.

C. Coordinate with the contractor performing the terminal building electrical power upgrades and with the PBB manufacturer for power supplied on the PBB to the PCAir mounted under the PBB “C” Tunnel.

1.7 WARRANTY

A. Special Project Warranty: Provide special project warranty, signed by Contractor, PBB Installation subcontractor and the PCAir Manufacturer, agreeing to replace, repair, or restore defective materials and workmanship of any product, materials or work provide pursuant to this Specification during a warranty period of 2 years from final acceptance of the Owner.

B. PCAir Manufacturer shall also provide directly to the Owner, a 5-year warranty from the date of final acceptance of the Owner, to replace defective:

1. PLC and I/O Units if PCAir is PLC controlled
2. Direct Digital Controller (DDC) if PCAir unis is DDC controlled
3. PCAir unit compressors, motors, and coils.
C. These warranties shall be in addition to, and not a limitation of, other rights the Owner may have against the Contractor under the Contract Documents.

D. "Defective" is defined to include, but not be limited to, operation or control system failures, performances below required minimums, excessive wear, unusual deterioration or aging of materials or finishes, unsafe conditions, the need for excessive maintenance, abnormal noise or vibration, and similar unusual, unexpected, and unsatisfactory conditions.

E. Warranty Claim Response time: The manufacturer shall ship repair parts and send a qualified service technician (if required), to the Owner within 24 hours of being notified of an equipment failure while under warranty and parts shall be delivered at the applicable Owner facility within 48 hours from the date the order was placed by the Owner. If the manufacturer is unable to obtain the parts to restore the equipment to service, the Owner reserves the right to obtain the replacement parts or service elsewhere and charge the total cost to the manufacturer, including labor and administrative fees. The manufacturer shall pay all Customs fees, taxes and freight for warranty parts during the warranty period.

1.8 MAINTENANCE

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

1. Filters: One set of filters for each PCAir unit

1.9 SUPPLY OF RECOMMENDED SPARE PARTS

A. The Owner shall determine which parts and the quantities of each part, the Contractor shall supply from the Recommended Spare Parts List submitted per paragraph 1.5.J.

1. The Owner shall advise the Contractor of the selected PCAir Spare parts and quantities, equal to the PCAir Spare Parts Allowance, within sixty (60) days of the Owner’s approval of the PCAir Manufacturer’s Recommended Spare Parts list.

2. The Contractor shall deliver these spare parts to the Owner no later than the Substantial Completion date of the Scope of Work at the first gate.
PART 2 - PRODUCTS

2.1 GENERAL

A. In this Specification, the term “or Owner approved equal” may be used to indicate that the Contractor shall have the option of proposing an alternative to what has been specified. The Contractor’s alternative must be equal to or exceed the performance, functionality and safety requirements of the Specification.

2.2 MANUFACTURERS

A. Subject to compliance with requirements of this Specification, the Contractor shall make every effort to supply materials that match the existing equipment in use at FAY so as to minimize the spare parts requirements for the Owner’s Maintenance group. In addition, the Owner has established a minimum standard of quality and reliability for certain parts and components that are routinely purchased to maintain the Owner’s equipment. The list below reflects this standard and is in support of the Owner’s spare parts objectives. The manufacturers on this list shall not be perceived or construed as favored or preferred. This list shall, in no way, preclude other manufacturers, provided that their equipment and components have been reviewed by the Owner’s PM and determined to be of equivalent or similar quality, functionality, and reliability. The Owner’s decision in this regard shall be final. The use of specific product manufacturers or models on previous Owner’s projects does not constitute pre-approval on this Project.

1. PCAir Unit:
   a. JBT AeroTech Jetway
   b. Twist / Aero
   c. Cavotec - INET

2. Flexible and Spiral Wound Ductwork / Hose and Adaptors:
   a. J&B Aviation Services, Inc.

3. Aircraft Adapter Nozzle:
   a. J&B Aviation Services, Inc.

4. Preconditioned Air Hose Reels / Baskets:
   a. J&B Aviation Services, Inc. – Hose Reels
   b. Ameribridge Services, Inc. – Hose Baskets

5. Telescoping Air Ducts (TAD)
   a. Cavotec – INET
   b. Aero Bridgeworks

2.3 MATERIALS

A. Where components are not otherwise indicated
1. Provide standard components published by manufacturer as included in standard pre-engineered Pre-Conditioned Air Unit and as required for a complete system.

2. All equipment and parts furnished shall be the manufacturer's latest listed and published stock models, except as permitted or required by the Owner PM.

3. The equipment and parts shall meet all the applicable requirements of the specifications.

B. Material Specifications:

<table>
<thead>
<tr>
<th>Component</th>
<th>Applicable Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Plate/Steel/Shapes</td>
<td>ASTM-A36 or ASTM A572 Grade 50</td>
</tr>
<tr>
<td>Structural Tube</td>
<td>ASTM-A500 Grade B</td>
</tr>
<tr>
<td>Steel Pipe</td>
<td>ASTM-A53 Grade b</td>
</tr>
<tr>
<td>Steel Sheet</td>
<td>ASTM-A570, ASTM A569 or ASTM A653</td>
</tr>
<tr>
<td>Steel Plate</td>
<td>ASTM-A514, ASTM 517</td>
</tr>
<tr>
<td>Bolts-Standard</td>
<td>ASTM A307</td>
</tr>
<tr>
<td>Bolts-High Strength</td>
<td>ASTM A325, SAE-J429 Grade 5 or 8, or ASTM A490</td>
</tr>
<tr>
<td>Electrical and Electronic Components</td>
<td>NFPA 70, NFPA 79, UL listed</td>
</tr>
</tbody>
</table>

2.4 DIRECT EXPANSION PRECONDITIONED AIR UNIT (PCAIR)

A. Design Conditions - The following conditions shall govern the design of the preconditioned air system:

   a. A 0.4% tolerance shall be added to the ASHRE conditions to further define Design Day conditions.

2. Aircraft Cabin Design -Summer 75°F - Winter 72°F.

3. Each PCAir unit shall be sized for 80% passenger and crew load, 50% electrical load, maximum solar load, design ambient temperatures, and 100% outside air for peak cooling capacity.

4. Each PCAir unit shall be sized to use 100% outdoor air. Return air to the air handling unit shall not be used.

5. The PCAir shall be designed to operate in an ambient environment of -20° F to +110° F at 0 to 100% relative humidity

B. Design Parameters and Requirements:
1. The PCAir supplied shall be a nominal 60 30 ton unit and shall meet the requirements of this Specification.
   a. If any requirements of this paragraph “B. Design Parameters” are in conflict with the Manufacturer’s nominal 60 30 ton PCAir unit, the Contractor shall identify these as such during the Bid Q&A period.
   b. The Owner shall reserve the right to accept or deny these exceptions to these Specifications.

2. The Aircraft Mix for each gate is as follows:
   a. A1 and A2
      (1) Prop – Q400 (Q200/300 ground load from terminal)
      (2) RJ – ERJ-135/145, CRJ-200/700/900
      (3) NB – EMB-170/175/190, MD-80/90, B717, B737-700/800, A319, A320
   b. B2
      (1) RJ – ERJ-135/145, CRJ-200/700/900
   c. B3
      (1) RJ – ERJ-135/145, CRJ-200/700/900
      (2) NB – EMB-170/175/190, MD-80/90, B717, A319

3. The PCAir unit shall be mounted on the PBB, such that the operational characteristics of the PBB are unrestricted, and the PBB’s structural integrity is uncompromised.

4. There shall be a single PCAir unit installed at the specified gates.

5. The new PCAir unit shall have a single discharge hose for aircraft service and one additional discharge hose for PBB precooling/preheating.

6. The PCAir unit shall contain evaporator coils, evaporator blower, compressors, condenser coils, condenser fans, electric heating coils, refrigeration and temperature controls, safety controls, air filters, smoke detector, complete motor starting equipment (including disconnect switch), condensate drain pan, and condensate discharge pump to provide the required cooling, heating, or ventilation air to meet the requirements specified, and to provide precooling/preheating to the PBB.

7. The PCAir unit(s) shall have the required refrigeration and air volume and pressure capacity required to sufficiently cool the aircraft in the Aircraft Mix for the Project, considering temperature, pressure and volume of air to be delivered TO THE AIRCRAFT.

5. The PCAir unit shall provide the required airflow and pressure and heating and cooling capacity based on the type of aircraft (Commuter, NB, WB) selected on the PCAir unit’s pendant control so as to deliver preconditioned air to the aircraft within the range of design parameters and without exceeding airflow, pressure, or temperature limitations of the aircraft.

6. The PCAir unit shall provide preconditioned air to the Commuter, Narrow Body and Wide Body aircraft via one aircraft hose.
7. Cooling shall be provided for outdoor air temperatures of 55 F and above during the cooling season.

8. Ventilation shall be provided for outdoor air temperatures between 45 F and 55 F.

9. The PCAir unit's electric strip heaters shall provide heating for outdoor air temperature of 45 F and below during the heating season.

10. The PCAir shall be designed to use one blower system.
   a. The airflow shall be reduced with a VFD controlled blower motor and shall adjust the airflow to meet the requirements for any of the specified aircraft.
   b. This outlet damper or VFD controlled motor shall also ensure that the airflow to the aircraft shall never be of sufficient volume or pressure to damage the aircraft air conditioning ductwork or systems.
   c. The outlet damper shall be located on the supply air or discharge side of the system and shall also restrict airflow with the initial activation of the pre-conditioned air unit to prevent hose snap.

11. The PCAir unit design shall meet the following requirements for preconditioned air delivered to the aircraft.
   a. The static pressure and air flow at the inlet to the aircraft shall be greater than the minimum and less than the maximum values allowed by the aircraft manufactures for all aircraft as specified.
   b. The static pressure, air flow and temperature at the inlet to the aircraft shall be sufficient to meet the “Steady State” cooling and heating requirements, as defined by the Aircraft manufacturers, at ambient Design Day conditions.
   c. If the PCAir unit uses a “Hot Gas Bypass” or other means to defrost the compressors, the temperature of the air at the aircraft connection shall NOT exceed 50° F AT ANY TIME.
   d. In the cooling mode, the temperature of the preconditioned air at the aircraft shall not exceed the temperature required to cool and maintain the aircraft steady state temperature at design day conditions, when the unit is operating normally and NOT in “Hot Gas Bypass” or other defrost cycle.
      (1) This temperature shall be determined by the aircraft cooling calculations submitted by the PCAir manufacturer and approved by the Owner.
   e. The PCAir unit shall be designed and sized to use 100% outdoor air.
      (1) Return air to the PCAir unit shall not be used.

12. The Contractor shall supply with their offer, the calculations and technical data to confirm that the offered PCAir unit meets the requirements of 2.4.A and 2.4.B.11 above for the largest aircraft in each of the Commuter and NB aircraft categories.
   a. Specific data and requirements from the various aircraft manufactures shall be supplied to support the Contractor’s calculations.
   b. The Contractor shall supply the assumptions included in their calculations with respect to the varying conditions that could occur with the hoses and other accessories between the PCAir unit and the aircraft.
   c. Calculations, with appropriate assumptions shall be supplied for delivery of preconditioned air TO THE AIRCRAFT and not just at the unit.
13. The PCAir unit shall be designed with an “OVERNIGHT” capability to provide cooling or heating, based on the ambient temperature, if the temperature probe is removed from the aircraft and the aircraft door closed when the aircraft is parked overnight at the gate.

14. The PCAir design shall consist of multiple refrigeration systems, such as Pre-Cool, Primary and Secondary.
   a. This configuration should provide multiple stages of control for the discharge air temperature, volume and pressure.

15. Control of the PCAir unit for delivery of conditioned air to the aircraft shall be by a remote pendant control station mounted to plate, which shall be large enough to accommodate the PCAir pendant control AND the 400Hz GPU / Cable hoist controls, attached to the wheel bogie cross tube, left side of the PBB, facing the aircraft.

16. The PCAir unit shall utilize a temperature probe, which can be placed into the cabin of the aircraft when the aircraft is docked to the PBB, to control the supply air temperature to the aircraft.
   a. The temperature probe shall be mounted on the exterior of the front PBB cab wall, below the forward Operator vision window.

17. The PCAir unit shall have a PBB Pre-Cool / Pre-Heat function:
   a. The PBB Pre-Cool / Pre-Heat function shall be controlled by a button on the PBB Operator Console or HMI screen. This will allow the PCAir to be started, in Pre-cool / Pre-Heat mode, from the PBB Operator Console of the PBB.
   b. The airflow to the PBB Pre-Cool / Pre-Heat opening shall be controlled with a VFD controlled blower motor and shall adjust the airflow to the PBB.
   c. The temperature of the air, both heat and cool, delivered to the PBB shall be the same as when the PCAir unit is in NB mode.
   d. The PCAir unit control system shall have a PBB Pre-cool / Pre-Heat timer
      (1) that is adjustable from the unit’s controller, the units PLC visualization pager, the PBB HMI or by using a laptop and PLC software.
      (2) that shall be set to 90 minutes
      (3) but be adjustable from 30 minutes to 120 minutes.
   e. The PBB Pre-Cool / Pre-Heat function shall also be turned off if the PCAir unit is started in Aircraft mode from the pendant control.

18. The PCAir unit shall filter the intake ambient air with a cleanable, viscous impingement corrosion resistant type filter.

19. The PCAir shall be designed so that the condenser fan(s) and motor(s), compressors and blower fan and motor can be COMPLETELY removed and replaced without removing the PCAir from the Passenger Boarding Bridge.

20. Interlock circuits shall be provided so the PBB motion can be disabled if the PCAir unit is operating in either Aircraft mode or Pre-cool / Pre-heat mode.
   a. There shall be two (2) separate PBB interlock circuits, one (1) if the PCAir is operating in aircraft mode and one (1) if the PCAir is operating in Pre-cool / Pre-heat mode.
21. The PCAir shall be designed so that the maximum dBA, as measured by SAE ARP 1801, is 91.
   a. Certification or Test Results showing compliance to this dBA requirement shall be submitted to the Owner PM for review and approval.

22. The PCAir unit shall have a condensate collection and removal system and shall discharge the condensate to the ramp at the PCAir location.

23. The PCAir unit shall have an Owner approved smoke and CO detectors installed downstream of the electric strip heater.
   a. There shall be a red indication light on the front (towards the PBB wheel bogie) of the unit to indicate when smoke or CO detector has been activated or faulted.
   b. There shall be an audible alarm near the red indication light to indicate when the smoke or CO alarm has been activated or faulted.
   c. The indication light and audible alarm shall be labeled as Smoke / CO Detector Alarm.

24. The PCAir unit shall provide information to the PBB HMI so that the PBB HMI can display status and error messages that will include, but not limited to:
   a. A graphic representation of the PCAir unit and its major components
   b. Status of each compressor
   c. Status of each condensing coil
   d. Status of each blower motor
   e. Status of each condensing fan
   f. Status of condensate pump
   g. Status of filters
   h. Status of PCAir smoke / CO alarm
   i. Temperature settings – ambient, discharge, temperature probe
   j. Pendant Control settings
   k. Any fault or error messages

C. Unit Construction.

1. Manufacturer's standard casing construction and shall have corrosion protection coating, and exterior finish.
   a. Exterior casing surfaces shall have either:
      (1) Steel or aluminum parts - a baked enamel finish coat.
      (2) Steel parts – zinc rich epoxy primer w/ polyester power top coat.
      (3) Aluminum parts – polyester powder top coat
   b. Color shall match the color of the PBB’s and shall be coordinated with Owner PM.

2. Square tubing frame components shall have a ¼” hole drilled to allow condensate water to escape.

3. Maintenance access doors or panels:
   a. All panels and doors that must be opened to access the interior of the PCAir unit for ANY maintenance, repairs or adjustments
      (1) shall be hinged, lockable and equipped with a hold open mechanism
(2) shall be equipped with lift off pin type hinges to facilitate easy removal of the panel or door.
(3) Tool operated locks are acceptable.

b. The access door to the PCAir’s main power and control panel shall be equipped with a door interlock switch that trips the unit’s main shunt trip breaker when opened.
(1) The door interlock must be able to be by-passed for maintenance access to the unit.

4. Any unused holes or penetrations in the exterior of the PCAir shall be plugged.
a. If the holes are threaded, SST bolts shall be used to plug the hole.

5. Lifting points for crane straps and / or the location of fork lift forks shall be clearly labeled on both sides of the PCAir unit.
a. Fork lift brackets shall be incorporated into the PCAir frame so that lifting the PCAir unit with a fork lift does not damage the PCAir unit.

6. Attached to the interior of the each of the PCAir access doors door shall be a:
a. Laminated drawings or drawings printed on adhesive polyester film, which provide an elevation view of the interior compartment viewed from the access door and identifies each component’s location, as well as the component’s description and manufacturer’s part number.
b. Wiring schematic showing the all wires by wire number and termination point for connections visible from the access door.

7. Mounting brackets used to attach the new PCAir to the PBB shall be painted with a 2-coat corrosion resistant coating system.
a. Color shall match the existing color of the PBB’s and shall be coordinated with the Owner PM.
b. Mounting method to the PBB must be a “bolt through” connection to the PBB rail.

8. The PCAir unit shall have a minimum of 1” rubatex type insulation installed on all interior walls / panels of the unit’s top, sides and ends.
a. The insulation shall be installed to the interior of the unit to help in deadening the operating noise of the unit.
b. The insulation shall be secured in place with adhesive and aluminum insulation stick pins and tabs.
(1) The insulation material and installation shall meet the requirements of UL 1995 and NFPA-90A.

9. If the intake air from the PCAir comes in through the side panels of the PCAir, these panels shall be mounted so that air intake louvers are pointed up to avoid pulling the hot air discharged from the bottom of the PCAir unit.

D. Maintenance: The following items shall be fully removable and replaceable by removal of access panels without removal of the PCAir unit from the bridge.

1. Compressors.

2. Blower/damper.
3. Air filters.

4. Controls.

E. Air Conditioning Components

1. Refrigerant Compressor:
   a. The refrigerant compressors shall be hermetic scroll type, 2-pole motor, unidirectional
   b. Compressor shall have an oil sight glass and oil charging valve.
   c. Compressor shall have integral vibration isolators.
   d. The PCAir unit shall have the required number of compressors and number of steps of refrigeration capacity control to provide the cooling capacity required to cool the aircraft per the specified design requirements.
      (1) A “nominal” 30 ton PCAir unit shall have a minimum of 2 compressors.
      (2) A “nominal” 60 ton PCAir unit shall have a minimum of 3 compressors.
      (3) A “nominal” 90 /100 ton PCAir unit shall have a minimum of 4 compressors.
   e. Compressors shall use non ozone depleting refrigerant.
   f. Compressors shall have expansion valves, filter dryers, sight glasses, compressor service valves, liquid line service valves
   g. A minimum of two refrigerant circuits for PCAir unit having two or more compressors
   h. Compressors shall have fan-cycling control for low ambient control to 350F (20C).
   i. Compressors shall have a system to provide flexibility in the suction and discharge connections to prevent leaks from compressor and PCAir unit vibration and movement. System shall submitted to the Owner PM for review and approval.

2. Condenser and Evaporator Coils:
   a. Coils shall be aluminum plate fins and seamless copper tube type.
   b. Fins have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes.
   c. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing.
   d. Other coil designs shall be an Owner approved equal.
      a. Coils shall be mounted in the coil casing with same end connections accessible for service.
      b. Coils shall be removable from the unit.
      c. Coil section shall be completely insulated.
      d. Coils shall be constructed and certified in accordance with ASHRAE 15 and ARI 410.
      e. Coils shall be have a multi-dip Bronze-Glow Coil Coating for corrosion resistance.
      f. Provide expansion valve, solenoid valve, and distributor for each coil.
      g. Coils shall be proof 400 psig and leak 250 psig tested with air pressure under water, then cleaned, dehydrated, and sealed with a holding charge of nitrogen.
      h. If refrigerant R410A is used, test pressures shall be adjusted for higher pressure system.

