PROJECT MANUAL

WEST REGIONAL LIBRARY RENOVATION

4000 LOUIS STEPHENS DRIVE
CARY, NC 27519

Permit Set
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Clearscapes, PA

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Book 2 of 2
Divisions 21 through 28

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SECTION 210500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

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. Piping materials and installation instructions common to most piping systems.
2. Sleeves.
3. Escutcheons.
4. Grout.
5. Fire-suppression equipment and piping demolition.
6. Equipment installation requirements common to equipment sections.
7. Painting and finishing.
8. Concrete bases.
9. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Piping materials Escutcheons.

2. Welding certificates.

1.5 QUALITY ASSURANCE

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

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces.

D. Coordinate locations of flexible couplings on both sides of fire rated partitions to limit the number of sway braces required.

E. Coordinate all seismic braces with other trades and building structure.

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 manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 21 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

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

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

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.5 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. Split-Plate, Stamped-Steel Type: With exposed-rivet hinge, set screw or spring clips, and chrome-plated finish.

F. One-Piece, Floor-Plate Type: Cast-iron floor plate.

G. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

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

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are to be 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. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

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

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

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

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

1. New Piping:

   a. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
   b. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.
   c. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
   d. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

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

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

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

P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials. Provide flexible couplings within 12” of either side of wall to eliminate sleeves in these locations.

R. Verify final equipment locations for roughing-in.

3.2 PIPING JOINT CONSTRUCTION

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

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

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

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

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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

3.3 PAINTING

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

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

3.4 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.

B. Field Welding: Comply with AWS D1.1.

C. Provide seismic restraints per NFPA 13 chapter 9.

END OF SECTION 210500

SECTION 211000 - WET-PIPE SPRINKLER SYSTEMS

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 specifies wet-pipe sprinkler systems for buildings and structures.

B. Products specified in this Section with installation not in Contract include sprinkler cabinets with spare sprinklers and sprinkler wrenches. Deliver to the Owner's maintenance personnel.

1.3 DEFINITIONS

A. Pipe sizes used in this Section are nominal pipe size (NPS) specified in inches. Tube sizes are standard tube size specified in inches. Equivalent or approximate SI (metric) sizes are indicated in millimeters (mm) in parentheses.

B. Working plans as used in this Section refer to documents (including drawings and calculations) prepared pursuant to requirements in NFPA 13 for obtaining approval of authority having jurisdiction.

C. Other definitions for fire protection systems are included in referenced NFPA standards.

1.4 SYSTEM DESCRIPTION

A. Wet-Pipe Sprinkler System: System with automatic sprinklers attached to piping system containing water and connected to water supply so that water discharges immediately from sprinklers when they are opened by fire.

B. Sprinkler System Protection Limits: All spaces within areas indicated. Include closets, toilet areas, and special applications areas.

1.5 SYSTEM PERFORMANCE REQUIREMENTS

A. Obtain approval from Authority Having Jurisdiction for fire protection systems specified.

B. Minimum Pipe Sizes: Not smaller than sizes indicated for connection to water supply piping, standpipes, and branches from standpipes to sprinklers.

C. The water supply is to be taken from the flow data shown on the drawings. Allow 10% cushion. Calculations start at the existing water lines outside the buildings and must include all valves and fittings. Use the “1.4 Rule”, and include a 100 gpm hose stream allowance for light hazard and 250 gpm hose stream for ordinary hazard. Limit water velocity to 25fps, except use 18fps for any segment with a vane type water-flow switch (to comply with UL listing).

D. Hydraulically design sprinkler systems according to:

1. Sprinkler System Occupancy Light and Ordinary Hazard Group I Classification.
2. Minimum Density Requirements for Automatic Sprinkler System Hydraulic Design: Refer to sprinkler design data on Sheet FP001.
3. Maximum Sprinkler Spacing: Refer to sprinkler design data on Sheet FP001.

E. Components and Installation: Capable of producing piping systems with the following minimum working pressure ratings except where indicated otherwise.

1. Sprinkler Systems: 175 psig.

1.6 SUBMITTALS

A. Product data for fire protection system components. Include the following:

1. Valves.
2. Specialty valves, accessories, and devices.
3. Alarm devices. Include electrical data.
4. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other data.