3. Filter-Drier:
   a. A replaceable core type filter-drier shall be in the liquid line, to remove moisture and contamination.
   b. The filter shall be removable via a bolted access plate.
c. Valves shall be used to isolate the unit so that the filter can be replaced without impacting the system
   (1) Isolation valves shall be within 3” to 6” of the filter-drier.

4. Sight Glass:
   a. A combination moisture and liquid indicator shall be installed in the liquid line to monitor the flow and moisture content of the refrigerant.
   b. The sight glass color indicator is to be protected by a pad and screen and changes color on the basis of relative moisture in the refrigerant.

5. Expansion Valve:
   a. An expansion valve shall automatically meter the refrigerant flow to the evaporator coil by sensing evaporating pressure and temperature of the vapor leaving the evaporator coil.

6. Evaporator Pressure Regulation:
   a. Shall be required if the Proposed PCAir design is unable to prevent the coils from dropping below freezing by reducing the number of compressors operating.
   b. If Evaporator Pressure Regulation is required, it shall be located on the suction line and shall regulate the evaporator suction pressure.

7. Pressure Switches:
   a. If used, shall be located as appropriate according to sound engineering practices, the switches shall be fully encapsulated, non-adjustable, SPST, direct mount controls for use with non-corrosive refrigerants.
   b. The switches shall be automatic or manual reset in open low or open high configurations.
   c. These controls shall be fitted with a 1/4 inch SAE female flare fitting with an internal depressor for the Schroeder valves located in the piping to prevent refrigerant loss during replacement.
   d. If Pressure Switches are not used, a Pressure Sensing System, controlled by the unit’s PLC shall be utilized.

8. Gauge Ports:
   a. Gauge ports shall be required for refrigeration circuit.
   b. Pressure and temperature ports shall be required on the PCAir unit outlet plenum.
   c. All gauge ports shall have caps secured by a chain or plastic strap.

9. Access (Schroeder) Valves:
   a. 1/4 inch SAE male valves designed for flare connection shall be used as ports for pressure switch connections and access to the system.

10. Refrigerant Tubing:
    a. Tubing shall be bent and modular in design to reduce & eliminate the amount of silver soldered fitting and prevent Freon leaks.
    b. Neat and clean silver soldered joints are required for all tubing connections.

11. Tubing Supports:
    a. All tubing shall be supported with rubber covered clamps
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Owner: City of Fayetteville
Fayetteville, North Carolina

AP#1515
DK Consultants, LLC March 23, 2017

F. Blowers and Fans

1. Supply Air Blower:
   a. Shall be squirrel cage type, direct drive, with forward curved or radial blades.
   b. The blower shall be centrifugal type and sized for the specified variable volume airflow requirements.
   c. Horsepower shall be selected based on manufacturer's choice of equipment which affects the external resistance of the system.
   d. Contractor shall furnish the blower motor and unit size adequate for final total static pressure and maximum brake horsepower requirements.

2. Fans:
   a. Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with required capacities and characteristics.
   b. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
   c. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70% of the first critical speed at the top of the speed range of the fan's class.
   d. Shaft Bearings: Provide bearings having a median life "Rating Life" (AFBMA L50) of 200,000, calculated in accordance with AFBMA 9 for ball bearings or AFBMA 11 for roller bearings.
   e. Evaporator Fans: Centrifugal, direct-drive blower, no belt drive; with either permanently sealed bearings or bearings with a grease port, as per the motor manufacturer’s standard.
   f. Condenser Fans: Propeller-type, direct-driven fans with either permanently sealed bearings or bearings with a grease port, as per the motor manufacturer’s standard.

G. Motors:

1. General Requirements:
   a. Motors 1/2 HP and Larger: Polyphase.
   b. Frequency Rating: 60 Hz.
   c. Voltage Rating: Determined by voltage of circuit to which motor is connected.
   d. Service Factor: According to NEMA MG 1, unless otherwise indicated.
   e. Capacity and Torque Characteristics: Rated for continuous duty and sufficient to start, accelerate, and operate connected loads at designated speeds, in indicated environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2. Polyphase Motors:
   a. Description: NEMA MG 1, medium induction motor.
      (1) Design Characteristics: NEMA MG 1, Design B, unless otherwise indicated.
      (2) Energy-Efficient Design.
      (3) Stator: Copper windings. Multispeed motors have separate winding for each speed.
      (4) Rotor: Squirrel cage.
      (5) Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.
      (6) Temperature Rise: Per Motor Manufacturer’s standard.
      (7) Insulation: Class F.
b. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for indicated controller, with required motor leads brought to motor terminal box to suit control method.

c. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   (1) Critical vibration frequencies are not within operating range of controller output.
   (2) Temperature Rise: Per Motor Manufacturer’s standard.
   (3) Insulation: Class F.
   (4) Thermal Protection: Where indicated, conform to NEMA MG 1 requirements for thermally protected motors.

d. Rugged-Duty Motors: Motors shall be totally enclosed with 1.25 minimum service factor, permanently lubricated bearings, integral condensate drains, and capped relief vents.
   (1) Windings shall be insulated with non-hygroscopic material.
   (2) External finish shall be chemical-resistant paint over corrosion-resistant primer.

e. Source Quality Control: Motor manufacturer shall perform the following routine tests on blower motors according to NEMA MG 1 and submit test results:
   (1) Measurement of winding resistance.
   (2) No-load readings of current and speed at rated voltage and frequency.
   (3) Locked rotor current at rated frequency.
   (4) High-potential test.
   (5) Alignment.

H. Solid-State, Variable Frequency Drive

1. Provide solid-state speed adjustment with adjustable frequency and voltage output that shall provide a constant volt per hertz excitation of a three-phase, squirrel-cage induction motor up to 60 hertz.
   a. The variable frequency drive shall be selected by the manufacturer based on the maximum blower motor brake horsepower required.
   b. The controller shall have a 50% overload rating for one minute. The controller shall have a minimum efficiency of 95% at rated load.
   c. The controller shall operate in an ambient temperature of -15°C to 40°C for elevations up to 3,300 feet above sea level and within a humidity range of 0 to 95% noncondensing.
   d. The variable torque controller starting current shall be limited to 150% of the full load current.

2. The controller input shall be rated 460V (+10% to -10%), three-phase, and 60-hertz. The converter shall utilize a three-phase, full-wave, diode-bridge. Provide a 6 or 12 pulse unit.

3. The DC voltage shall be inverted with a pulse width modulated (PWM) transistor inverter to an adjustable frequency output.
   a. The output frequency stability to be +1.0% to -1.0% and the output voltage regulation to be +2% to -2%.

4. The controller shall
   a. maintain a minimum lagging power factor of 0.95 at any speed or load.
   b. have input line filtering in compliance with IEEE 519
c. not generate harmonics of a magnitude that create power line disturbances objectionable to the local utility.

I. Electric Heaters:

1. General: Provide electric resistance open coil duct-type or finned tubular heaters to provide heat to the supply air.
   a. Provide either a PWM or SCR controller or a minimum of three or four steps of electric resistance open coil capacity control shall be required in the heating mode.

2. Heating Elements: Open-wire type, 80% nickel, 20% chromium or SST elements
   a. uniformly distributed
   b. supported in aluminized- or galvanized-steel frame
   c. with vertical support brackets
   d. insulated with ceramic bushings.

3. Controls: Provide thermal cutouts, primary and secondary controls, contactors, circuit fusing, airflow switch, and fused control transformer.
   a. Include integral primary automatic and secondary manual reset thermal-protection devices and airflow switches.

J. Safety Provisions And Components

1. Circuit Protection: The following systems and/or components will be protected against short-circuit currents or grounds by means of properly selected circuit breakers:
   a. Main Power
   b. Blower motor
   c. Fan motors
   d. Compressor motors
   e. Heater stages
   f. Transformer primary winding (by fuse or circuit breaker)
   g. Transformer secondary winding, 24 volt (by fuse or circuit breaker)

2. Overload Protection: Each motor shall be protected from damaging overload currents as follows:
   a. Compressor motors: With manual reset type and adjustable range relays.
   b. Blower Motor: With relays of the manual reset type and adjustable setting range type.
   c. Fan Motors: With relays of the manual reset type and adjustable setting range type.
   e. Compressors shall have motor protection modules with monitoring warning and diagnostic capabilities to include protective features of thermal overload, phase loss, phase reversal, phase imbalance, ground fault, short circuit, over temperature (thermistor input), start time monitoring, stall during start and multiple starts.
   f. Compressor Short Cycling Protection: Each refrigerant compressor motor shall be protected against short cycling (multiple starts and stops over a short period) by a run-limit timer or software.
      (1) The timer or software shall provide a minimum 3-minute delay on re-energizing the compressor motors after each stop.
3. Refrigerant Extreme Pressure Protection: high and low-pressure limit switches or a pressure sensing system controlled by the unit’s PLC shall protect all refrigeration systems.

4. Compressors shall have the following Safety Controls:
   a. Low refrigerant pressure cutout, automatic or manual reset;
   b. High refrigerant pressure cutout, automatic or manual reset;
   c. Compressor motor overload protection, internal and external, manual reset;

5. Main Contactor: Heater contactors shall be controlled by a main contactor and thermal overload contactors so that in the event the heater contactor fails to trip or becomes fused, the thermal overloads will disconnect power to the heater elements.

6. The PCAir shall have:
   a. a “bumper” on the bottom corners of the unit to protect against injuries to the head.
   b. yellow and black safety tape shall be applied to the bottom circumference of the unit.

7. For any input power phase sensitivity, the PCAir shall monitor input power phases and display an error message if input power has improper phasing.

K. Temperature Control:

1. The PCAir unit shall utilize a temperature probe, which can be placed into the cabin of the aircraft when the aircraft is docked to the PBB, to control the supply air temperature to the aircraft.

2. In case of temperature probe failure, damage or removal, the PCAir unit will operate in an automatic mode as follows:
   a. Cooling shall be provided for outdoor air temperatures of 55 F and above during the cooling season.
   b. Ventilation shall be provided for outdoor air temperatures between 45 F and 55 F.
   c. The PCAir unit's electric strip heaters shall provide heating for outdoor air temperature of 45 F and below during the heating season.

3. The PCAir unit shall be designed with an “OVERNIGHT” capability to provide cooling or heating, based on the ambient temperature, if the temperature probe is removed from the aircraft and the aircraft door closed when the aircraft is parked overnight at the gate.
   a. Cooling shall be provided for outdoor air temperatures of 55 F and above during the cooling season.
   b. Ventilation shall be provided for outdoor air temperatures between 45 F and 55 F.
   c. The PCAir unit's electric strip heaters shall provide heating for outdoor air temperature of 45 F and below during the heating season.

4. The output air temperature from the PCAir unit in the PBB Pre-cool / Pre-heat mode shall be the same as when the PCAir unit is running at full cool or full heat in Narrow Body (NB) mode.

L. Electrical Service / Components / Workmanship
1. Unit shall require only a single feed 480/3/60 electrical connection. Provide transformers as required to feed components and controls utilizing other voltages. The 60 30 ton nominal PCAir unit shall operate on 225 125 amps MAXIMUM.

2. All electrical equipment and components shall be manufactured in Inch-Pound units and conform to recommendations and standards listed in the Quality Assurance Article.

3. If cable trays are used for the power and control cables to route cables beyond the cable conveyance system towards the PCAir unit, the cable tray shall be aluminum or SST.

4. All power and control circuit cables from the cable conveyance system shall terminate directly into terminal blocks in the PCAir disconnect at the PBB rotunda and the PCAir unit mounted on the PBB. An intermediate junction box shall not be allowed.

5. All circuits shall be protected by circuit breakers, except low voltage control circuits of 10 amps 50Vdc / 50Vac OR LESS, which may be protected be either circuit breakers or fuses.

6. All circuits shall have suitable overload protection.
   a. Each conductor shall be sized to have current carrying capacity as allowed by the National Electric Code (NEC) equal to or greater than the capacity of the circuit breaker provided for the circuit.
   b. Circuit breakers shall be grouped in convenient locations and suitably marked for size and function.
   c. Protection devices shall be sized to protect wiring, motors and other electrical components from damage due to overload and prevent electrical or mechanical damage to any associated PCAir components or ancillary equipment due to failure of any PCAir component or ancillary equipment.

7. Connections between the PCAir unit and the Pendant Control, Temperature Probe and PBB interlock shall be heavy duty Quick Disconnect type.

8. Quick Disconnect fittings shall be UL or ETL approved.
   a. Quick Disconnect receptacles and plugs shall be labeled with a permanent type label to indicate which receptacle goes with which plug.

9. Exterior toggle switches must comply with MIL-S-3950 and be rated for the loads which they control.

13. Unit shall be equipped with main breaker, which shall be either:
   a. shunt tripped with a maintenance by-pass switch.
      (1) Shunt trip shall engage whenever the main power panel door is opened and the breaker box door is opened / both ways: or,
      b. integral to the main power panel door and must be manually switched off in order to open the main power panel door.

14. If a separate disconnect is provided on the exterior of the unit:
   a. Disconnect shall be stainless steel NEMA 3R or 4 enclosure with a re-settable breaker and a lockable pull handle
b. Disconnect shall have a drain device for condensate.

15. Wiring and Terminal Blocks
a. All interior wiring, connections, terminal blocks, wire routings, use of cable trays / conduit shall comply with the requirements of UL 1995.
   (1) If any requirements of this Specification conflict with the requirements of UL 1995, the requirements of UL 1995 shall take precedence.

b. Wires shall not be pulled tight in the PCAir unit or subjected to chafing or damage by vibration of the PCAir or by the operation of the PBB.

c. Wires shall not droop or sag in their routing.

d. All wiring shall be brought to mounted terminal blocks.
   (1) Wire splices or wire nuts of any type shall NOT be used.
   (2) Terminal blocks shall NOT be allowed to hang free in air.
   (3) In junction boxes where space does not allow for the use of terminal blocks, mounted Wago type connectors are acceptable.

e. Wiring in all enclosures and junction boxes shall comply with the NEC requirement in Table 314.16 for the wiring fill capacity for the enclosure or junction box.

f. Wiring shall be formed and restrained to give a neat appearance.

g. All wires, including spares, within junction boxes, control cabinets, disconnects, other electrical enclosures shall be neatly secured and routed.
   (1) Wire routing trays shall be used when space permits.

h. Grommets and suitable anti-chafe material shall be used where wires are required to pass through structure or similar relief or opening which exposes the wire to possible chafing.

i. All wiring shall be identified using stamped labels or other Owner approved wire labels.
   (1) Labels shall be visible and located within 1 in. of their termination point.
   (2) Wires are to be numbered in a logical sequence.
   (3) All wire numbers are to be indicated on wiring diagrams.

j. Spare wires shall be numbered and also labeled as “SPARE”.

k. Spare wires shall be indicated on the wiring diagrams.

l. Wires must meet the bend radius requirements of NEC.
   (1) Ninety degree bends shall not be allowed.

m. Ferrules or insulated ring terminals shall be used on any fine stranded wire, depending on the terminal block connection.
   (1) Fork or Spade terminals shall ONLY be allowed to make connections to purchased components that have ring terminals and are assembled into the PCAir. No other use of fork or spade terminals shall be allowed.
   (2) Direct connection of fine stranded wire to a terminal block shall NOT be allowed.

n. Terminal blocks shall be either:
   (1) Finger proof or tamper proof design
   (2) Stud or open style design with a protective cover supplied by the terminal block manufacturer.
   (3) Other terminal block designs shall not be accepted.

o. Terminal blocks must meet the applicable requirements of SAE J561, J858 and J928.

p. Wire ties SHALL NOT be used to secure and support any wiring.

q. NEC / UL approved clamps and methods must be used to secure and support wiring.
   (1) Clamps used shall be specifically designed for the wiring being clamped (e.g. clamps for flat pack cable are not the same as clamps for SO cable).

r. Wire ties shall only be used to keep wires together for appearance and routing to various
16. Enclosures and Junction Boxes (except main power / control panel)
   a. All exterior enclosures and junction boxes shall be labeled with engraved placards.
      (1) Placards shall contain the nomenclature used on the drawings or schematics for the
          enclosure or junction box.
   b. All exterior electrical components, including terminal blocks / terminal strips, shall be
      housed in weather tight, stainless steel (SST) enclosures.
   c. All exterior enclosures and junction boxes, including pass through junction boxes shall:
      (1) be weather tight, stainless steel (SST) enclosures of NEMA 3R or 4 rating.
      (2) have a hinged, SST cover which shall be retained by SST latch(s) or SST self-
          retaining screws.
      (3) shall have a weather gasket for the cover.
      (4) shall have a drain device for condensate.
   d. All exterior electrical devices, including, but not limited to, lights, beacons, sensors,
      temperature probes and switches shall be a weather proof design with a NEMA 3R or 4
      rating.
      (1) All mounting boxes for electrical devices shall be SST and be a weather proof design
          with a NEMA 3R or 4 rating.
      (2) The enclosure cover shall be hinged, SST and be retained by SST latch(s) or SST
          self-retaining screws.
      (3) The enclosure covers shall also have a weather gasket
      (4) The enclosure shall have a drain device for condensate.
      (5) The device should be mounted to the hinged cover
   e. All enclosures and junction boxes containing power circuits shall have applicable
      warning or symbol stickers as required by Code.
   f. All components mounted in enclosures and junction boxes shall be mounted to a backing
      plate supplied by the enclosure manufacturer
      (1) Components shall be intended for use in the enclosure or junction box.
      (2) Mounting directly to the enclosure or junction box wall shall NOT be allowed.

17. Main Power / Control Panel Enclosure shall:
   a. comply with the requirements of UL 1995.
   b. be labeled with an engraved placard containing the nomenclature used on the drawings or
      schematics for the enclosure.
   c. Shall be constructed out of SST, aluminum or steel with a corrosion resistant coating
      system.
   d. be weather tight with a NEMA 3R or 4 rating.
   e. have a hinged cover which is SST, aluminum or steel with a corrosion resistant coating
      and retained by SST latch(s) or SST self-retaining screws.
   f. have a weather gasket for the cover.
   g. have a drain device for condensate.
   h. have applicable warning or symbol stickers as required by Code.
   i. have clamping fittings for all conduits and wiring routed into the enclosure and the fitting
      threads shall have bushings installed
M. Other PCAir System Components:

1. PCAir Pendant Control
   a. Pendant control shall be mounted to plate, which shall be large enough to accommodate the PCAir pendant control AND the 400Hz GPU / Cable hoist controls, attached to the wheel bogie cross tube, left side of the PBB, facing the aircraft.
   b. All voltages in the Pendant Control shall be low voltage – 28 volts maximum.
   d. Quick Disconnect fittings must be MS standard receptacles and plugs and shall be UL or ETL approved.
      (1) Quick Disconnect receptacles and plugs shall be labeled with a permanent type label to indicate which receptacle goes with which plug.
   e. Pendant control enclosures shall:
      (1) be SST
      (2) be NEMA 3R or 4 rated
      (3) have a SST cover with piano style SST hinge and be retained by SST latch(s) or SST self-retaining screws.
      (4) have a drain device for condensate.
   f. The pendant control station shall have a minimum of three (3) push buttons.
      (1) One button each for Start, for Stop, and an E-Stop button.
      (2) The Start button shall be illuminated “green” when the unit is on.
      (3) The Stop button shall be illuminated “red” when a fault has occurred and shall reset the unit when depressed.
      (4) The E-Stop button shall be a raised, mushroom type and;
         ii) Shall be illuminated w/ 28V LED light
         iii) Shall be able to be activated by pressing or hitting the E-Stop button with the palm of the hand.
         iv) Shall be pulled to disengage
         v) Shall NOT be turned to disengage
         vi) Shall NOT be illuminated when disengaged.
   g. The pendant control shall have either:
      (1) a switch to select between Narrow Body, Wide Body and OVERNIGHT modes.
      (2) separate start buttons for Narrow Body, Wide Body and OVERNIGHT modes.
   h. The pendant control shall have a switch to select the PCAir unit operation modes of heat, cool or vent.
   i. Each button on the Pendant control or indicator shall be labeled with an engraved, weather resistant placard identifying the button or indicator function.
   j. The Pendant Control shall also have an engraved placard identifying it as the PCAir pendant control.
   k. Shall comply with the requirements of 2.4.L.15 and 16.

2. Temperature Probe
   a. The temperature probe shall be mounted on the exterior of the front PBB cab wall, below the forward Operator vision window, in the same location as the existing temperature probe.
   b. Temperature probe shall be a weather proof design with a NEMA 3R or 4 rating.
   c. The mounting box for the temperature probe shall
      (1) be SST and be a weather proof design with a NEMA 3R or 4 rating.
      (2) have an enclosure cover that is SST, hinged, retained by SST latch(s) or SST self-
retaining screws.

(3) have an enclosure cover that has a weather gasket.

d. The temperature probe should be mounted to the hinged cover.

a. The temperature probe shall utilize a “jack” type connection to an outlet on the PBB cab wall.

b. A light shall be provided on the temperature probe outlet to notify the PBB operator that the PCAir is operating in automatic mode due to the failure of the temperature probe.

3. PBB Pre-Cool / Pre-Heat

a. The PBB Pre-Cool / Pre-Heat function shall be controlled by a button on the PBB Operator Console. This will allow the PCAir to be started, in Pre-Cool / Pre-Heat mode, from the PBB Operator Console of the PBB.

b. Safety features will be provided so that the Pre-Cool / Pre-Heat mode can only be started when the PBB is NOT in Auto Level and the PCAir is not already running.

c. If a push button on the remote pendant control is depressed to start / stop or select a mode for the PCAir unit, the PBB Pre-Cool / Pre-Heat function shall be stopped.

d. Coordinate design and installation of PBB Pre-Cool / Pre-Heat plenum, mounted in “C” tunnel of PBB with PBB Manufacturer.

4. Input Air Filters.

a. Provide factory-fabricated, flat panel type cleanable (washable) air filters with holding frames, with 2-inch-thick cleanable filtering media constructed of galvanized woven and crimped steel screening, with 20-gauge galvanized steel frame.

b. Filters shall be cleanable with rated face velocity of 500 foot per minute, initial resistance not greater than 0.10-inch water gauge.

c. Air filter equipment shall comply with ARI 850.

d. Air filters shall comply with ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates.

5. Condensate Pump

a. A condensate pump and drain pan shall be provided for each PCAir unit and shall discharge condensate:

(1) to the ramp via a condensate hose routed through the lift column scissor and terminated 4-6” below the wheel bogie cross tube, left side.

(2) through a condensate hose in the PBB cable carrier to a condensate piping connection at the terminal face.

b. The condensate pump shall be lightweight, self-priming, and capable of running dry.

c. Minimum pump rating and size shall be:

(1) 3 gpm, 40-foot head

(2) determined by the PCAir manufacturer and be capable of pumping the PCAir condensate from the PCAir unit to the terminal building with the PBB at full extension and servicing the smallest aircraft in the specified aircraft mix.

d. Position the drain pan under the coil section.

e. Drain pan shall be stainless steel with capability of complete drainage leaving no standing water in pan, regardless of the slope of the PBB.

6. Smoke / CO Detectors

a. PCAir unit shall include an equipment appropriate smoke detector and CO detector,
which shall be approved by the Owner.
b. Smoke and CO detectors shall be installed downstream of the electric strip heater but upstream from the condenser coils.
c. Smoke detector shall be ionization type and listed by UL per UL 268A.
d. Smoke detector shall operate at air velocities from 300 to 4,000 feet per minute.
e. When smoke or CO is sensed, the supply air blower shall shut down.
f. Visual indication and an audible alarm shall be provided on the front of the PCAir unit (facing the PBB wheel bogie).
   (1) The visual indication shall be red LED light.
   (2) Light and alarm shall have an engraved label identifying them as a smoke / CO alarm / fault.
g. A manual reset shall be located on the front of the devices.
h. Smoke or CO detector heads shall not require additional filters or screens which must be maintained.

2.5 PCAIR ACCESSORIES

A. Refer to 2.2.A regarding PCAir accessory Manufacturers.

<table>
<thead>
<tr>
<th>Description – Per PBB Configuration with One (1) Primary Hose Reel Basket w/ MD80 Cart</th>
<th>J&amp;B Part Number</th>
<th>Quantity Per PBB</th>
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<tr>
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<td>Connector, Swivel, PCAir Hose</td>
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<td>Hose, Spiral, Bridge Supply, 10&quot; x 25'</td>
<td>JZ1022-25</td>
<td>2</td>
</tr>
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</table>

B. The Contractor shall supply the necessary elbows (1 per PBB), installed just forward of the PBB lift columns, to route the PCAir spiral wound hose from the PCAir unit to the PCAir hose reels.

B. The Contractor shall supply the necessary elbows (2 per PBB), installed on the rotunda side of the lift column, to route the PCAir hose from the PCAir unit to the PCAir side mounted hose basket. The elbow at the left side of the PBB, shall be mounted with an adjustable bracket so the elbow can be aligned directly over the basket.

C. The Contractor shall supply the necessary metal mounting straps (minimum 2 in. wide) to secure the Aircraft and PBB Pre-cool spiral wound hose under the PBB cab bubble.

D. The Contractor shall supply a side front-mounted PCAir Hose Basket for each gate.
1. Hose basket shall have 2 sections – a primary section for 60 ft. of flat duct hose and a detachable MD80 cart for 20 ft. of flat duct for the MD80 extension.

2. The hose basket shall be attached to the PBB wheel bogie cross tube, move with the PBB.

3. The hose basket shall be mounted forward of the wheel bogie cross tube, towards the PBB cab to the left side of the PBB.

4. The hose basket shall be mounted so that the front of the basket is facing forward, towards the PBB cab.

5. The hose basket should be compact in design and shall not interfere with access to the GPU / Cable Hoist / PCAir pendant controls.

6. The hose basket shall be easily detachable from the PBB to facilitate servicing the wheel bogie.

7. Hose basket shall not interfere with the operation of the PBB wheel guard system.

8. Contactor shall coordinate design of the hose basket mounting with the hose basket manufacturer.

9. The primary section of the hose basket shall not exceed 24 in. interior width so that the hose, when rolled up, will not fall over in the basket.

10. The detachable hose cart shall also be a maximum of 24 in interior width. The detachable hose cart shall be fully captured in the hose basket when not in use and shall be easily deployed from the hose basket in order to service the MD80 aircraft.

11. The main basket shall have a hinged, drop down, front door that will provide easy access for the ramp personnel to load and unload the PCAir aircraft supply hose. The drop down door shall be covered with expanded metal or grating to prevent ramp personnel from stepping through it and must support the weight of ramp personnel if they step on the drop down door.

12. The hose basket wheels shall have grease fittings in wheel axle and swivel bearing. The wheel tread shall be designed with a tread to minimize wear.

13. The hose basket color shall be safety yellow.

14. The Owner recommends that the hose basket be purchased from Ameribridge, LLC (see below). Contact information for Ameribrige Inc. is:
   Kenny Sprague
   Ameribridge LLC
   Aftermarket Sales Manager
   (Office) 317-826-2000 Ext 111
   (Cell) 317-331-2473

PRECONDITIONED AIR UNIT AND ACCESSORIES 238121 - 32
15. If the hose baskets are not purchased from Ameribridge, LLC, they must fully meet the requirements of 2.5.D

D. The Contractor shall supply PCAir hose reel for each gate.

1. Hose reel shall be the specified J&B hose reel or Owner approved equivalent.

2. Hose reel shall be mounted forward of the wheel bogie, towards the PBB cab.

3. Hose reel shall not interfere with the operation of the PBB wheel guard system.

4. The hose reel shall have grease fittings in wheel axle and swivel bearing. The wheel tread shall be designed with a tread to minimize wear.

5. The hose reel color shall be safety yellow.
PART 3 - EXECUTION

3.1 SITE EXAMINATION

A. The Contractor shall coordinate with and provide assistance as needed to the PBB Manufacturer in the performance of the Site Examination requirements specified in PART 3 – EXECUTION of Specification 347713 – PASSENGER BOARDING BRIDGES.

3.2 INSTALLATION

A. PCAir units shall be mounted underneath the PBB “C” tunnel, behind the bogie wheels.

1. PCAir units shall not transmit vibration to the passenger bridges.

2. Connections from the PCAir unit to the PCAir pendant control, PCAir temperature probe, and PBB interlock circuits shall be run through rigid conduit or aluminum or SST cable trays to the entry points of the PBB console or PBB cable scissor at the wheel bogie.

B. The PCAir manufacturer shall supply the necessary drawings, instructions, manuals and all materials, accessories, components, etc., required to fully assemble, commission and test the PCAir units and accessories.

C. All such materials shall be packaged as an Installation “Kit” with clearly labeled and indexed containers and materials within containers. These Installation Kits shall be packaged and protected so that they may be stored in an exterior uncovered environment for several months.

D. The PCAir manufacturer shall provide qualified manufacturer's technical representative / service personnel during the PCAir installation, testing and commissioning process AT EACH GATE to assure a proper installation, and to provide adequate and reliable field service support to correct any and all equipment failures that may occur during the commissioning and testing and during the initial operating period. This representation shall be available at FAY for the first 15 days after the first PCAir is installed and accepted by the Owner. The manufacturer's field service representative shall monitor and ensure that the approved PBB Installation Subcontractor follows:

1. The manufacturer's field installation manual.

2. Compliance with all safety requirements.

3. Accurate and complete reports and records maintenance

4. Applicable requirements of the Project Specifications and Drawings

E. Refer to SECTION 347713 – PASSENGER BOARDING BRIDGES for additional installation information, requirements and specifications.
3.3 TRAINING

A. Contractor shall provide Operations and Maintenance classes for the PCAir units supplied on this Project.

1. The training shall be specific to the PCAir units supplied to FAY. A “standard” training class is not acceptable.

2. Training shall utilize prepared texts, power point presentations and other instructional aids as appropriate. Contractor shall supply whatever equipment is required to present training materials.

3. The Contractor shall conduct two (2) Operations Training Classes during each group to facilitate the scheduling of Owner and Tenant Airline personnel.
   a. Operations training classes shall be a minimum of 4 hours and shall consist of both classroom and hands on training.
   b. Operator training shall include, at a minimum, the proper demonstration as well as actual use of correct PCAir operations to avoid damaging the equipment or aircraft or personal injury, by improper use of the PCAir and its controls.
   c. The anticipated class size shall be 10.

5. The Contractor shall conduct two (2) Maintenance Training Classes during each group to facilitate the scheduling of Owner and Owner maintenance contractor personnel.
   a. Maintenance training classes shall be a minimum of 8 hours and shall consist of both classroom and hands on training.
   b. Maintenance training shall include, at a minimum:
      (1) proper demonstration of cut-away models of critical parts, full instruction of proper maintenance and troubleshooting, and instructions on proper use of manuals.
      (2) Instruction in proper use, operation, and daily maintenance of the PCAir.
      (3) Emergency provisions, including emergency access and procedures to be followed at time of failure in operation and other building emergencies.
      (4) Normal procedures to be followed in checking for sources of operational failures or malfunctions.
      (5) Use of the hardware / software tools required to upload and download control programs, trouble shoot the PCAir control software, perform equipment diagnostics and review data flow.
      (6) Requirements for a complete PCAir PM Maintenance program, including monthly, quarterly, semiannual and annual checks.
      (7) Warranty, technical support and parts ordering procedures.
   c. The anticipated class size shall be 5.

6. The Contractor shall video tape one complete Operations training session and one complete Maintenance training session and provide these recordings to the Owner.

7. Training dates and times shall be coordinated with the Owner PM.

8. The Owner, Owner’s Maintenance Contractor and tenant Airline shall assign their respective
employees to be trained.

9. Contractor shall submit a Training Syllabus for all training classes to be conducted at FAY within sixty (60) days of the Notice to Proceed. Format and content of Contractor’s proposed Training classes shall be subject to approval of the Owner.

10. The Contractor’s PCAir operator and maintenance training classes shall be conducted concurrent with the PBB and GPU training classes.

11. The Contractor’s PCAir training program must meet the requirements of this Specification and be done within the allowance for the GPU, PCAir and PBB operator and maintenance training classes, as stated in the Project Bid Documents.

SPECIFICATION CONTINUED ON NEXT PAGE
PART 4 - CONTRACTOR QUALITY CONTROL REQUIREMENTS

4.1 QUALITY ASSURANCE

A. The Contractor shall comply with, and perform all of the quality control, inspections, factory testing and on-site testing requirements as specified in PART 4 – CONTRACTOR QUALITY CONTROL REQUIREMENTS in Specification 347713 – PASSENGER BOARDING BRIDGES.

4.2 FACTORY ACCEPTANCE

A. The following shall replace the requirements of Specification 347713 – 4.6 FACTORY ACCEPTANCE TESTING

B. Factory testing shall meet the following requirements.

1. The Contractor shall develop a comprehensive Factory Test Plan, identifying the specifics of the tests to be carried out, and the acceptance criteria of such test, to ensure the PCAir units comply with the requirements of the Specification and Contract Documents.

2. The Factory Test Plan shall be submitted to the Owner PM 60 days prior to the factory tests being conducted.

4. At a minimum, the following tests shall be part of the PCAir Factor Test Procedure.
   a. At specified cooling design day conditions, verify temperature, pressure and volume of unit on all Cooling Mode settings, including Vent and Pre-cool.
   b. At specified heating design day conditions, verify temperature, pressure and volume of unit on all Heat Mode Settings.
   c. The above 2 tests shall either:
      (1) be conducted with the supplied PCAir unit fully contained within an environmentally controlled test chamber that can create Design Day Conditions (both heating and cooling) so that the unit can be tested and the test results can confirm that the PCAir unit will produce an airflow at the required temperature, volume and pressure at Design Day conditions: or,
      (2) have been conducted previously on the identical model PCAir unit being supplied within an environmentally controlled test chamber that did create Design Day Conditions (both heating and cooling) so that the design of the unit being supplied was tested and the test results from those tests confirm that the PCAir unit being supplied will produce an airflow at the required temperature, volume and pressure at Design Day conditions.
   d. Verify all functions of Pendant Control
   e. Verify noise level, per the requirements of:
      (1) ARP 1801 - Measurement of Exterior Sound Level of Specialized Aircraft Ground Support Equipment.
      (2) ARP 5374 - Method of Testing Preconditioned Air Equipment.

5. The results of the Factory Testing shall be supplied to the Owner PM prior to shipment. The Owner will NOT approve shipment of the PCAir units without the Owner PM’s review and
approval of the Factory Test Results.
# APPENDIX I– SUBMITTAL SCHEDULE

## SHOP DRAWINGS AND SAMPLES

<table>
<thead>
<tr>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index of Shop Drawings, Samples and Required Documentation that will be</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>submitted by Contractor</td>
<td></td>
</tr>
<tr>
<td>Product Data / Cut Sheets</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>PCAir Unit Design Drawings and Data</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Accessory Product Data</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Installation Drawings and Information</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>As Built Drawings</td>
<td>30 Days from Final Acceptance of first Gate</td>
</tr>
<tr>
<td>Software, as required by Specifications</td>
<td>Substantial Completion of First Gate</td>
</tr>
</tbody>
</table>

## REQUIRED DOCUMENTATION

<table>
<thead>
<tr>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certification by Third Party agency or NRTL to UL-1995 and CSA-C22.22 No. 236</td>
<td>With Contractor Proposal or prior to Contract Award.</td>
</tr>
<tr>
<td>Evidence of such certification from the NRTL (e.g. the Authorization to Mark)</td>
<td></td>
</tr>
<tr>
<td>Documentation of PCAir components certified to UL-1012 and CSA C22.2.107.1-M91</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Certificate of Compliance – Signed by QA, Engineering and General Managers</td>
<td>Prior to First Factory Inspection</td>
</tr>
<tr>
<td>PCAir cooling and heating calculations – Requirements at AIRCRAFT CONNECTION</td>
<td>Within 30 Days of Award</td>
</tr>
<tr>
<td>for largest aircraft in RJ, NB and WB aircraft in aircraft mix.</td>
<td></td>
</tr>
<tr>
<td>Description of Operation</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Documentation of coordination with PBB manufacturer</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Recommended Spare Parts List w/ Pricing</td>
<td>With Shop Drawing Submittal</td>
</tr>
<tr>
<td>Project Progress Schedule</td>
<td>30 Days from NTP</td>
</tr>
<tr>
<td>Written notification of Start of Fabrication for 1st unit</td>
<td>30 Days prior to start of Fabrication</td>
</tr>
<tr>
<td>Written Notification of completion of assembly and readiness for factory</td>
<td>15 Days prior to completion of assembly.</td>
</tr>
<tr>
<td>inspection and testing – each unit.</td>
<td></td>
</tr>
<tr>
<td>Training plan and class syllabus for all training</td>
<td>60 Days from NTP</td>
</tr>
<tr>
<td>Proposed content and format of O&amp;M Manuals</td>
<td>60 Days from NTP</td>
</tr>
</tbody>
</table>
### Quality Assurance / Testing

<table>
<thead>
<tr>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Plan, specific to the Project and including at a minimum, the following:</td>
<td></td>
</tr>
<tr>
<td>• Review, Inspection, Hold and Witness points, with acceptance criteria, that will be performed during the contract review, design, manufacturing, factory testing, installation and field testing / commission.</td>
<td>60 Days from NTP</td>
</tr>
<tr>
<td>• Scope of inspections and tests to be performed, with acceptance criteria</td>
<td></td>
</tr>
<tr>
<td>• Test plans, procedures, methods, techniques for Factory Acceptance Testing.</td>
<td></td>
</tr>
<tr>
<td>• Test plans, procedures, methods, techniques for Onsite Functional Testing and Commissioning</td>
<td></td>
</tr>
<tr>
<td>Contractor’s Factory Test results and records – Each piece of equipment</td>
<td>Prior to Shipment of each piece of equipment</td>
</tr>
<tr>
<td>Contractor’s On-Site Functional Test Results and Records – Gate by Gate</td>
<td>With Final Acceptance of a Gate</td>
</tr>
</tbody>
</table>

### Installation

See Specification 347713 – PASSENGER BOARDING BRIDGES for submittal requirements for the installation of the PCAir units.

### Maintenance and Spare Parts

<table>
<thead>
<tr>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>One (1) Set of Filters per PCAir Unit</td>
<td>Ship with the unit.</td>
</tr>
<tr>
<td>Owner selected spare parts</td>
<td>At Substantial Completion of 1st gate.</td>
</tr>
</tbody>
</table>

END OF SECTION 238121
SECTION 238121 - PRECONDITIONED AIR UNIT AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. The City of Fayetteville, North Carolina (Owner) proposes to add two (2) new Passenger Boarding Bridges (PBB’s) and associated equipment for the new “A” terminal at the Fayetteville Regional Airport (FAY). .

1. The Contractor shall supply and install two (2) new PCAir units on new PBB’s at new “A” terminal, as indicated on the Drawings and in these Specifications, including all structural, support, mechanical, electrical, and accessories to serve the aircraft mix indicated on the Drawings and in these Specifications.

B. The Owner also wishes to receive bids for three (3) Add Alternates.

1. Add Alternate 1 – Supply and install a new PCAir unit on new PBB at Gate B2, as indicated on the Drawings and in these Specifications, including all structural, support, mechanical, electrical, and accessories to serve the aircraft mix indicated on the Drawings and in these Specifications.