B. The sprinkler contractor must submit “working plans or shop/fabrication drawings” and hydraulic calculations to Sigma Engineered Solutions for review, prior to any fabrication or installation work. No fabrication and or installation shall begin without approved submittals from Sigma Engineered Solutions, PC and AHJ.

C. Test reports and certificates as described in NFPA 13. Include "Contractor's Material & Test Certificate for Aboveground Piping" and "Contractor's Material & Test Certificate for Underground Piping."

D. Maintenance data for each type of fire protection specialty specified, for inclusion in Operating and Maintenance Manual specified in Division 1.

E. 2 copies of NFPA 25 "Standard for Inspection, Testing and Maintenance of Water Based Fire Protection Systems." Deliver to Owner's maintenance personnel.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms whose equipment, specialties, and accessories are listed by product name and manufacturer in UL Fire Protection Equipment Directory and FM Approval Guide and that conform to other requirements indicated.

B. Listing/Approval Stamp, Label, or Other Marking: On equipment, specialties, and accessories made to specified standards.

C. Listing and Labeling: Equipment, specialties, and accessories that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in "National Electrical Code," Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

D. Comply with requirements of authority having jurisdiction for submittals, approvals, materials, hose threads, installation, inspections, and testing.

E. Comply with requirements of the North Carolina Department of Insurance for submittals, approvals, materials, installation, inspections, and testing.

F. Installer's Qualifications: Firms qualified to install and alter fire protection piping, equipment, specialties, and accessories, and repair and service equipment. A qualified firm is one that is experienced (minimum of 5 previous projects similar in size and scope to this Project) in such work, familiar with precautions required, and in compliance with the requirements of the authority having jurisdiction. Submit evidence of qualifications to the Sigma Engineered Solutions upon request"

G. NFPA Standards: Equipment, specialties, accessories, installation, and testing complying with the following:

1. NFPA 13 "Standard for the Installation of Sprinkler Systems."
2. NFPA 26 "Recommended Practice for the Supervision of Valves Controlling Water Supplies for Fire Protection."
3. NFPA 70 "National Electrical Code."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Specialty Valves:

   a. ASCOA Fire Systems, Figgie International Co.
   b. Central Sprinkler Corp.
   c. Firematic Sprinkler Devices, Inc.
   d. Gem Sprinkler Co. Div., Grinnell Corp.
   e. Globe Fire Sprinkler Corp.
   f. Reliable Automatic Sprinkler Co., Inc.
   g. Star Sprinkler Corp.
   h. Viking Corp.

2. Sprinklers:

   a. ASCOA Fire Systems, Figgie International Co.
   b. Firematic Sprinkler Devices, Inc.

c. Gem Sprinkler Co. Div., Grinnell Corp.
d. Globe Fire Sprinkler Corp.
e. Reliable Automatic Sprinkler Co., Inc.
f. Star Sprinkler Corp.
g. Victaulic Company of America.
h. Viking Corp.

3. Grooved Couplings for Steel Piping:

a. Grinnell Supply Sales Co., Grinnell Corp.
b. Gustin-Bacon Div., Tyler Pipe Subsid., Tyler Corp.
c. Sprink-Line by Sprink, Inc.
d. Stockham Valves and Fittings, Inc.
e. Victaulic Company of America.

2.2 PIPES AND TUBES

A. Refer to Part 3 Articles "Piping Installation" for identification of systems where pipe and fitting materials specified below are used.

B. All piping shall be as follows:

1. 2 1/2" through 8" pipe size: ASTM A135, schedule 10 black steel, grooved or welded joints and fittings.
2. 2" and smaller pipe size: ASTM A135, schedule 40 black steel pipe with standard weight cast iron or malleable iron threaded joints and fittings, or schedule 40 black steel welded joints and fittings. Mechanical tees, grooved or threaded may be used.

2.3 PIPE AND TUBE FITTINGS

A. NO SADDLE FITTINGS AND NO MECHANICAL TEES.

B. Cast-Iron Threaded Flanges: ASME B16.1, Class 125, raised ground face, bolt holes spot faced.

C. Ductile-Iron and Gray-Iron Flanged Fittings: AWWA C110, 125-psig minimum pressure rating, with AWWA C104 cement-mortar lining.