2. Add Alternate 2 - Supply and install a new PCAir unit on new PBB at Gate B3, as indicated on the Drawings and in these Specifications, including all structural, support, mechanical, electrical, and accessories to serve the aircraft mix indicated on the Drawings and in these Specifications.

3. Add Alternate 3 – Supply and install a semi-permanent boarding ramp that will be used to transit passengers from the PBB at gate B2 to the apron for a ground loading operation during construction of the new “A” terminal. No scope of work for the Contractor for this Add Alternate.

C. The Contractor and PCAir manufacturer shall provide the necessary information, product data, project management, coordination and installation support to the PBB manufacturer so that the PCAir supplied fully integrates and functions with the PBB and meets all of the PCAir requirements of Section 347713 – PASSENGER BOARDING BRIDGES.

D. The PCAir manufacturer shall also be required to fully coordinate with the Contractor performing the other parts of this Project.

E. Related Work Specified Elsewhere:

1. GENERAL PROVISIONS

2. DIVISION 01 – GENERAL REQUIREMENTS

3. SECTION 238121 - PRECONDITIONED AIR UNIT AND ACCESSORIES
4. SECTION 347713 – PASSENGER BOARDING BRIDGES

1.1 REFERENCES

A. The PCAir shall be designed and manufactured to meet U.S. Codes and Regulations that have been adopted by the Aircraft Preconditioned Air and Passenger Boarding Bridge industry. Portions or all of certain recognized industry or association standards referred to herein as being a requirement of these Specifications shall be considered as binding as though the reproduced in full herein unless supplemented and/or modified by more stringent requirements in this Specification. Unless otherwise stated, the reference standard shall be the standard which is current as of the date of issuance of these Specifications

B. Applicable Standards:

1. American Bearing Manufacturers Association (ABMA).
   a. 9 - Load Rating and Fatigue Life for Ball Bearings.
   b. 11 - Load Rating and Fatigue Life for Roller Bearings.

2. Air-Conditioning and Refrigeration Institute (ARI):
   b. 850 - Commercial and Industrial Filter Equipment.

3. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

4. Canadian Standards Association (CSA):
   a. C22.2.107.1 - General Use Power Supplies.
   b. C22,2,236 – Heating and Cooling Equipment

5. International Air Transport Association (IATA) – Airport Handling Manual (AHM)
   a. 973 & 974 – Air Conditioning and Heating

6. Institute of Electrical and Electronic Engineers (IEEE)

   a. 70 - National Electrical Code.
   b. 79 – Electrical Standard for Industrial Machinery
   c. 90A - Standard for Installation of Air Conditioning and Ventilation Systems.

8. National Electrical Manufacturer's Association (NEMA):
   a. MG1 - Motors and Generators.

9. Society of Automotive Engineers (SAE):
   b. ARP 5374 - Method of Testing Preconditioned Air Equipment.
10. Underwriters Laboratories (UL):
   a. 1012 - Power Units Other than Class 2.
   b. 268A - Smoke Detectors for Duct Application.
   c. 1995 – Heating and Cooling Equipment

11. Applicable state, county and local construction and electrical codes

1.3 DEFINITIONS

A. The City of Fayetteville, North Carolina is the Owner and contracting entity for this project.

B. The Owner shall appoint a Project Manager (Owner PM) as the Owner representative for this Project. All project correspondence, submittals, RFI’s, questions, etc. shall be directed to the Owner PM. The Owner shall notify the Contractor of the Owner PM’s contact information when the contract is awarded.

C. The term “Day” or “Days” shall refer to work days not calendar days.

D. The terms "Preconditioned Air Unit", or “PCAir” and specified components of these, whether referred to in singular or plural form, apply to each unit provided for this Project.

E. PBB Tunnels "A," "B," and "C", if referred to, are referred to in the order from closest to the terminal to closest to the aircraft.

E. The terms "right" and "left" refer to directions looking down the PBB tunnels toward the aircraft.

F. The term “Contractor” shall refer jointly to the General Contractor, the PCAir manufacturer and PBB Installation Subcontractor who are supplying the Scope of Work defined in this Specification, including the removal and scrap of some of the existing PCAir units, the removal and storage of some existing PCAir units, design and manufacturing of the new PCAir units, and the installation and commissioning of new PCAir units and the re-installation of some existing PCAir units.

G. The term “Manufacturer” shall mean the PCAir and / or PCAir accessory manufacturer(s).

H. Any Specification language that is lined through shall not be considered requirements for this Project.

1.3 SUBMITTALS

A. Shop Drawings, Samples and Required Documentation (Submittals) shall be supplied in accordance with the requirements of this Specification and of DIVISION 01 – GENERAL REQUIREMENTS.

   1. All Shop Drawings, Samples and Required Documentation submitted in English language and in Inch-Pound units, including dimensions, volumes, weights, and forces.
2. The Owner’s review, comment, approval or rejection of the Contractor’s Submittals shall not be considered a prerequisite for the Contractor to undertake the design, procurement of materials and manufacturing of the PCAir and accessories.
   a. If the Contractor is required to undertake the design, procurement of materials and manufacturing of the PCAir and accessories prior to the Owner’s review and approval of the Contractor’s submittals, the Contractor shall undertake these activities at its own risk and shall modify the design, material procurement and manufacturing based on the Owner’s review, comment, approval or rejection of the Contractor’s Submittals.
   b. Any such modification shall be at the cost of the Contractor and shall not impact the Project schedule.

B. **Shop Drawings** - All drawings, diagrams, illustrations, schedules, test reports, certifications, cut sheets, calculations and other data or information which are specifically prepared and submitted by the Contractor to demonstrate that the Contractor will provide a PCAir and accessories which meets the requirements of the Project Specifications and Drawings.

1. Shop Drawing submittals shall show sufficient detail to indicate conformance to the requirements of the Project Specifications and Drawings.

2. Shop Drawing submittals shall be organized in a manner so that compliance to Project Specifications and Drawings can be easily determined by the Owner.

3. Before submitting each Shop Drawing package, the Contractor shall have determined and verified that the Shop Drawing submittal does in fact demonstrate compliance to the Project Specifications and Drawings.
   a. Shop Drawing packages that contain information that is not in compliance with the Project Specifications and Drawings will be rejected and will require re-submittal.

4. Manufacturer's assembly or fabrication drawings that do not provide information needed to determine compliance with requirements of the Project Specifications and Drawings are not acceptable and shall not be submitted.

C. **Samples** - Physical examples of materials, equipment, or workmanship that are representative of some portion or all of the PCAir or its components and accessories and which establish the standards by which certain portions of the PCAir, its components, accessories or installation will be judged.

D. Contractor shall submit Shop Drawings, Samples and Required Other Documentation for Owner’s review and approval in accordance with the schedule required in approved Progress Schedule and APPENDIX I – SUBMITTAL SCHEDULE.

1. All submittals will be identified as required and furnished in the number of copies specified in the Contract Documents.

2. The data shown on the Shop Drawings and Required Documentation will be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Owner the services, materials, and equipment Contractor proposes to
E. Shop Drawings and Samples shall include but not be limited to the following:

1. An index prepared in sequential order listing all drawings, sketches, details, and material submitted.

2. Product Data: Manufacturer's technical product data, including specifications. Include data substantiating that materials comply with requirements.

3. PCAir Unit Data: Manufacturer's technical product data, including but not limited to the following:
   a. Fan performance curves with system operating conditions indicated.
   b. Motor ratings and electrical characteristics plus motor and fan accessories.
   c. Blower motor manufacturer specifications.
   d. Materials, gauges, and finishes.
   e. Filters
   f. Condensate pump and system
   g. Compressor data.
   h. Data on coil design, construction, coating, etc.
   i. Refrigerant line routing, installation and supports
   j. Refrigerant line dryers and mounting
   k. Access doors and panels
   l. Temperature Probe
   m. Pendant Control
   n. Electrical / Controls schematics.
   o. Wiring diagrams detailing wiring for power, signal, and control systems and differentiate between portions of wiring that are factory-installed and portions to be field-installed.
   p. Insulation details
   q. Interface details / information to PBB HMI display
   r. Methods of field assembly, components, and locations and size of each field connection. Detail mounting and securing to passenger boarding bridges, including brackets.

4. Accessory Product Data: Submit manufacturer's technical data for each type of ductwork, support straps, support elbows, fitting, flexible connection, aircraft adaptor nozzle, and hose basket reel, including dimensions, capacities, and materials of construction; and installation instructions.

5. Provide drawings and procedures that will be provided to installation subcontractor the required details and information for the removal, scrap or storage of PCAir and ancillary equipment and the installation of the new or existing PCAir and new ancillary equipment.
   a. Drawings and procedures shall provide sufficient detail so that the installation subcontractor can successfully complete the removal, scrap or storage of the existing PCAir and ancillary equipment and install the new or existing PCAir and new ancillary equipment.
6. Contractor shall provide within 30 days of Contract Award, all technical data and calculations to demonstrate that the offered 6030-ton PCAir units shall have the capability to provide the Steady State cooling and heating performance at the specified design day conditions for each of the largest RJ, NB and WB aircraft in the aircraft mix.
   a. Calculations shall identify the required volume, pressure and temperature of the air AT THE AIRCRAFT CONNECTION to meet these cooling and heating requirements.
   b. Air temperature, volume and pressure loss assumptions for the greatest length of PCAir hose required by the aircraft mix and any Telescoping Air Duct (TAD) shall be shown and be taken into consideration when determining the air temperature, pressure and volume required at the unit SO THAT the required temperature, pressure and volume are delivered at the aircraft connection.
   c. The PCAir manufacturer shall NOT rely solely on supplying calculations based on air temperature, pressure and volume at the discharge of the unit.
   d. Calculations shall be based on and reference the requirements defined in the specified Aircraft Planning Manuals or other information provided by the aircraft manufacturer.
   e. Calculations shall reflect the temperature rise that occurs during any compressor defrost cycle. The amount and duration of such temperature rise shall not impact the ability of the PCAir unit to provide the required air temperature at the aircraft connection required to maintain the Steady State cooling performance at the specified design day conditions of the largest RJ, NB and WB aircraft in the aircraft mix.

7. Contractor shall provide a Description of Operation that defines the method of capacity control for refrigeration (i.e., cylinder unloading, hot-gas bypass) and heating systems, defrost cycle, air volume control, and overload protection.
   a. Include the number of tubes and fin spacing for coil selection.

F. The Contractor shall not be relieved of responsibility for compliance to the requirements of the Project Drawings and Specifications by the Owner’s approval of Shop or working drawings, product data, samples or similar submittals. Deviations from the requirements of the Project Drawings and Specifications shall not be approved unless:

1. the Contractor has specifically submitted a formal deviation or substitution request to the Owner in writing, per the requirements of the Contract Documents. This DOES NOT include information in the submittal document or making notes on submittal documents that such deviation is included within the Contractor’s submittal, and;

2. the Owner has given written approval of each such deviation by specific written response to the Contractor.

G. If deviations from the Project Drawings and Specification requirements are included in approved Shop Drawings or other submittals documents and they are NOT identified and approved per paragraph F above, these deviations shall NOT be considered approved

H. Certifications

1. The PCAir shall be certified by an NRTL for compliance to UL-1995 and CSA-C22.22 No.
236. Evidence of such certification from the NRTL (e.g. the Authorization to Mark) must be supplied with the Contractor’s Proposal OR prior to Contract award.

2. Independent 3rd Party Labeling from an NRTL, such as UL or ETL, shall be affixed to the name plate of the PCAir prior to shipment, either by permission or by inspection of the Independent 3rd Party NRTL. This labeling shall indicate compliance to the requirements of UL-1995 and CSA-C22.22 No. 236.

3. Components shall be certified by an NRTL for compliance with UL 1012 and CSA C22.2.107.1-M91. Provide documentation of certifications to the Owner PM for review and approval.

I. Contractor shall supply documentation of coordination with the PBB manufacturer indicating coordination efforts, including mounting requirements, loads, power, communication, control, interlock, precool control, and condensate coordination.

J. Spare Parts: In addition to the manufacturer’s complete illustrated parts manual, the Contractor shall supply a list of the PCAir manufacturer’s recommended stocking levels of critical repair parts to include the manufacturer’s item description, part number, assemblies per unit, the recommended on-hand stocking level, and a firm list price for a period of two (2) years from the date of Final Acceptance of the PCAir by the Owner.

1. The total value of this recommended spare parts list shall be equal to the PCAir Spare Parts Allowance in the Bid Documents.

K. Operation and Maintenance Manuals:

1. Proposed format and content of the O&M manuals shall be submitted to the Owner for review and approval thirty (30) days prior to shipment of the first PCAir.

2. Supply, upon delivery of the first PCAir unit, ten (10) copies of the PCAir Operations and Maintenance (O&M) Manuals for the PCAir units.

3. O&M Manuals shall not be generic in nature and shall reflect the exact construction of the PCAir units furnished.

4. Non-applicable items and drawings shall not be included in the manuals.

5. Manuals may have descriptive type photographs.

6. Pages shall have reinforced edges.

7. Manuals shall be compact in size and bound.

8. Manufacturer shall also provide three (3) CD-ROM copies of the O&M Manual. Each section of this electronic O&M manual shall be directly accessible via an index provided with the electronic O&M manual.
8. O&M manuals shall contain the following information:
   a. Description and operation of all systems and components.
   b. Electrical drawings specific for each unit furnished. Provide two sets of bound, laminated electrical drawings for each unit, to be placed inside an access door to the unit controls.
   c. Maintenance instructions including troubleshooting/diagnostics guidelines.
   d. PCAir PLC Control Documentation
   e. Instructions for software access, programming upload and download and system diagnostics.
   f. Overhaul instructions.
   g. List of parts and part numbers.
   h. Illustrated parts list of all components.
   i. Recommended spare parts list and sources.
   j. Complete and detailed Preventive Maintenance Program for each type of PCAir furnished under this Contract.

L. Quality Assurance, Inspections, Testing and Commissioning – See APPENDIX I – SUBMITTAL SCHEDULE.

M. Training: See APPENDIX I – SUBMITTAL SCHEDULE.

N. Other Documentation: See APPENDIX I – SUBMITTAL SCHEDULE.

O. As Built Drawings: The Contractor shall supply the Owner with an As Built set of Shop Drawings within thirty (30) days of Final Acceptance by the Owner of the work at the first gate.
   1. Quantity and submittal of the As Built drawings shall be per the requirements of the Contract Documents.

P. Project Schedule: Contractor shall develop and submit a Project Schedule, per the Contract Requirements, within thirty (30) days of the NTP.
   1. Project Schedule shall include, but is not limited to the following:
      a. Complete list and schedule for of all required submittal documentation
      b. Contract Review activities
      c. Design and Engineering activities
      d. Material Procurement activities
      e. Manufacturing activities
      f. Shipment activities
      g. Installation activities
      h. Quality Assurance activities, included all inspection and hold points, factory inspections and testing, onsite inspections and testing, substantial completion and final acceptance.
      i. Training activities
   2. Schedule should be on a gate by gate basis
   3. Schedule should include activities for PCAir design, manufacturing, factory testing, installation and field testing and commission.
4. Schedule should include a one (1) week for tenant Airline “familiarization period” Airline employees to become familiar with the equipment at each gate. This familiarization process will utilize aircraft to “test” all equipment.

5. Schedule shall be coordinated with PBB manufacturer and the overall Project schedule.

Q. Software and Laptop: Contractor will supply at Substantial Completion of the first gate, copies of any and all software and the required interface cables so that the Authorities maintenance personnel can reload the PCAir’s control software and make any necessary adjustments, as allowed by the manufacturer, to the PCAir control software.

1. If any software licenses are required to use this software, the Contractor shall supply any and all required licenses.

2. PCAir manufacturer shall coordinated with the PBB Contractor, who is to supply one (1) laptop computer for the Project with the latest Windows Operating System and all of the necessary software that would be required to access and use the PCAir software.

1.4 QUALITY ASSURANCE

A. PCAir units shall be products of a single manufacturer.

B. PCAir Unit Manufacturer's Qualifications: The PCAir manufacturer shall be in the specific business to design and manufacture the specially constructed PCAir required by this Specification.

1. The PCAir manufacturer must have a minimum of ten (10) years’ experience in producing the PCAir design proposed.

2. The PCAir design being proposed MUST have been in continuous use for a minimum of five (5) years.

3. Specific design features included in this ten (5) year requirement shall be the:
   a. Refrigeration circuit, system and component design, including the use of hot gas bypass or other defrost technology
   b. Heating system and components
   c. Blower system design and components
   d. Evaporator and condenser coil design and construction
   e. PCAir electronic controls system.

C. Accessory Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork and equipment, of types and sizes required, whose products have been in satisfactory use for not less than five (5) years. Ductwork and accessories must have demonstrated successful operation with the submitted and approved PCAir unit. Refer to 2.1 Manufacturers for additional information.

D. ARI Compliance: Coils shall comply with ARI 410; Air filter equipment shall comply with
A. Factory and Field Storage.

1. Store PCAir units at the factory and on site during installation process, and protect equipment and material against rust, debris, water and other damage, including the covering of all openings.

2. The Contractor shall have the flexibility to produce the PCAir units to facilitate their production schedule if the production schedule does not match the requirements for the PCAir units to be in FAY for installation.

3. The on-site installation schedule shall be coordinated with the Owner PM.
   a. The two (2) A gates should be able to be installed at the same time.
   b. Only one (1) of the B2 or B3 gates shall be taken out of service at any one time.
c. Therefore, the Contractor shall make the necessary provisions to store the PCAir units and accessories at the manufacturing location and deliver the PCAir units and accessories to meet the on-site installation schedule.

4. The Contractor shall coordinate all deliveries with the Owner PM so that the PCAir units and accessories are delivered to FAY to correspond to their scheduled installation.
   a. It is the objective of the delivery and installation process to NOT have any PCAir units stored on-site at FAY.

B. Lift and support PCAir units with the manufacturer's designated lifting brackets or supporting points on the units frame.

C. Deliver PCAir units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

D. Deliver and store flexible aircraft ducts (hose), aircraft adapter nozzles, baskets, and "across the-bridge" devices to the jobsite in original unopened containers with labels informing about manufacturer, product name, and other pertinent information.

E. The shipment, unloading and checking of equipment shall be coordinated with the Owner PM. Under no circumstances will the equipment be released for shipment or delivered to jobsite without prior approval.

F. Examine all equipment and material delivered to the jobsite for concealed damage. The Contractor shall be responsible for loss or damage until equipment is off loaded at FAY. Report any damage to the Owner PM.

1.6 SEQUENCING AND SCHEDULING

A. Working Area: Coordinate location of PCAir staging area, storage area and erection area with the Owner PM.

B. Coordinate with the Contractor performing the installation of the PBB, 400 Hz GPU, PCAir units and bag slides.

C. Coordinate with the contractor performing the terminal building electrical power upgrades and with the PBB manufacturer for power supplied on the PBB to the GPU mounted under the PBB cab.

1.7 WARRANTY

A. Special Project Warranty: Provide special project warranty, signed by Contractor, PBB Installation subcontractor and the PCAir Manufacturer, agreeing to replace, repair, or restore defective materials and workmanship of any product, materials or work provide pursuant to this Specification during a warranty period of 2 years from final acceptance of the Owner.
B. PCAir Manufacturer shall also provide directly to the Owner, a 5-year warranty from the date of final acceptance of the Owner, to replace defective:

1. PLC and I/O Units if PCAir is PLC controlled
2. Direct Digital Controller (DDC) if PCAir units is DDC controlled
3. PCAir unit compressors, motors, and coils.

C. These warranties shall be in addition to, and not a limitation of, other rights the Owner may have against the Contractor under the Contract Documents.

D. "Defective" is defined to include, but not be limited to, operation or control system failures, performances below required minimums, excessive wear, unusual deterioration or aging of materials or finishes, unsafe conditions, the need for excessive maintenance, abnormal noise or vibration, and similar unusual, unexpected, and unsatisfactory conditions.

E. Warranty Claim Response time: The manufacturer shall ship repair parts and send a qualified service technician (if required), to the Owner within 24 hours of being notified of an equipment failure while under warranty and parts shall be delivered at the applicable Owner facility within 48 hours from the time the order was placed by the Owner. If the manufacturer is unable to obtain the parts to restore the equipment to service, the Owner reserves the right to obtain the replacement parts or service elsewhere and charge the total cost to the manufacturer, including labor and administrative fees. The manufacturer shall pay all Customs fees, taxes and freight for warranty parts during the warranty period.

1.8 MAINTENANCE

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

1. Filters: One set of filters for each PCAir unit

1.9 SUPPLY OF RECOMMENDED SPARE PARTS

A. The Owner shall determine which parts and the quantities of each part, the Contractor shall supply from the Recommended Spare Parts List submitted per paragraph 1.5.J.

1. The Owner shall advise the Contractor of the selected PCAir Spare parts and quantities, equal to the PCAir Spare Parts Allowance, within sixty (60) days of the Owner’s approval of the PCAir Manufacturer’s Recommended Spare Parts list.

2. The Contractor shall deliver these spare parts to the Owner no later than the Substantial Completion date of the Scope of Work at the first gate.
PART 2 - PRODUCTS

2.1 GENERAL

A. In this Specification, the term “or Owner approved equal” may be used to indicate that the Contractor shall have the option of proposing an alternative to what has been specified. The Contractor’s alternative must be equal to or exceed the performance, functionality and safety requirements of the Specification.

2.2 MANUFACTURERS

A. Subject to compliance with requirements of this Specification, the Contractor shall make every effort to supply materials that match the existing equipment in use at FAY so as to minimize the spare parts requirements for the Owner’s Maintenance group. In addition, the Owner has established a minimum standard of quality and reliability for certain parts and components that are routinely purchased to maintain the Owner’s equipment. The list below reflects this standard and is in support of the Owner’s spare parts objectives. The manufacturers on this list shall not be perceived or construed as favored or preferred. This list shall, in no way, preclude other manufacturers, provided that their equipment and components have been reviewed by the Owner’s PM and determined to be of equivalent or similar quality, functionality, and reliability. The Owner’s decision in this regard shall be final. The use of specific product manufacturers or models on previous Owner’s projects does not constitute pre-approval on this Project.

1. PCAir Unit:
   a. JBT AeroTech Jetway
   b. Twist / Aero
   c. Cavotec - INET

2. Flexible and Spiral Wound Ductwork / Hose and Adaptors:
   a. J&B Aviation Services, Inc.

3. Aircraft Adapter Nozzle:
   a. J&B Aviation Services, Inc.

4. Preconditioned Air Hose Reels / Baskets:
   a. J&B Aviation Services, Inc – Hose Reels
   b. Ameribridge Services, Inc. – Hose Baskets

5. Telescoping Air Ducts (TAD)
   a. Cavotec – INET
   b. Aero Bridgeworks

2.3 MATERIALS

A. Where components are not otherwise indicated
1. Provide standard components published by manufacturer as included in standard pre-engineered Pre-Conditioned Air Unit and as required for a complete system.

2. All equipment and parts furnished shall be the manufacturer's latest listed and published stock models, except as permitted or required by the Owner PM.

3. The equipment and parts shall meet all the applicable requirements of the specifications.

B. Material Specifications:

<table>
<thead>
<tr>
<th>Component</th>
<th>Applicable Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Plate/Steel/Shapes</td>
<td>ASTM-A36 or ASTM A572 Grade 50</td>
</tr>
<tr>
<td>Structural Tube</td>
<td>ASTM-A500 Grade B</td>
</tr>
<tr>
<td>Steel Pipe</td>
<td>ASTM-A53 Grade b</td>
</tr>
<tr>
<td>Steel Sheet</td>
<td>ASTM-A570, ASTM A569 or ASTM A653</td>
</tr>
<tr>
<td>Steel Plate</td>
<td>ASTM-A514, ASTM 517</td>
</tr>
<tr>
<td>Bolts-Standard</td>
<td>ASTM A307</td>
</tr>
<tr>
<td>Bolts-High Strength</td>
<td>ASTM A325, SAE-J429 Grade 5 or 8, or ASTM A490</td>
</tr>
</tbody>
</table>

Electrical and Electronic Components | NFPA 70, NFPA 79, UL listed

2.4 DIRECT EXPANSION PRECONDITIONED AIR UNIT (PCAIR)

A. Design Conditions - The following conditions shall govern the design of the preconditioned air system:

   a. A 0.4% tolerance shall be added to the ASHRE conditions to further define Design Day conditions.

2. Aircraft Cabin Design -Summer 75°F - Winter 72°F.

3. Each PCAir unit shall be sized for 80% passenger and crew load, 50% electrical load, maximum solar load, design ambient temperatures, and 100% outside air for peak cooling capacity.

4. Each PCAir unit shall be sized to use 100% outdoor air. Return air to the air handling unit shall not be used.

5. The PCAir shall be designed to operate in an ambient environment of -20° F to +110° F at 0 to 100% relative humidity

B. Design Parameters and Requirements:
1. The PCAir supplied shall be a nominal 60 30 ton unit and shall meet the requirements of this Specification.
   a. If any requirements of this paragraph “B. Design Parameters” are in conflict with the Manufacturer’s nominal 60 30 ton PCAir unit, the Contractor shall identify these as such during the Bid Q&A period.
   b. The Owner shall reserve the right to accept or deny these exceptions to these Specifications.

2. The Aircraft Mix for each gate is as follows:
   a. A1 and A2
      (1) Prop – Q400 (Q200/300 ground load from terminal)
      (2) RJ – ERJ-135/145, CRJ-200/700/900
      (3) NB – EMB-170/175/190, MD-80/90, B717, B737-700/800, A319, A320
   b. B2
      (1) RJ – ERJ-135/145, CRJ-200/700/900
   c. B3
      (1) RJ – ERJ-135/145, CRJ-200/700/900
      (2) NB – EMB-170/175/190, MD-80/90, B717, A319

3. The PCAir unit shall be mounted on the PBB, such that the operational characteristics of the PBB are unrestricted, and the PBB’s structural integrity is uncompromised.

4. There shall be a single PCAir unit installed at the specified gates. The new PCAir unit shall have a single discharge hose for aircraft service and one additional discharge hose for PBB precooling/preheating.

5. The PCAir unit shall contain evaporator coils, evaporator blower, compressors, condenser coils, condenser fans, electric heating coils, refrigeration and temperature controls, safety controls, air filters, smoke detector, complete motor starting equipment (including disconnect switch), condensate drain pan, and condensate discharge pump to provide the required cooling, heating, or ventilation air to meet the requirements specified, and to provide precooling/preheating to the PBB.

6. The PCAir unit(s) shall have the required refrigeration and air volume and pressure capacity required to sufficiently cool the aircraft in the Aircraft Mix for the Project, considering temperature, pressure and volume of air to be delivered TO THE AIRCRAFT.

5. The PCAir unit shall provide the required airflow and pressure and heating and cooling capacity based on the type of aircraft (Commuter, NB, WB) selected on the PCAir unit’s pendant control so as to deliver preconditioned air to the aircraft within the range of design parameters and without exceeding airflow, pressure, or temperature limitations of the aircraft.

6. The PCAir unit shall provide preconditioned air to the Commuter, Narrow Body and Wide Body aircraft via one aircraft hose.

7. Cooling shall be provided for outdoor air temperatures of 55 F and above during the cooling season.
8. Ventilation shall be provided for outdoor air temperatures between 45 F and 55 F.

9. The PCAir unit's electric strip heaters shall provide heating for outdoor air temperature of 45 F and below during the heating season.

10. The PCAir shall be designed to use one blower system.
    a. The airflow shall be reduced with a VFD controlled blower motor and shall adjust the airflow to meet the requirements for any of the specified aircraft.
    b. This outlet damper or VFD controlled motor shall also ensure that the airflow to the aircraft shall never be of sufficient volume or pressure to damage the aircraft air conditioning ductwork or systems.
    c. The outlet damper shall be located on the supply air or discharge side of the system and shall also restrict airflow with the initial activation of the pre-conditioned air unit to prevent hose snap.

11. The PCAir unit design shall meet the following requirements for preconditioned air delivered to the aircraft.
    a. The static pressure and air flow at the inlet to the aircraft shall be greater than the minimum and less than the maximum values allowed by the aircraft manufactures for all aircraft as specified.
    b. The static pressure, air flow and temperature at the inlet to the aircraft shall be sufficient to meet the “Steady State” cooling and heating requirements, as defined by the Aircraft manufacturers, at ambient Design Day conditions.
    c. If the PCAir unit uses a “Hot Gas Bypass” or other means to defrost the compressors, the temperature of the air at the aircraft connection shall NOT exceed 50° F for more than five (5) minutes.
    d. In the cooling mode, the temperature of the preconditioned air at the aircraft shall not exceed the temperature required to cool and maintain the aircraft steady state temperature at design day conditions, when the unit is operating normally and NOT in “Hot Gas Bypass” or other defrost cycle.
       (1) This temperature shall be determined by the aircraft cooling calculations submitted by the PCAir manufacturer and approved by the Owner.
    e. The PCAir unit shall be designed and sized to use 100% outdoor air.
       (1) Return air to the PCAir unit shall not be used.

12. The Contractor shall supply with their offer, the calculations and technical data to confirm that the offered PCAir unit meets the requirements of 2.4.A and 2.4.B.11 above for the largest aircraft in each of the Commuter and NB aircraft categories.
    a. Specific data and requirements from the various aircraft manufactures shall be supplied to support the Contractor’s calculations.
    b. The Contractor shall supply the assumptions included in their calculations with respect to the varying conditions that could occur with the hoses and other accessories between the PCAir unit and the aircraft.
    c. Calculations, with appropriate assumptions shall be supplied for delivery of preconditioned air TO THE AIRCRAFT and not just at the unit.

13. The PCAir unit shall be designed with an “OVERNIGHT” capability to provide cooling or
heating, based on the ambient temperature, if the temperature probe is removed from the aircraft and the aircraft door closed when the aircraft is parked overnight at the gate.

14. The PCAir design shall consist of multiple refrigeration systems, such as Pre-Cool, Primary and Secondary.
   a. This configuration should provide multiple stages of control for the discharge air temperature, volume and pressure.

15. Control of the PCAir unit for delivery of conditioned air to the aircraft shall be by a remote pendant control station mounted to plate, which shall be large enough to accommodate the PCAir pendant control AND the 400Hz GPU / Cable hoist controls, attached to the wheel bogie cross tube, left side of the PBB, facing the aircraft.

16. The PCAir unit shall utilize a temperature probe, which can be placed into the cabin of the aircraft when the aircraft is docked to the PBB, to control the supply air temperature to the aircraft.
   a. The temperature probe shall be mounted on the exterior of the front PBB cab wall, below the forward Operator vision window.

17. The PCAir unit shall have a PBB Pre-Cool / Pre-Heat function:
   a. The PBB Pre-Cool / Pre-Heat function shall be controlled by a button on the PBB Operator Console or HMI screen. This will allow the PCAir to be started, in Pre-cool / Pre-Heat mode, from the PBB Operator Console of the PBB.
   b. The airflow to the PBB Pre-Cool / Pre-Heat opening shall be controlled with a VFD controlled blower motor and shall adjust the airflow to the PBB.
   c. The temperature of the air, both heat and cool, delivered to the PBB shall be the same as when the PCAir unit is in NB mode.
   d. The PCAir unit control system shall have a PBB Pre-cool / Pre-Heat timer
      (1) that is adjustable from the unit’s controller
      (2) that shall be set to 90 minutes
      (3) but be adjustable from 30 minutes to 120 minutes.
   e. The PBB Pre-Cool / Pre-Heat function shall also be turned off if the PCAir unit is started in Aircraft mode from the pendant control.

18. The PCAir unit shall filter the intake ambient air with a cleanable, viscous impingement corrosion resistant type filter.

19. The PCAir shall be designed so that the condenser fan(s) and motor(s), compressors and blower fan and motor can be COMPLETELY removed and replaced without removing the PCAir from the Passenger Boarding Bridge.

20. Interlock circuits shall be provided so the PBB motion can be disabled if the PCAir unit is operating in either Aircraft mode or Pre-cool / Pre-heat mode.
   a. There shall be two (2) separate PBB interlock circuits, one (1) if the PCAir is operating in aircraft mode and one (1) if the PCAir is operating in Pre-cool / Pre-heat mode.

21. The PCAir shall be designed so that the maximum dBA, as measured by SAE ARP 1801, is 91.
a. Certification or Test Results showing compliance to this dBA requirement shall be submitted to the Owner PM for review and approval.

22. The PCAir unit shall have a condensate collection and removal system and shall discharge the condensate to the ramp at the PCAir location.

23. The PCAir unit shall have an Owner approved smoke and CO2 detectors installed downstream of the electric strip heater.
   a. There shall be a red indication light on the front (towards the PBB wheel bogie) of the unit to indicate when smoke or CO2 detector has been activated or faulted.
   b. There shall be an audible alarm near the red indication light to indicate when the smoke or CO2 alarm has been activated or faulted.
   c. The indication light and audible alarm shall be labeled as Smoke / CO2 Detector Alarm.

24. The PCAir unit shall provide information to the PBB HMI so that the PBB HMI can display status and error messages that will include, but not limited to:
   a. A graphic representation of the PCAir unit and its major components
   b. Status of each compressor
   c. Status of each condensing coil
   d. Status of each blower motor
   e. Status of each condensing fan
   f. Status of condensate pump
   g. Status of filters
   h. Status of PCAir smoke / CO2 alarm
   i. Temperature settings – ambient, discharge, temperature probe
   j. Pendant Control settings
   k. Any fault or error messages

C. Unit Construction.

1. Manufacturer's standard casing construction and shall have corrosion protection coating, and exterior finish.
   a. Exterior casing surfaces shall have either:
      (1) Steel or aluminum parts - a baked enamel finish coat.
      (2) Steel parts – zinc rich epoxy primer w/ polyester power top coat.
      (3) Aluminum parts – polyester powder top coat
   b. Color shall match the color of the PBB’s and shall be coordinated with Owner PM.

2. Square tubing frame components shall have a ¼” hole drilled to allow condensate water to escape.

3. Maintenance access doors or panels:
   a. All panels and doors that must be opened to access the interior of the PCAir unit for ANY maintenance, repairs or adjustments
      (1) shall be hinged, lockable and equipped with a hold open mechanism
      (2) shall be equipped with lift off pin type hinges to facilitate easy removal of the panel or door.
      (3) Tool operated locks are acceptable.
b. The access door to the PCAir’s main power and control panel shall be equipped with a door interlock switch that trips the unit’s main shunt trip breaker when opened. (1) The door interlock must be able to be by-passed for maintenance access to the unit.

4. Any unused holes or penetrations in the exterior of the PCAir shall be plugged.
   a. If the holes are threaded, SST bolts shall be used to plug the hole.

5. Lifting points for crane straps and / or the location of fork lift forks shall be clearly labeled on both sides of the PCAir unit.
   a. Fork lift brackets shall be incorporated into the PCAir frame so that lifting the PCAir unit with a fork lift does not damage the PCAir unit.

6. Attached to the interior of the each of the PCAir access doors door shall be a:
   a. Laminated drawings or drawings printed on adhesive polyester film, which provide an elevation view of the interior compartment viewed from the access door and identifies each component’s location, as well as the component’s description and manufacturer’s part number.
   b. Wiring schematic showing the all wires by wire number and termination point for connections visible from the access door.

7. Mounting brackets used to attach the new PCAir to the PBB shall be painted with a 2-coat corrosion resistant coating system.
   a. Color shall match the existing color of the PBB’s and shall be coordinated with the Owner PM.
   b. Mounting method to the PBB must be a “bolt through” connection to the PBB rail.

8. The PCAir unit shall have a minimum of 1” rubatex type insulation installed on all interior walls / panels of the unit’s top, sides and ends.
   a. The insulation shall be installed to the interior of the unit to help in deadening the operating noise of the unit.
   b. The insulation shall be secured in place with adhesive and aluminum insulation stick pins and tabs.
      (1) The insulation material and installation shall meet the requirements of UL 1995 and NFPA-90A.

D. Maintenance: The following items shall be fully removable and replaceable by removal of access panels without removal of the PCAir unit from the bridge.

1. Compressors.

2. Blower/damper.

3. Air filters.

4. Controls.

E. Air Conditioning Components
1. Refrigerant Compressor:
   a. The refrigerant compressors shall be hermetic scroll type, 2-pole motor, unidirectional
   b. Compressor shall have an oil sight glass and oil charging valve.
   c. Compressor shall have integral vibration isolators.
   d. The PCAir unit shall have the required number of compressors and number of steps of refrigeration capacity control to provide the cooling capacity required to cool the aircraft per the specified design requirements.
      (1) A “nominal” 30 ton PCAir unit shall have a minimum of 2 compressors.
      (2) A “nominal” 60 ton PCAir unit shall have a minimum of 3 compressors.
      (3) A “nominal” 90/100 ton PCAir unit shall have a minimum of 4 compressors.
   e. Compressors shall use non ozone depleting refrigerant.
   f. Compressors shall have expansion valves, filter dryers, sight glasses, compressor service valves, liquid line service valves
   g. A minimum of two refrigerant circuits for PCAir unit having two or more compressors
   h. Compressors shall have fan-cycling control for low ambient control to 350°F (20°C).
   i. Compressors shall have a system to provide flexibility in the suction and discharge connections to prevent leaks from compressor and PCAir unit vibration and movement. System shall submitted to the Owner PM for review and approval.

2. Condenser and Evaporator Coils:
   a. Coils shall be aluminum plate fins and seamless copper tube type.
   b. Fins have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes.
   c. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing.
   d. Other coil designs shall be an Owner approved equal.
      a. Coils shall be mounted in the coil casing with same end connections accessible for service.
      b. Coils shall be removable from the unit.
      c. Coil section shall be completely insulated.
      d. Coils shall be constructed and certified in accordance with ASHRAE 15 and ARI 410.
      e. Coils shall have a multi-dip Bronze-Glow Coil Coating for corrosion resistance.
      f. Provide expansion valve, solenoid valve, and distributor for each coil.
      g. Coils shall be proof 400 psig and leak 250 psig tested with air pressure under water, then cleaned, dehydrated, and sealed with a holding charge of nitrogen.
      h. If refrigerant R410A is used, test pressures shall be adjusted for higher pressure system.

3. Filter-Drier:
   a. A replaceable core type filter-drier shall be in the liquid line, to remove moisture and contamination.
   b. The filter shall be removable via a bolted access plate.
   c. Valves shall be used to isolate the unit so that the filter can be replaced without impacting the system
      (1) Isolation valves shall be within 3” to 6” of the filter-drier.

4. Sight Glass:
   a. A combination moisture and liquid indicator shall be installed in the liquid line to monitor the flow and moisture content of the refrigerant.
b. The sight glass color indicator is to be protected by a pad and screen and changes color on the basis of relative moisture in the refrigerant.

5. Expansion Valve:
   a. An expansion valve shall automatically meter the refrigerant flow to the evaporator coil by sensing evaporating pressure and temperature of the vapor leaving the evaporator coil.

6. Evaporator Pressure Regulation:
   a. Shall be required if the Proposed PCAir design is unable to prevent the coils from dropping below freezing by reducing the number of compressors operating.
   b. If Evaporator Pressure Regulation is required, it shall be located on the suction line and shall regulate the evaporator suction pressure.