D. Cast-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern, with threads according to ASME B1.20.1.

E. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threads according to ASME B1.20.1.

F. Grooved-End Fittings for Ductile-Iron Pipe: ASTM A 536 ductile-iron or ASTM A 47 malleable-iron, AWWA pipe-size, designed to accept AWWA C606 grooved couplings. Include cement lining or Food and Drug Administration (FDA)-approved interior coating.

G. Steel Fittings: ASTM A 234/A 234M, seamless or welded; ASME B16.9, buttwelding; or ASME B16.11, socket-welding type for welded joints.

H. Steel Flanges and Flanged Fittings: ASME B16.5.

I. Grooved-End Fittings for Steel Pipe: UL-listed and FM-approved, ASTM A 536, Grade 65-45-12 ductile iron or ASTM A 47 Grade 32510 malleable iron, with grooves or shoulders designed to accept grooved couplings.

2.4 JOINING MATERIALS

A. Flanged Joints for Ductile-Iron Pipe and Ductile-Iron or Cast-Iron Fittings: AWWA C115 ductile-iron or gray-iron pipe flanges, rubber gaskets, and high-strength steel bolts and nuts.

B. Couplings for Grooved-End Steel Pipe and Grooved-End Ferrous Fittings: UL 213, AWWA C606, ASTM A 536 ductile-iron or ASTM A 47 malleable-iron housing, with enamel finish. Include synthetic-rubber gasket with central-cavity, pressure-responsive design; ASTM A 183 carbon-steel bolts and nuts; and locking pin, toggle, or lugs to secure grooved pipe and fittings.

C. Couplings for Grooved-End Ductile-Iron Pipe and Fittings: UL 213, AWWA C606, ASTM A 536 ductile-iron housing, with enamel finish. Include synthetic-rubber gasket with central-cavity, pressure-responsive design, and ASTM A 183 carbon-steel bolts and nuts to secure grooved pipe and fittings.

2.5 SPRINKLERS

A. NO FLEX SPRINKLER HEADS.

B. Automatic Sprinklers: With heat-responsive element conforming to:

1. UL 199, for applications except residential.

C. Sprinkler types and categories are as indicated on plans and as required by application. Furnish automatic sprinklers with nominal 1/2-inch orifice for "Ordinary" temperature classification rating except where otherwise indicated and required by application.

D. Sprinkler types, features, and options include:

1. Quick response recessed pendent sprinklers in lay in ceiling.
2. Quick response upright sprinklers in areas with exposed piping.
3. Quick response dry sidewall sprinklers where indicated.

E. Sprinkler Finishes: As indicated on plans.

F. Sprinkler Escutcheons: Materials, types, and finishes for following sprinkler mounting applications. Escutcheons for concealed type sprinklers are specified with sprinklers. In layin ceilings escutcheons shall be suitable for easy ceiling tile replacement.

1. Ceiling Pendent Mounting: Finish as indicated on plans, 2-piece, recessed.

2.6 SPECIALTY SPRINKLER FITTINGS

A. Specialty Fittings: UL-listed and FM-approved, made of steel, ductile iron, or other materials compatible with system materials and applications where used.

B. Mechanical-Cross Fittings: UL 213, ductile-iron housing with pressure-responsive gaskets, bolts, and threaded or grooved outlets.

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

D. Sprinkler Alarm Test Fittings: Ductile-iron housing with 1-1/2-inch inlet and outlet, integral test valves, combination orifice and sight glass, and threaded or locking-lug ends.

2.7 PRESSURE GAGES

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

2.8 SEISMIC SWAY BRACES

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

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

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

1. Shutoff Duty: Use ball or butterfly valves.
2. Throttling Duty: Use globe, ball, or butterfly valves.

3.2 JOINT CONSTRUCTION

A. Grooved-End Pipe and Grooved-End Fitting Joints: Use grooved-end fittings and grooved couplings that are made by the same manufacturer and that are listed for use together. Groove pipe and assemble joints with grooved coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

1. Groove Type: Rolled.

B. Dissimilar Materials Piping Joints: Make joints using adapters compatible with both piping materials.

3.3 PIPING INSTALLATIONS

A. Locations and Arrangements: Drawings indicate general location and arrangement of piping and are provided for informational purposes. Every fitting and length of pipe may not be shown on the contract documents. It is the contractor’s responsibilities to review the contract documents and coordinate the fire protection system installation with the building architectural, structural, mechanical and electrical systems. The contractor shall create "working plans or shop/fabrication drawings" showing all pipe sizes, location, routing and elevations that are a result of this coordination effort. Necessary offsets or changes in pipe routing from the contract documents that are required to properly install the fire protection system as to take up minimum space shall be furnished and install by the contractor with no additional expense to the owner. Install piping as indicated, as far as practical.