7. Pressure Switches:
   a. If used, shall be located as appropriate according to sound engineering practices, the switches shall be fully encapsulated, non-adjustable, SPST, direct mount controls for use with non-corrosive refrigerants.
   b. The switches shall be automatic or manual reset in open low or open high configurations.
   c. These controls shall be fitted with a 1/4 inch SAE female flare fitting with an internal depressor for the Schroeder valves located in the piping to prevent refrigerant loss during replacement.
   d. If Pressure Switches are not used, a Pressure Sensing System, controlled by the unit’s PLC shall be utilized.

8. Gauge Ports:
   a. Gauge ports shall be required for refrigeration circuit.
   b. Pressure and temperature ports shall be required on the PCAir unit outlet plenum.
   c. All gauge ports shall have caps secured by a chain or plastic strap.

9. Access (Schroeder) Valves:
   a. 1/4 inch SAE male valves designed for flare connection shall be used as ports for pressure switch connections and access to the system.

10. Refrigerant Tubing:
    a. Tubing shall be bent and modular in design to reduce & eliminate the amount of silver soldered fitting and prevent Freon leaks.
    b. Neat and clean silver soldered joints are required for all tubing connections.

11. Tubing Supports:
    a. All tubing shall be supported with rubber covered clamps

F. Blowers and Fans

1. Supply Air Blower:
   a. Shall be squirrel cage type, direct drive, with forward curved or radial blades.
   b. The blower shall be centrifugal type and sized for the specified variable volume airflow requirements.
   c. Horsepower shall be selected based on manufacturer's choice of equipment which affects
the external resistance of the system.

d. Contractor shall furnish the blower motor and unit size adequate for final total static pressure and maximum brake horsepower requirements.

2. Fans:
   a. Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with required capacities and characteristics.
   b. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
   c. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70% of the first critical speed at the top of the speed range of the fan's class.
   d. Shaft Bearings: Provide bearings having a median life "Rating Life" (AFBMA L50) of 200,000, calculated in accordance with AFBMA 9 for ball bearings or AFBMA 11 for roller bearings.
   e. Evaporator Fans: Centrifugal, direct-drive blower, no belt drive; with either permanently sealed bearings or bearings with a grease port, as per the motor manufacturer’s standard.
   f. Condenser Fans: Propeller-type, direct-driven fans with either permanently sealed bearings or bearings with a grease port, as per the motor manufacturer’s standard.

G. Motors:

1. General Requirements:
   a. Motors 1/2 HP and Larger: Polyphase.
   b. Frequency Rating: 60 Hz.
   c. Voltage Rating: Determined by voltage of circuit to which motor is connected.
   d. Service Factor: According to NEMA MG 1, unless otherwise indicated.
   e. Capacity and Torque Characteristics: Rated for continuous duty and sufficient to start, accelerate, and operate connected loads at designated speeds, in indicated environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2. Polyphase Motors:
   a. Description: NEMA MG 1, medium induction motor.
      (1) Design Characteristics: NEMA MG 1, Design B, unless otherwise indicated.
      (2) Energy-Efficient Design.
      (3) Stator: Copper windings. Multispeed motors have separate winding for each speed.
      (4) Rotor: Squirrel cage.
      (5) Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.
      (6) Temperature Rise: Per Motor Manufacturer’s standard.
      (7) Insulation: Class F.
   b. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for indicated controller, with required motor leads brought to motor terminal box to suit control method.
   c. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
      (1) Critical vibration frequencies are not within operating range of controller output.
      (2) Temperature Rise: Per Motor Manufacturer’s standard.
(3) Insulation: Class F.
(4) Thermal Protection: Where indicated, conform to NEMA MG 1 requirements for thermally protected motors.
d. Rugged-Duty Motors: Motors shall be totally enclosed with 1.25 minimum service factor, permanently lubricated bearings, integral condensate drains, and capped relief vents.
   (1) Windings shall be insulated with non-hygroscopic material.
   (2) External finish shall be chemical-resistant paint over corrosion-resistant primer.
e. Source Quality Control: Motor manufacturer shall perform the following routine tests on blower motors according to NEMA MG 1 and submit test results:
   (1) Measurement of winding resistance.
   (2) No-load readings of current and speed at rated voltage and frequency.
   (3) Locked rotor current at rated frequency.
   (4) High-potential test.
   (5) Alignment.

H. Solid-State, Variable Frequency Drive

1. Provide solid-state speed adjustment with adjustable frequency and voltage output that shall provide a constant volt per hertz excitation of a three-phase, squirrel-cage induction motor up to 60 hertz.
   a. The variable frequency drive shall be selected by the manufacturer based on the maximum blower motor brake horsepower required.
   b. The controller shall have a 50% overload rating for one minute. The controller shall have a minimum efficiency of 95% at rated load.
   c. The controller shall operate in an ambient temperature of -15°C to 40°C for elevations up to 3,300 feet above sea level and within a humidity range of 0 to 95% noncondensing.
   d. The variable torque controller starting current shall be limited to 150% of the full load current.

2. The controller input shall be rated 460V (+10% to -10%), three-phase, and 60-hertz. The converter shall utilize a three-phase, full-wave, diode-bridge. Provide a 6 or 12 pulse unit.

3. The DC voltage shall be inverted with a pulse width modulated (PWM) transistor inverter to an adjustable frequency output.
   a. The output frequency stability to be +1.0% to -1.0% and the output voltage regulation to be +2% to -2%.

4. The controller shall
   a. maintain a minimum lagging power factor of 0.95 at any speed or load.
   b. have input line filtering in compliance with IEEE 519
   c. not generate harmonics of a magnitude that create power line disturbances objectionable to the local utility.

I. Electric Heaters:

1. General: Provide electric resistance open coil duct-type or finned tubular heaters to provide heat to the supply air.
a. Provide either a PWM or SCR controller or a minimum of four steps of electric resistance open coil capacity control shall be required in the heating mode.

2. Heating Elements: Open-wire type, 80% nickel, 20% chromium elements
   a. uniformly distributed
   b. supported in aluminized- or galvanized-steel frame
   c. with vertical support brackets
   d. insulated with ceramic bushings.

3. Controls: Provide thermal cutouts, primary and secondary controls, contactors, circuit fusing, airflow switch, and fused control transformer.
   a. Include integral primary automatic and secondary manual reset thermal-protection devices and airflow switches.

J. Safety Provisions And Components

1. Circuit Protection: The following systems and/or components will be protected against short-circuit currents or grounds by means of properly selected circuit breakers:
   a. Main Power
   b. Blower motor
   c. Fan motors
   d. Compressor motors
   e. Heater stages
   f. Transformer primary winding (by fuse or circuit breaker)
   g. Transformer secondary winding, 24 volt (by fuse or circuit breaker)

2. Overload Protection: Each motor shall be protected from damaging overload currents as follows:
   a. Compressor motors: With manual reset type and adjustable range relays.
   b. Blower Motor: With relays of the manual reset type and adjustable setting range type.
   c. Fan Motors: With relays of the manual reset type and adjustable setting range type.
   d. Compressors shall have motor protection modules with monitoring warning and diagnostic capabilities to include protective features of thermal overload, phase loss, phase reversal, phase imbalance, ground fault, short circuit, over temperature (thermistor input), start time monitoring, stall during start and multiple starts.
   e. Compressor Short Cycling Protection: Each refrigerant compressor motor shall be protected against short cycling (multiple starts and stops over a short period) by a run-limit timer or software.
      (1) The timer or software shall provide a minimum 3-minute delay on re-energizing the compressor motors after each stop.

3. Refrigerant Extreme Pressure Protection: high and low-pressure limit switches or a pressure sensing system controlled by the unit’s PLC shall protect all refrigeration systems.

4. Compressors shall have the following Safety Controls:
   a. Low refrigerant pressure cutout, automatic or manual reset;
   b. High refrigerant pressure cutout, automatic or manual reset;
   c. Compressor motor overload protection, internal and external, manual reset;
5. Main Contactor: Heater contactors shall be controlled by a main contactor and thermal overload contactors so that in the event the heater contactor fails to trip or becomes fused, the thermal overloads will disconnect power to the heater elements.

6. The PCAir shall have:
   a. a “bumper” on the bottom corners of the unit to protect against injuries to the head.
   b. yellow and black safety tape shall be applied to the bottom circumference of the unit.

7. For any input power phase sensitivity, the PCAir shall monitor input power phases and display an error message if input power has improper phasing.

K. Temperature Control:

1. The PCAir unit shall utilize a temperature probe, which can be placed into the cabin of the aircraft when the aircraft is docked to the PBB, to control the supply air temperature to the aircraft.

2. In case of temperature probe failure, damage or removal, the PCAir unit will operate in an automatic mode as follows:
   a. Cooling shall be provided for outdoor air temperatures of 55 F and above during the cooling season.
   b. Ventilation shall be provided for outdoor air temperatures between 45 F and 55 F.
   c. The PCAir unit's electric strip heaters shall provide heating for outdoor air temperature of 45 F and below during the heating season.

3. The PCAir unit shall be designed with an “OVERNIGHT” capability to provide cooling or heating, based on the ambient temperature, if the temperature probe is removed from the aircraft and the aircraft door closed when the aircraft is parked overnight at the gate.
   a. Cooling shall be provided for outdoor air temperatures of 55 F and above during the cooling season.
   b. Ventilation shall be provided for outdoor air temperatures between 45 F and 55 F.
   c. The PCAir unit's electric strip heaters shall provide heating for outdoor air temperature of 45 F and below during the heating season.

4. The output air temperature from the PCAir unit in the PBB Pre-cool / Pre-heat mode shall be the same as the when the PCAir unit is running at full cool or full heat in Narrow Body (NB) mode.

L. Electrical Service / Components / Workmanship

1. Unit shall require only a single feed 480/3/60 electrical connection. Provide transformers as required to feed components and controls utilizing other voltages. The 60 30 ton nominal PCAir unit shall operate on 225 125 amps MAXIMUM.

2. All electrical equipment and components shall be manufactured in Inch-Pound units and conform to recommendations and standards listed in the Quality Assurance Article.
3. If cable trays are used for the power and control cables to route cables beyond the cable conveyance system towards the PCAir unit, the cable tray shall be aluminum or SST.

4. All power and control circuit cables from the cable conveyance system shall terminate directly into terminal blocks in the PCAir disconnect at the PBB rotunda and the PCAir unit mounted on the PBB. An intermediate junction box shall not be allowed.

5. All circuits shall be protected by circuit breakers, except low voltage control circuits of 10 amps 50Vdc / 50Vac OR LESS, which may be protected be either circuit breakers or fuses.

6. All circuits shall have suitable overload protection.
   a. Each conductor shall be sized to have current carrying capacity as allowed by the National Electric Code (NEC) equal to or greater than the capacity of the circuit breaker provided for the circuit.
   b. Circuit breakers shall be grouped in convenient locations and suitably marked for size and function.
   c. Protection devices shall be sized to protect wiring, motors and other electrical components from damage due to overload and prevent electrical or mechanical damage to any associated PCAir components or ancillary equipment due to failure of any PCAir component or ancillary equipment.

7. Connections between the PCAir unit and the Pendant Control, Temperature Probe and PBB interlock shall be heavy duty Quick Disconnect type.

8. Quick Disconnect fittings shall be UL or ETL approved.
   a. Quick Disconnect receptacles and plugs shall be labeled with a permanent type label to indicate which receptacle goes with which plug.

9. Exterior toggle switches must comply with MIL-S-3950 and be rated for the loads which they control.

13. Unit shall be equipped with main breaker, which shall be either:
   a. shunt tripped with a maintenance by-pass switch.
      (1) Shunt trip shall engage whenever the main power panel door is opened and the breaker box door is opened / both ways: or,
   b. integral to the main power panel door and must be manually switched off in order to open the main power panel door.

14. If a separate disconnect is provided on the exterior of the unit:
   a. Disconnect shall be stainless steel NEMA 3R or 4 enclosure with a re-settable breaker and a lockable pull handle
   b. Disconnect shall have a drain device for condensate.

15. Wiring and Terminal Blocks
   a. All interior wiring, connections, terminal blocks, wire routings, use of cable trays / conduit shall comply with the requirements of UL 1995. (1) If any requirements of this Specification conflict with the requirements of UL 1995, the requirements of UL 1995 shall take precedence.
b. Wires shall not be pulled tight in the PCAir unit or subjected to chafing or damage by vibration of the PCAir or by the operation of the PBB.

c. Wires shall not droop or sag in their routing.

d. All wiring shall be brought to mounted terminal blocks.
   (1) Wire splices or wire nuts of any type shall NOT be used.
   (2) Terminal blocks shall NOT be allowed to hang free in air.
   (3) In junction boxes where space does not allow for the use of terminal blocks, mounted Wago type connectors are acceptable.

e. Wiring in all enclosures and junction boxes shall comply with the NEC requirement in Table 314.16 for the wiring fill capacity for the enclosure or junction box.

f. Wiring shall be formed and restrained to give a neat appearance.

g. All wires, including spares, within junction boxes, control cabinets, disconnects, other electrical enclosures shall be neatly secured and routed.
   (1) Wire routing trays shall be used when space permits.

h. Grommets and suitable anti-chafe material shall be used where wires are required to pass through structure or similar relief or opening which exposes the wire to possible chafing.

i. All wiring shall be identified using stamped labels or other Owner approved wire labels.
   (1) Labels shall be visible and located within 1 in. of their termination point.
   (2) Wires are to be numbered in a logical sequence.
   (3) All wire numbers are to be indicated on wiring diagrams.

j. Spare wires shall be numbered and also labeled as “SPARE”.

k. Spare wires shall be indicated on the wiring diagrams.

l. Wires must meet the bend radius requirements of NEC.
   (1) Ninety degree bends shall not be allowed.

m. Ferrules or insulated ring terminals shall be used on any fine stranded wire, depending on the terminal block connection.
   (1) Fork or Spade terminals shall ONLY be allowed to make connections to purchased components that have ring terminals and are assembled into the PCAir. No other use of fork or spade terminals shall be allowed.
   (2) Direct connection of fine stranded wire to a terminal block shall NOT be allowed.

n. Terminal blocks shall be either:
   (1) Finger proof or tamper proof design
   (2) Stud or open style design with a protective cover supplied by the terminal block manufacturer.
   (3) Other terminal block designs shall not be accepted.

o. Terminal blocks must meet the applicable requirements of SAE J561, J858 and J928.

p. Wire ties SHALL NOT be used to secure and support any wiring.

q. NEC / UL approved clamps and methods must be used to secure and support wiring.
   (1) Clamps used shall be specifically designed for the wiring being clamped (e.g. clamps for flat pack cable are not the same as clamps for SO cable).

r. Wire ties shall only be used to keep wires together for appearance and routing to various components.

16. Enclosures and Junction Boxes (except main power / control panel)
   a. All exterior enclosures and junction boxes shall be labeled with engraved placards.
      (1) Placards shall contain the nomenclature used on the drawings or schematics for the enclosure or junction box.
   b. All exterior electrical components, including terminal blocks / terminal strips, shall be
housed in weather tight, stainless steel (SST) enclosures.

c. All exterior enclosures and junction boxes, including pass through junction boxes shall:
   (1) be weather tight, stainless steel (SST) enclosures of NEMA 3R or 4 rating.
   (2) have a hinged, SST cover which shall be retained by SST latch(s) or SST self-retaining screws.
   (3) shall have a weather gasket for the cover.
   (4) shall have a drain device for condensate.

d. All exterior electrical devices, including, but not limited to, lights, beacons, sensors, temperature probes and switches shall be a weather proof design with a NEMA 3R or 4 rating.
   (1) All mounting boxes for electrical devices shall be SST and be a weather proof design with a NEMA 3R or 4 rating.
   (2) The enclosure cover shall be hinged, SST and be retained by SST latch(s) or SST self-retaining screws.
   (3) The enclosure covers shall also have a weather gasket
   (4) The enclosure shall have a drain device for condensate.
   (5) The device should be mounted to the hinged cover

e. All enclosures and junction boxes containing power circuits shall have applicable warning or symbol stickers as required by Code.

f. All components mounted in enclosures and junction boxes shall be mounted to a backing plate supplied by the enclosure manufacturer
   (1) Components shall be intended for use in the enclosure or junction box.
   (2) Mounting directly to the enclosure or junction box wall shall NOT be allowed.

g. Conduits and wiring routed into enclosures, junction boxes and panels shall have clamping fittings and the fitting threads shall have bushings installed

17. Main Power / Control Panel Enclosure shall:
   a. comply with the requirements of UL 1995.
   b. be labeled with an engraved placard containing the nomenclature used on the drawings or schematics for the enclosure.
   c. Shall be constructed out of SST, aluminum or steel with a corrosion resistant coating system.
   d. be weather tight with a NEMA 3R or 4 rating.
   e. have a hinged cover which is SST, aluminum or steel with a corrosion resistant coating and retained by SST latch(s) or SST self-retaining screws.
   f. have a weather gasket for the cover.
   g. have a drain device for condensate.
   h. have applicable warning or symbol stickers as required by Code.
   i. have clamping fittings for all conduits and wiring routed into the enclosure and the fitting threads shall have bushings installed

M. Other PCAir System Components:

1. PCAir Pendant Control
   a. Pendant control shall be mounted to plate, which shall be large enough to accommodate the PCAir pendant control AND the 400Hz GPU / Cable hoist controls, attached to the wheel bogie cross tube, left side of the PBB, facing the aircraft.
   b. All voltages in the Pendant Control shall be low voltage – 28 volts maximum.
d. Quick Disconnect fittings must be MS standard receptacles and plugs and shall be UL or ETL approved.
   (1) Quick Disconnect receptacles and plugs shall be labeled with a permanent type label to indicate which receptacle goes with which plug.

e. Pendant control enclosures shall:
   (1) be SST
   (2) be NEMA 3R or 4 rated
   (3) have a SST cover with piano style SST hinge and be retained by SST latch(s) or SST self-retaining screws.
   (4) have a drain device for condensate.

f. The pendant control station shall have a minimum of three (3) push buttons.
   (1) One button each for Start, for Stop, and an E-Stop button.
   (2) The Start button shall be illuminated “green” when the unit is on.
   (3) The Stop button shall be illuminated “red” when a fault has occurred and shall reset the unit when depressed.
   (4) The E-Stop button shall be a raised, mushroom style E-Stop button.

g. The pendant control shall have a either:
   (1) a switch to select between Narrow Body, Wide Body and OVERNIGHT modes.
   (2) separate start buttons for Narrow Body, Wide Body and OVERNIGHT modes.

h. The pendant control shall have a switch to select the PCAir unit operation modes of heat, cool or vent.

i. Each button on the Pendant control or indicator shall be labeled with an engraved, weather resistant placard identifying the button or indicator function.

j. The Pendant Control shall also have an engraved placard identifying it as the PCAir pendant control.

k. Shall comply with the requirements of 2.4.L.15 and 16.

2. Temperature Probe
a. The temperature probe shall be mounted on the exterior of the front PBB cab wall, below the forward Operator vision window, in the same location as the existing temperature probe.

b. Temperature probe shall be a weather proof design with a NEMA 3R or 4 rating.

c. The mounting box for the temperature probe shall
   (1) be SST and be a weather proof design with a NEMA 3R or 4 rating.
   (2) have an enclosure cover that is SST, hinged, retained by SST latch(s) or SST self-retaining screws.
   (3) have an enclosure cover that has a weather gasket.

    d. The temperature probe should be mounted to the hinged cover.
    a. The temperature probe shall utilize a “jack” type connection to an outlet on the PBB cab wall.
    b. A light shall be provided on the temperature probe outlet to notify the PBB operator that the PCAir is operating in automatic mode due to the failure of the temperature probe.

3. PBB Pre-Cool /Pre-Heat
a. The PBB Pre-Cool / Pre-Heat function shall be controlled by a button on the PBB Operator Console. This will allow the PCAir to be started, in Pre-Cool / Pre-Heat mode, from the PBB Operator Console of the PBB.

b. Safety features will be provided so that the Pre-Cool / Pre-Heat mode can only be started
when the PBB is NOT in Auto Level and the PCAir is not already running.
c. If a push button on the remote pendant control is depressed to start / stop or select a mode for the PCAir unit, the PBB Pre-Cool / Pre-Heat function shall be stopped.
d. Coordinate design and installation of PBB Pre-Cool / Pre-Heat plenum, mounted in “C” tunnel of PBB with PBB Manufacturer.

4. Input Air Filters.
   a. Provide factory-fabricated, flat panel type cleanable (washable) air filters with holding frames, with 2-inch-thick cleanable filtering media constructed of galvanized woven and crimped steel screening, with 20-gauge galvanized steel frame.
   b. Filters shall be cleanable with rated face velocity of 500 foot per minute, initial resistance not greater than 0.10-inch water gauge.
   c. Air filter equipment shall comply with ARI 850.
   d. Air filters shall comply with ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates.

5. Condensate Pump
   a. A condensate pump and drain pan shall be provided for each PCAir unit and shall discharge condensate:
      (1) to the ramp via a condensate hose routed through the lift column scissor and terminated 4-6” below the wheel bogie cross tube, left side.
      (2) through a condensate hose in the PBB cable carrier to a condensate piping connection at the terminal face.
   b. The condensate pump shall be lightweight, self-priming, and capable of running dry.
   c. Minimum pump rating and size shall be:
      (1) 3 gpm, 40-foot head
      (2) determined by the PCAir manufacturer and be capable of pumping the PCAir condensate from the PCAir unit to the terminal building with the PBB at full extension and servicing the smallest aircraft in the specified aircraft mix.
   d. Position the drain pan under the coil section.
   e. Drain pan shall be stainless steel with capability of complete drainage leaving no standing water in pan, regardless of the slope of the PBB.

6. Smoke / CO2 Detectors
   a. PCAir unit shall include an equipment appropriate smoke detector and CO2 detector, which shall be approved by the Owner.
   b. Smoke and CO2 detectors shall be installed downstream of the electric strip heater but upstream from the condenser coils.
   c. Smoke detector shall be ionization type and listed by UL per UL 268A.
   d. Smoke detector shall operate at air velocities from 300 to 4,000 feet per minute.
   e. When smoke or CO2 is sensed, the supply air blower shall shut down.
   f. Visual indication and an audible alarm shall be provided on the front of the PCAir unit (facing the PBB wheel bogie).
      (1) The visual indication shall be red LED light.
      (2) Light and alarm shall have an engraved label identifying them as a smoke / CO2 alarm / fault.
   g. A manual reset shall be located on the front of the devices.
   h. Smoke or CO2 detector heads shall not require additional filters or screens which must be
2.5 PCAIR ACCESSORIES

A. Refer to 2.2.A regarding PCAir accessory Manufacturers.

<table>
<thead>
<tr>
<th>Description – Per PBB Configuration with One (1) Primary Hose Reel Basket w/MD80 Cart</th>
<th>J&amp;B Part number</th>
<th>Quantity Per PBB</th>
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<tr>
<td>Starter Spiral Wound Hose 14”x 3’</td>
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<td>Spiral Wound Hose 14” x 10’</td>
<td>VS1442-10</td>
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<td>JB680-1Y</td>
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<tr>
<td>Reel, Primary, Low-Profile</td>
<td>JB680-7/8U</td>
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<td>Connector, Aircraft</td>
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<tr>
<td>Connector, Swivel, PCAir Hose</td>
<td>JB360</td>
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<tr>
<td>Hose, Spiral, Bridge Supply, 10”x 25’</td>
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<td>1</td>
</tr>
</tbody>
</table>

B. The Contractor shall supply the necessary elbows (1 per PBB), installed just forward of the PBB lift columns, to route the PCAir spiral wound hose from the PCAir unit to the PCAir hose reels.

B. The Contractor shall supply the necessary elbows (2 per PBB), installed on the rotunda side of the lift column, to route the PCAir hose from the PCAir unit to the PCAir side mounted hose basket. The elbow at the left side of the PBB, shall be mounted with an adjustable bracket so the elbow can be aligned directly over the basket.

C. The Contractor shall supply the necessary metal mounting straps (minimum 2 in. wide) to secure the Aircraft and PBB Pre-cool spiral wound hose under the PBB cab bubble.

D. The Contractor shall supply a side front mounted PCAir Hose Basket for each gate.

1. Hose basket shall have 2 sections – a primary section for 60 ft. of flat duct hose and a detachable MD80 cart for 20 ft. of flat duct for the MD80 extension.

2. The hose basket shall be attached to the PBB wheel bogie cross tube, move with the PBB, forward of the wheel bogie cross tube, towards the PBB cab to the left side of the PBB.

3. The hose basket shall be mounted so that the front of the basket is facing forward, towards the PBB cab.
5. The hose basket should be compact in design and shall not interfere with access to the GPU / Cable Hoist / PCAir pendant controls.

6. The hose basket shall be easily detachable from the PBB to facilitate servicing the wheel bogie.

7. Hose basket shall not interfere with the operation of the PBB wheel guard system.

8. Contactor shall coordinate design of the hose basket mounting with the hose basket manufacturer.

9. The primary section of the hose basket shall not exceed 24 in. interior width so that the hose, when rolled up, will not fall over in the basket.

10. The detachable hose cart shall also be a maximum of 24 in interior width. The detachable hose cart shall be fully captured in the hose basket when not in use and shall be easily deployed from the hose basket in order to service the MD80 aircraft.

11. The main basket shall have a hinged, drop down, front door that will provide easy access for the ramp personnel to load and unload the PCAir aircraft supply hose. The drop down door shall be covered with expanded metal or grating to prevent ramp personnel from stepping through it and must support the weight of ramp personnel if they step on the drop down door.

12. The hose basket wheels shall have grease fittings in wheel axle and swivel bearing. The wheel tread shall be designed with a tread to minimize wear.

13. The hose basket color shall be safety yellow.

14. The Owner recommends that the hose basket be purchased from Ameribridge, LLC (see below). Contact information for Ameribrige Inc. is:
   Kenny Sprague
   Ameribridge LLC
   Aftermarket Sales Manager
   (Office) 317-826-2000 Ext 111
   (Cell) 317-331-2473
15. If the hose baskets are not purchased from Ameribridge, LLC, they must fully meet the requirements of 2.5.D

D. The Contractor shall supply PCAir hose reel for each gate.

1. Hose reel shall be the specified J&B hose reel or Owner approved equivalent.

2. Hose reel shall be mounted forward of the wheel bogie, towards the PBB cab.

3. Hose reel shall not interfere with the operation of the PBB wheel guard system.

4. The hose reel shall have grease fittings in wheel axle and swivel bearing. The wheel tread shall be designed with a tread to minimize wear.

5. Hose reel color shall be safety yellow.

SPECIFICATION CONTINUED ON NEXT PAGE
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Owner: City of Fayetteville
Fayetteville, North Carolina

AP#1515
DK Consultants, LLC
July 18, 2016

PART 3 - EXECUTION

3.1 SITE EXAMINATION

A. The Contractor shall coordinate with and provide assistance as needed to the PBB Manufacturer in the performance of the Site Examination requirements specified in PART 3 – EXECUTION of Specification 347713 – PASSENGER BOARDING BRIDGES.

3.2 INSTALLATION

A. PCAir units shall be mounted underneath the PBB “C” tunnel, behind the bogie wheels.
   1. PCAir units shall not transmit vibration to the passenger bridges.
   2. Connections from the PCAir unit to the PCAir pendant control, PCAir temperature probe, and PBB interlock circuits shall be run through rigid conduit to the entry points of the PBB console or PBB cable scissor at the wheel bogie.

B. The PCAir manufacturer shall supply the necessary drawings, instructions, manuals and all materials, accessories, components, etc., required to fully assemble, commission and test the PCAir units and accessories.

C. All such materials shall be packaged as an Installation “Kit” with clearly labeled and indexed containers and materials within containers. These Installation Kits shall be packaged and protected so that they may be stored in an exterior uncovered environment for several months.

D. The PCAir manufacturer shall provide qualified manufacturer's technical representative / service personnel during the PCAir installation, testing and commissioning process AT EACH GATE to assure a proper installation, and to provide adequate and reliable field service support to correct any and all equipment failures that may occur during the commissioning and testing and during the initial operating period. This representation shall be available at FAY for the first 15 days after the first PCAir is installed and accepted by the Owner. The manufacturer's field service representative shall monitor and ensure that the approved PBB Installation Subcontractor follows:
   1. The manufacturer's field installation manual.
   2. Compliance with all safety requirements.
   3. Accurate and complete reports and records maintenance
   4. Applicable requirements of the Project Specifications and Drawings

E. Refer to SECTION 347713 – PASSENGER BOARDING BRIDGES for additional installation information, requirements and specifications.
3.3 TRAINING

A. Contractor shall provide Operations and Maintenance classes for the PCAir units supplied on this Project.

1. The training shall be specific to the PCAir units supplied to FAY. A “standard” training class is not acceptable.

2. Training shall utilize prepared texts, power point presentations and other instructional aids as appropriate. Contractor shall supply whatever equipment is required to present training materials.

3. The Contractor shall conduct two (2) Operations Training Classes during each group to facilitate the scheduling of Owner and Tenant Airline personnel.
   a. Operations training classes shall be a minimum of 4 hours and shall consist of both class room and hands on training.
   b. Operator training shall include, at a minimum, the proper demonstration as well as actual use of correct PCAir operations to avoid damaging the equipment or aircraft or personal injury, by improper use of the PCAir and its controls.
   c. The anticipated class size shall be 10.

5. The Contractor shall conduct two (2) Maintenance Training Classes during each group to facilitate the scheduling of Owner and Owner maintenance contractor personnel.
   a. Maintenance training classes shall be a minimum of 8 hours and shall consist of both class room and hands on training.
   b. Maintenance training shall include, at a minimum:
      (1) proper demonstration of cut-away models of critical parts, full instruction of proper maintenance and troubleshooting, and instructions on proper use of manuals.
      (2) Instruction in proper use, operation, and daily maintenance of the PCAir.
      (3) Emergency provisions, including emergency access and procedures to be followed at time of failure in operation and other building emergencies.
      (4) Normal procedures to be followed in checking for sources of operational failures or malfunctions.
      (5) Use of the hardware / software tools required to upload and download control programs, trouble shoot the PCAir control software, perform equipment diagnostics and review data flow.
      (6) Requirements for a complete PCAir PM Maintenance program, including monthly, quarterly, semiannual and annual checks.
      (7) Warranty, technical support and parts ordering procedures.
   c. The anticipated class size shall be 5.

6. The Contractor shall video tape one complete Operations training session and one complete Maintenance training session and provide these recordings to the Owner.

7. Training dates and times shall be coordinated with the Owner PM.

8. The Owner, Owner’s Maintenance Contractor and tenant Airline shall assign their respective
employees to be trained.

9. Contractor shall submit a Training Syllabus for all training classes to be conducted at FAY within sixty (60) days of the Notice to Proceed. Format and content of Contractor’s proposed Training classes shall be subject to approval of the Owner.

10. The Contractor’s PCAir operator and maintenance training classes shall be conducted concurrent with the PBB and GPU training classes.

11. The Contractor’s PCAir training program must meet the requirements of this Specification and be done within the allowance for the GPU, PCAir and PBB operator and maintenance training classes, as stated in the Project Bid Documents.
PART 4 - CONTRACTOR QUALITY CONTROL REQUIREMENTS

4.1 QUALITY ASSURANCE

A. The Contractor shall comply with, and perform all of the quality control, inspections, factory testing and on-site testing requirements as specified in PART 4 – CONTRACTOR QUALITY CONTROL REQUIREMENTS in Specification 347713 – PASSENGER BOARDING BRIDGES.

4.2 FACTORY ACCEPTANCE

A. The following shall replace the requirements of Specification 347713 – 4.6 FACTORY ACCEPTANCE TESTING

B. Factory testing shall meet the following requirements.

1. The Contractor shall develop a comprehensive Factory Test Plan, identifying the specifics of the tests to be carried out, and the acceptance criteria of such test, to ensure the PCAir units comply with the requirements of the Specification and Contract Documents.

2. The Factory Test Plan shall be submitted to the Owner PM 60 days prior to the factory tests being conducted.

4. At a minimum, the following tests shall be part of the PCAir Factor Test Procedure.
   a. At specified cooling design day conditions, verify temperature, pressure and volume of unit on all Cooling Mode settings, including Vent and Pre-cool.
   b. At specified heating design day conditions, verify temperature, pressure and volume of unit on all Heat Mode Settings.
   c. The above 2 tests shall either:
      (1) be conducted with the supplied PCAir unit fully contained within an environmentally controlled test chamber that can create Design Day Conditions (both heating and cooling) so that the unit can be tested and the test results can confirm that the PCAir unit will produce an airflow at the required temperature, volume and pressure at Design Day conditions: or,
      (2) have been conducted previously on the identical model PCAir unit being supplied within an environmentally controlled test chamber that did create Design Day Conditions (both heating and cooling) so that the design of the unit being supplied was tested and the test results from those tests confirm that the PCAir unit being supplied will produce an airflow at the required temperature, volume and pressure at Design Day conditions.
   d. Verify all functions of Pendant Control
   e. Verify noise level, per the requirements of:
      (1) ARP 1801 - Measurement of Exterior Sound Level of Specialized Aircraft Ground Support Equipment.
      (2) ARP 5374 - Method of Testing Preconditioned Air Equipment.

5. The results of the Factory Testing shall be supplied to the Owner PM prior to shipment. The Owner will NOT approve shipment of the PCAir units without the Owner PM’s review and
approval of the Factory Test Results.
### APPENDIX I– SUBMITTAL SCHEDULE

#### SHOP DRAWINGS AND SAMPLES

<table>
<thead>
<tr>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index of Shop Drawings, Samples and Required Documentation that will be</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>submitted by Contractor</td>
<td></td>
</tr>
<tr>
<td>Product Data / Cut Sheets</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>PCAir Unit Design Drawings and Data</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Accessory Product Data</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Installation Drawings and Information</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>As Built Drawings</td>
<td>30 Days from Final Acceptance of first Gate</td>
</tr>
<tr>
<td>Software, as required by Specifications</td>
<td>Substantial Completion of First Gate</td>
</tr>
</tbody>
</table>

#### REQUIRED DOCUMENTATION

<table>
<thead>
<tr>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certification by Third Party agency or NRTL to UL-1995 and CSA-C22.22</td>
<td>With Contractor Proposal or prior to Contract</td>
</tr>
<tr>
<td>No. 236. Evidence of such certification from the NRTL (e.g. the Authorization to Mark).</td>
<td>Award.</td>
</tr>
<tr>
<td>Documentation of PCAir components certified to UL-1012 and CSA C22.2.107.1-</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>M91.</td>
<td></td>
</tr>
<tr>
<td>Certificate of Compliance – Signed by QA, Engineering and General Managers</td>
<td>Prior to First Factory Inspection</td>
</tr>
<tr>
<td>PCAir cooling and heating calculations – Requirements at AIRCRAFT CONNECTION</td>
<td>Within 30 Days of Award</td>
</tr>
<tr>
<td>for largest aircraft in RJ, NB and WB aircraft in aircraft mix.</td>
<td></td>
</tr>
<tr>
<td>Description of Operation</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Documentation of coordination with PBB manufacturer</td>
<td>Per Contractor’s Submittal Schedule</td>
</tr>
<tr>
<td>Recommended Spare Parts List w/ Pricing</td>
<td>With Shop Drawing Submittal</td>
</tr>
<tr>
<td>Project Progress Schedule</td>
<td>30 Days from NTP</td>
</tr>
<tr>
<td>Written notification of Start of Fabrication for 1st unit</td>
<td>30 Days prior to start of Fabrication</td>
</tr>
<tr>
<td>Written Notification of completion of assembly and readiness for factory</td>
<td>15 Days prior to completion of assembly.</td>
</tr>
<tr>
<td>inspection and testing – each unit.</td>
<td></td>
</tr>
<tr>
<td>Training plan and class syllabus for all training</td>
<td>60 Days from NTP</td>
</tr>
<tr>
<td>Proposed content and format of O&amp;M Manuals</td>
<td>60 Days from NTP</td>
</tr>
</tbody>
</table>

**PRECONDITIONED AIR UNIT AND ACCESSORIES** 238121 - 39
QUALITY ASSURANCE / TESTING

<table>
<thead>
<tr>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Plan, specific to the Project and including at a minimum, the following</td>
<td>60 Days from NTP</td>
</tr>
<tr>
<td>• Review, Inspection, Hold and Witness points, with acceptance criteria, that will be performed during the contract review, design, manufacturing, factory testing, installation and field testing / commission.</td>
<td></td>
</tr>
<tr>
<td>• Scope of inspections and tests to be performed, with acceptance criteria</td>
<td></td>
</tr>
<tr>
<td>• Test plans, procedures, methods, techniques for Factory Acceptance Testing.</td>
<td></td>
</tr>
<tr>
<td>• Test plans, procedures, methods, techniques for Onsite Functional Testing and Commissioning</td>
<td></td>
</tr>
<tr>
<td>Contractor’s Factory Test results and records – Each piece of equipment</td>
<td>Prior to Shipment of each piece of equipment</td>
</tr>
<tr>
<td>Contractor’s On-Site Functional Test Results and Records – Gate by Gate</td>
<td>With Final Acceptance of a Gate</td>
</tr>
</tbody>
</table>

INSTALLATION

See Specification 347713 – PASSENGER BOARDING BRIDGES for submittal requirements for the installation of the PCAir units.

MAINTENANCE AND SPARE PARTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>One (1) Set of Filters per PCAir Unit.</td>
<td>Ship with the unit.</td>
</tr>
<tr>
<td>Owner selected spare parts</td>
<td>At Substantial Completion of 1st gate.</td>
</tr>
</tbody>
</table>
SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes split-system air-conditioning and heat pump units consisting of separate
   evaporator-fan and compressor-condenser components. Units are designed for exposed or
   concealed mounting, and may be connected to ducts.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of
   product indicated. Include performance data in terms of capacities, outlet velocities, static
   pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For split-system air-conditioning units to include in
   emergency, operation, and maintenance manuals.

F. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system
   units and are based on the specific system indicated. Refer to Division 01 Section "Product
   Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,
   Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for
   intended use.

D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

E. Units shall be designed to operate with HCFC-free refrigerants.

1.5 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 07 Section "Roof Accessories."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carrier Air Conditioning; Div. of Carrier Corporation.
   2. Daikin/McQuay
   3. Mitsubishi Electronics America, Inc.; HVAC Division.
2.2 WALL-MOUNTING, EVAPORATOR-FAN COMPONENTS

A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.

B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.

D. Fan: Direct drive, centrifugal fan.

E. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

F. Filters: Permanent, cleanable.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   1. Compressor Type: Rotary.
   2. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   3. Refrigerant Charge: R-410A.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.

E. Fan: Aluminum-propeller type, directly connected to motor.

F. Motor: Permanently lubricated, with integral thermal-overload protection.
G. Low Ambient Kit: Permits operation down to 45 deg F.

H. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
   1. Compressor time delay.
   2. 24-hour time control of system stop and start.
   3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
   4. Fan-speed selection, including auto setting.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Additional Monitoring:
   1. Monitor constant and variable motor loads.
   2. Monitor variable frequency drive operation.
   3. Monitor economizer cycle.
   4. Monitor cooling load.
   5. Monitor air distribution static pressure and ventilation air volumes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounting, compressor-condenser components on 4-inch thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
D. Install ground-mounting, compressor-condenser components on polyethylene mounting base.

E. Install roof-mounting compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

F. Install seismic restraints.

G. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

H. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping." Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

2. Remote Water-Cooled Condenser Connections: Comply with requirements in Division 23 Section "Hydronic Piping." Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

3. Steam Coil Connections: Comply with requirements in Division 23 Section "Steam and Condensate Heating Piping." Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.

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

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

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

END OF SECTION 238126
SECTION 238216 - AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following types of air coils that are not an integral part of air-handling units:
   1. Hot-water.
   2. Chilled-water.

B. Related Sections include the following:
   1. Division 23 Sections for air coils that are integral to air-handling units.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil. Include rated capacity and pressure drop for each air coil.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
1.5 PROJECT CONDITIONS

A. Altitude above Mean Sea Level: 830 feet.

PART 2 - PRODUCTS

2.1 WATER COILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aerofin Corporation.
   2. Carrier Corporation.
   3. Coil Company, LLC.
   4. Dunham-Bush, Inc.
   7. Trane.
   8. USA Coil & Air.

B. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig, 325 deg F.

D. Source Quality Control: Factory tested to 300 psig.

E. Tubes: ASTM B 743 copper seamless, 0.75 inch diameter with a minimum 0.049 inch thick.

F. Fins: Aluminum, minimum 0.010 inch thick.

G. Headers: Seamless copper tube with brazed joints, with drain and air vent toppings prime coated.

H. Frames: Galvanized-steel channel frame, for heating minimum 0.079 inch thick for slip-in mounting.

I. Frames: ASTM A 666, Type 304 stainless steel for cooling, minimum 0.0625 inch thick for slip-in mounting.

J. Hot-Water Coil Capacities and Characteristics: Refer to Schedules.

K. Chilled-Water Coil Capacities and Characteristics: Refer to Schedules.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install stainless-steel drain pan under each cooling coil.
   1. Construct drain pans according to ASHRAE 62.
   2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
   3. Extend drain pan upstream and downstream from coil face.
   4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Division 23 Section "Building automation System," and other piping specialties are specified in Division 23 Section "Hydronic Piping."
D. Connect refrigerant piping according to Division 23 Section "Refrigerant Piping."

E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 238216
SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes fan-coil units and accessories.

1.3 DEFINITIONS

A. BAS: Building automation system.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Ceiling suspension components.
   2. Structural members to which fan-coil units will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:
      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
   6. Perimeter moldings for exposed or partially exposed cabinets.

D. Samples for Initial Selection: For units with factory-applied color finishes.
E. Samples for Verification: For each type of fan-coil unit indicated.

F. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

I. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

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

1.6 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fan-Coil-Unit Filters: Furnish one spare filter for each filter installed.
2. Fan Belts: Furnish one spare fan belt for each unit installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. In the Fan-Coil-Unit Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FAN-COIL UNITS

A. Manufacturers:
   1. Carrier Corporation.
   2. Enviro-Tec.
   4. Trane.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: 1-inch (25-mm) thick, foil-covered, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

D. Main and Auxiliary Drain Pans: Stainless steel formed to slope from all directions to the drain connection as required by ASHRAE 62. Drain pans shall be removable.

E. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

F. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.
   1. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped discharge grilles.
   2. Steel recessing flanges for recessing fan-coil units into ceiling or wall.
G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. 1-inch pleated: 85 percent arrestance and 6 MERV.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

I. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   3. Wiring Termination: Connect motor to chassis wiring with plug connection.

J. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls" and

K. Basic Unit Controls:
   1. Control voltage transformer.
   2. Wall-mounting thermostat with the following features:
      b. Fan on-auto switch.
      c. Fan-speed switch.
      d. Automatic changeover.
      e. Adjustable deadband.
      f. Concealed set point.
      g. Concealed indication.
      h. Degree F indication.
   3. Wall-mounting humidistat.
      a. Concealed set point.
      b. Concealed indication.
   4. Unoccupied-period-override push button.
   5. Data entry and access port.
      a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
      b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

L. DDC Terminal Controller:
   1. Scheduled Operation: Twenty-four hours per day.
   2. Unit Supply-Air Fan Operation: Fan cycles to maintain room temperature.
   3. Hydronic-Cooling-Coil Operation:
      a. Modulate control valve to maintain room temperature.
   4. Heating-Coil Operation:
a. Modulate control valve to provide heating if room temperature falls below thermostat set point.

5. Reheat-Coil Operation:
   a. Humidity Control for Occupied and Unoccupied Periods:
      1) Humidistat modulates control valve to provide heating. As space temperature rises above the set point, cooling coil valve modulates to maintain room temperature.

6. Controller shall have volatile-memory backup.

M. BAS Interface Requirements:
   1. Interface relay for scheduled operation.
   2. Interface relay to provide indication of fault at the central workstation.
   3. Provide LonWorks interface for central BAS workstation for the following functions:
      a. Adjust set points.
      b. Fan-coil-unit start, stop, and operating status.
      c. Occupied and unoccupied schedules.

N. Electrical Connection: Factory wire motors and controls for a single electrical connection.

O. Capacities and Characteristics: Refer to equipment schedule on the drawings for additional information.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

   B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

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

3.2 INSTALLATION
   A. Install fan-coil units level and plumb.

   B. Install fan-coil units to comply with NFPA 90A.

   C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

   D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings
and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
   3. Connect condensate drain to indirect waste.
      a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.4 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to
two visits to Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION 238219
SECTION 238233 - CONVECTORS

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. This Section includes the following:

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Plans, elevations, sections, and details.
   2. Details of custom-fabricated enclosures indicating dimensions.
   3. Location and size of each field connection.
   4. Location and arrangement of piping valves and specialties.
   5. Location and arrangement of integral controls.
   6. Enclosure joints, corner pieces, access doors, and other accessories.

C. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Structural members, including wall construction, to which convection units will be attached.
   2. Method of attaching convection units to building structure.
   3. Penetrations of fire-rated wall and floor assemblies.

D. Color Samples for Initial Selection: For units with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish required.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For convection heating units to include in emergency, operation, and maintenance manuals.
1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 HOT-WATER FINNED-TUBE RADIATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Engineered Air.
   2. Modine.
   3. Slant/Fin.
   4. Trane.

B. Performance Ratings: Rate finned-tube radiators 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 tube end shall be belled. Refer to equipment schedule on the drawings for additional information.

D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

E. Front Panel: Minimum 0.0528-inch-thick steel.

F. Rust-Resistant Front Panel: Minimum 0.064-inch-thick, ASTM A 653/A 653M, G60 galvanized steel.

G. Wall-Mounting Back Panel: Minimum 0.0329-inch-thick steel, full height, with full-length channel support for front panel without exposed fasteners.

H. Floor-Mounting Pedestals: Conceal insulated piping at maximum 36-inch spacing. Pedestal-mounting back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.

I. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

J. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.

K. Damper: Knob-operated internal damper at enclosure outlet.

L. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size
6 by 7 inches, integral with enclosure.

M. 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.
      b. Anodized finish, color as selected by Architect from manufacturer's standard colors.
      c. Painted to match enclosure.
   3. Top Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      b. Anodized finish, color as selected by Architect from manufacturer's standard colors.
      c. Painted to match enclosure.

N. 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 convection heating units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for hydronic-piping connections to verify actual locations before convection heating unit installation.

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

3.2 FINNED-TUBE RADIATOR INSTALLATION

A. Install units level and plumb.

B. Install finned-tube radiators according to Guide 2000 - Residential Hydronic Heating.

C. Install enclosure continuously around corners, using outside and inside corner fittings.

D. Join sections with splice plates and filler pieces to provide continuous enclosure.

E. Install access doors for access to valves.

F. Install enclosure continuously from wall to wall.

G. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.
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H. Install valves within reach of access door provided in enclosure.
I. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.
J. Install piping within pedestals for freestanding units.

3.3 CONNECTIONS
A. Piping installation requirements are specified in Division 23 Section "Hydronic Piping."
   Drawings indicate general arrangement of piping, fittings, and specialties.
B. Connect hot-water units and components to piping according to Division 23 Section "Hydronic Piping."
   1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
C. Install control valves as required by Division 23 Section "Instrumentation and Control for HVAC."
D. Install piping adjacent to convection heating units to allow service and maintenance.

3.4 FIELD QUALITY CONTROL
A. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper convection heating unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
B. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

END OF SECTION 238233
SECTION 238239 - 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:

1. Cabinet unit heaters with centrifugal fans and [hot-water] [steam] [electric-resistance heating] coils.
2. Propeller unit heaters with [hot-water] [steam] [electric-resistance heating] coils.
3. Wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 DEFINITIONS

A. BAS: Building automation system.
B. CWP: Cold working pressure.
C. PTFE: Polytetrafluoroethylene plastic.
D. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Plans, elevations, sections, and details.
2. Location and size of each field connection.
3. Details of anchorages and attachments to structure and to supported equipment.
4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
5. Location and arrangement of piping valves and specialties.
6. Location and arrangement of integral controls.
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C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which 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.
   f. <Insert item.>

6. Perimeter moldings for exposed or partially exposed cabinets.

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 and wall and ceiling heaters indicated with factory-applied color finishes.

F. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.
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1.5 QUALITY ASSURANCE

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

1.6 EXTRA MATERIALS

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

1. Cabinet Unit Heater Filters: Furnish [one] <Insert number> spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 CABINET UNIT HEATERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:

2. Dunham-Bush, Inc.
3. Markel Products; a division of TPI Corporation.
5. McQuay International.
7. Trane.

D. Description: A factory-assembled and -tested unit complying with ARI 440.

E. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be [aluminum-foil facing] [erosion-resistant coating] to prevent erosion of glass fibers.

   1. Thickness: [1/2 inch] [1 inch] [1-1/2 inches].
   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
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1. Thickness: [3/8 inch] [1/2 inch] [3/4 inch] [1 inch].
2. Thermal Conductivity (k-Value): 0.24 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 C 411.
4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

G. Cabinet: Steel with [factory prime coating, ready for field painting] [baked-enamel finish with manufacturer's standard paint, in color selected by Architect] [baked-enamel finish with manufacturer's custom paint, in color selected by Architect].

1. Vertical Unit, Exposed Front Panels: Minimum [0.0528-inch-] [0.0677-inch-] thick, [galvanized,] sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. Horizontal Unit, Exposed Bottom Panels: Minimum [0.0528-inch-] [0.0677-inch-] thick, [galvanized,] sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
3. Recessing Flanges: Steel, finished to match cabinet.
4. Control Access Door: Key operated.
5. Base: Minimum 0.0528-inch- thick steel, finished to match cabinet, [4 inches] [6 inches] <Insert dimension> high with leveling bolts.
6. Extended Piping Compartment: [8-inch-] <Insert dimension> wide piping end pocket.
7. False Back: Minimum 0.0428-inch- thick steel, finished to match cabinet.
8. Outdoor-Air Wall Box: Minimum 0.1265-inch- thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen. Aluminum louver with [anodized] [baked-enamel] finish in color selected by Architect from manufacturer's [standard] [custom] colors.
   a. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with [manual] [electronic] [pneumatic], two-position actuators.

H. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Washable Foam: 70 percent arrestance and 3 MERV.
2. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
3. Pleated: 90 percent arrestance and 7 MERV.

I. 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.
J. Steam Coil: Copper[**distributing**] tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 75 psig.

K. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

L. Fan and Motor Board: Removable.
   1. Fan: Forward curved, [**high static**]double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

M. Factory, Hot-Water Piping Package: [**ASTM B 88, Type L**] [**ASTM B 88, Type M**] copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.
   1. [Two] [**Three**]-way, [**two-position**] [modulating] control valve.[**Three-way valve packages shall include bypass line with manually adjustable balance device.**]
   2. 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**] [**36 inches**] <**Insert dimension**>.
      b. Minimum Diameter: Equal to cabinet unit heater connection size.
   3. 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.
   4. 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.
   5. 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 with plus or minus 10 percent over differential pressure range of 2 to 80 psig.
   6. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, 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.

N. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

O. Basic Unit Controls:
1. Control voltage transformer.

2. [Wall-mounting] [Unit-mounted] thermostat with the following features.
   b. Fan on-auto switch.
   d. Adjustable deadband.
   e. [Concealed] [Exposed] set point.
   f. [Concealed] [Exposed] indication.
   g. Deg F indication.

3. [Wall-mounting] [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.

P. [DDC ]Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.

2. Unoccupied Period Override: [Two] <Insert number> hours.

3. Unit Supply-Air Fan Operations:
   a. Occupied Periods: Fan runs continuously.
   b. Unoccupied Periods: Fan cycles to maintain setback room temperature.

4. Heating Coil Operations:
   a. Occupied Periods: [Open control valve] [Modulate control valve] [Energize electric-resistance coil] to provide heating if room temperature falls below thermostat set point.
   b. Unoccupied Periods: Start fan and [open control valve] [modulate control valve] [energize electric-resistance coil] if room temperature falls below setback temperature.

5. Outdoor-Air Damper Operation:
   a. Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
   b. Unoccupied Periods: Close damper.

6. Controller shall have volatile-memory backup.

Q. BAS Interface Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at central workstation.
3. Interface shall be [BAC-net] [or] [LonWorks] compatible for central BAS workstation and include the following functions:
   a. Adjust set points.
   b. Cabinet unit heater start, stop, and operating status.
   c. Data inquiry, including [outdoor-air damper position, supply-air and room-air temperature.]
   d. Occupied and unoccupied schedules.

R. Electrical Connection: Factory wire motors and controls for a single field connection.

S. Capacities and Characteristics: Refer to equipment schedules on drawing for additional information.

1. Cabinet:
      1) Top: [Flat] [Sloped] [Flat or sloped].
      2) Air Inlet: [Open bottom] [Front, punched louver grille] [Front, extruded-aluminum bar grille].
      3) Air Outlet: [Front] [Top] [Front or top], [quad louver] [punched louver] [extruded-aluminum bar grille].
   b. Vertical, Surface Mounted: Downflow.
      1) Top: [Flat] [Sloped] [Flat or sloped].
      2) Air Inlet: [Front] [Top] [Front or top], [punched louver] [extruded-aluminum bar grille].
      3) Air Outlet: Front, [quad louver] [punched louver] [extruded-aluminum bar grille].
      1) Air Inlet: [Open bottom] [Front, punched louver grille] [Front, extruded-aluminum bar grille].
      2) Air Outlet: [Front] [Top] [Front or top], [quad louver] [punched louver] [extruded-aluminum bar grille].
   d. Vertical, Semirecessed: Downflow.
      1) Air Inlet: [Front] [Top] [Front or top], [punched louver] [extruded-aluminum bar grille].
      2) Air Outlet: Front, [quad louver] [punched louver] [extruded-aluminum bar grille].
   e. Vertical, Fully Recessed: [Upflow] [Downflow].
1) Air Inlet and Outlet: Front, [punched louver] [extruded-aluminum bar grille] inlet and [quad louver] [punched louver] [extruded-aluminum bar grille] outlet.

2) Air Inlet: [Front] [Duct connection], [punched louver] [extruded-aluminum bar grille].

3) Air Outlet: [Front] [Duct connection], [quad louver] [punched louver] [extruded-aluminum bar grille].

f. Horizontal, Surface Mounted:

1) Air Inlet: [Bottom] [Front] [Bottom or front], [punched louver] [extruded-aluminum bar grille].

2) Air Outlet: [Front] [Top] [Front or top], [quad louver] [punched louver] [extruded-aluminum bar grille].

g. Horizontal, Semirecessed:

1) Air Inlet: [Bottom] [Front] [Bottom or front], [punched louver] [extruded-aluminum bar grille].

2) Air Outlet: [Front] [Top] [Front or top], [quad louver] [punched louver] [extruded-aluminum bar grille].

h. Horizontal, Fully Recessed:

1) Air Inlet and Outlet: Front, [punched louver] [extruded-aluminum bar grille] inlet and [quad louver] [punched louver] [extruded-aluminum bar grille] outlet.

2) Air Inlet: [Front] [Duct connection], [punched louver] [extruded-aluminum bar grille].

3) Air Outlet: [Front] [Duct connection], [quad louver] [punched louver] [extruded-aluminum bar grille].

2. Filters:

a. Face Area: <Insert sq. ft.>

b. Thickness: [1/2 inch] [1 inch] <Insert thickness>.

2.2 PROPELLER UNIT HEATERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

1. Airtherm; a Mestek Company.
4. Trane.

C. Description: An assembly including casing, coil, fan, and motor in [vertical] [and] [horizontal] discharge configuration with adjustable discharge louvers.

D. Comply with UL 2021.

E. Comply with UL 823.

F. Cabinet: Removable panels for maintenance access to controls.

G. Cabinet Finish: Manufacturer's [standard] [custom] baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

H. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

I. General Coil Requirements: Test and rate [hot-water] [steam] propeller unit heater coils according to ASHRAE 33.

J. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, 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 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

K. Hot-Water Coil: Cupronickel tube, minimum 0.031-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 400 psig and a maximum entering-water temperature of 450 deg F, with manual air vent. Test for leaks to 600 psig underwater.

L. Hot-Water Coil: Red brass tube, minimum 0.049-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 260 psig and a maximum entering-water temperature of 390 deg F, with manual air vent. Test for leaks to 390 psig underwater.

M. Hot-Water Coil: Steel tube, minimum 0.049-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 400 psig and a maximum entering-water temperature of 450 deg F, with manual air vent. Test for leaks to 600 psig underwater.

N. Hot-Water Coil: Vertical steel tube, minimum 0.065-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 400 psig and a maximum entering-water temperature of 450 deg F, with steel headers at top and bottom. Test for leaks to 600 psig underwater.

O. Steam Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 75 psig.
P. Steam Coil: Red brass tube, minimum 0.049-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 75 psig.

Q. Steam Coil: Vertical steel tube, minimum 0.065-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of [100 psig] [200 psig], with steel headers at top and bottom.

R. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

S. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

T. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Type: Permanently lubricated, [explosion proof] [multispeed] [variable speed].

U. Control Devices:

1. [Unit-mounted] [Wall-mounting]. [variable ]fan-speed switch.
2. [Unit-mounted] [Wall-mounting] thermostat.

V. Capacities and Characteristics: Refer to equipment schedules on drawings for information.

2.3 WALL AND CEILING HEATERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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

C. Basis-of-Design Product: Subject to compliance with requirements, provide [the product indicated on Drawings] <Insert manufacturer's name; product name or designation> or a comparable product by one of the following:

2. Markel Products; a division of TPI Corporation.
3. QMark Electric Heating; a division of Marley Engineered Products.
4. Sterling.
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5. **Trane.**

D. **Description:** An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

E. **Cabinet:**

1. **Front Panel:** [Stamped-steel louver] [Extruded-aluminum bar grille], with removable panels fastened with tamperproof fasteners.
2. **Finish:** Baked enamel over baked-on primer with manufacturer's [standard] [custom] color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

F. **Surface-Mounting Cabinet Enclosure:** Steel with finish to match cabinet.

G. **Electric-Resistance Heating Coil:** Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high temperature protection. [Provide integral circuit breaker for overcurrent protection.]

H. **Fan:** Aluminum propeller directly connected to motor.

1. **Motor:** Permanently lubricated, multispeed. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

I. **Controls:** Unit-mounted thermostat. [Low-voltage relay with transformer kit.]

J. **Electrical Connection:** Factory wire motors and controls for a single field connection with disconnect switch.

K. **Capacities and Characteristics:** Refer to equipment schedules on drawings for information.

**PART 3 - EXECUTION**

3.1 **EXAMINATION**

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for [piping and] electrical connections to verify actual locations before unit heater installation.

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

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Install propeller unit heaters level and plumb.

D. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints. Vibration isolators and seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

E. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers with vertical-limit stop. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

G. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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 Division 23 Section "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 unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping."

G. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of unit heater. Steam specialties are specified in Division 23 Section "Steam and Condensate Heating Piping."
H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.4 FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two] visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION 238239