1. Deviations from approved "working plans" for sprinkler piping require written approval from authority with jurisdiction. File written approval with the engineer/owner's representative prior to deviating from approved "working plans."

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

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

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

E. Install "Inspector's Test Connections" in sprinkler piping, complete with shutoff valve, sized and located according to NFPA 13 and plumb to gang drain. Inspector's Test Connections should be operable from floor level whenever possible. Test Connections are permitted to be locked if vandalism is a concern.

F. Install sprinkler piping with drains for complete system drainage, and isolation drainage as shown on the Drawings.

G. Install sprinkler zone control valves, test assemblies, and drain headers.

H. Install ball drip valves to drain piping between fire department connections and check valves, and where indicated. Drain to suitable drain or outside building.

I. Install alarm devices including water motor gongs in piping systems.

J. Hangers and Supports: Comply with NFPA 13. Install according to NFPA 13 and NFPA 14.

1. Install hanger and support spacing and locations for steel piping joined with grooved mechanical couplings according to manufacturer's written instructions for rigid systems.

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

3.4 SPECIALTY SPRINKLER FITTING INSTALLATIONS

A. Install specialty sprinkler fittings according to manufacturer's written instructions.

3.5 SPRINKLER APPLICATIONS

A. Rooms without Ceilings: Upright style sprinklers.

B. Rooms with Ceilings: Pendent style recessed sprinklers.

3.6 SPRINKLER INSTALLATIONS

A. Install sprinklers in patterns indicated.

B. Install sprinklers in suspended ceilings in center of acoustical panels and tiles unless otherwise indicated.

C. Do not install wet-type sprinklers in areas subject to freezing. Heat tracing is NOT acceptable for dry pipe or preaction valve freeze protection. A heated room or closet must be provided to protect these vital components.

3.7 CONNECTIONS

A. Connect to specialty valves, hose valves, specialties, and accessories.

B. Connect water supplies to standpipe and sprinkler systems.

3.8 FIELD QUALITY CONTROL

A. Perform field acceptance tests of each fire protection system.

1. Flush, test, and inspect sprinkler piping systems according to NFPA 13 Chapter "System Acceptance."

B. Replace piping system components that do not pass test procedures specified, then retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.

1. Report test results promptly and in writing to Engineer and Owner.
2. Report test results promptly and in writing to authority having jurisdiction when required.

3.9 CLEANING

A. Clean dirt and debris from sprinklers. Replace sprinklers having paint other than factory finish with new sprinklers. Cleaning and reuse of painted sprinklers is prohibited.

3.10 COMMISSIONING

A. Starting Procedures: Follow manufacturer's written procedures. If no procedures are prescribed by manufacturer, proceed as follows:

1. Verify that specialty valves, trim, fittings, controls, and accessories have been installed correctly and operate correctly.
2. Verify that specified tests of piping are complete.
3. Check that damaged sprinklers and sprinklers with paint or coating not specified have been replaced with new, correct type of sprinklers.
4. Check that sprinklers are correct type, have correct finish and temperature ratings, and have guards where required for applications.
5. Check that potable water supplies have correct type of backflow preventer.
6. Check that fire department connections have threads compatible with local fire department equipment and have correct pressure rating.
7. Fill wet-pipe sprinkler systems with water.
8. Energize circuits to electrical equipment and devices.
9. Adjust operating controls and pressure settings.

B. Coordinate with fire alarm system tests. Operate systems as required.

3.11 PAINTING

A. Exposed piping in sprinkler riser mechanical room shall be painted OSHA red.

B. Exposed piping in rooms and corridors shall be painted to match existing finishes. Coordinate with owner.

3.12 DEMONSTRATION

A. Demonstrate equipment, specialties, and accessories. Review operating and maintenance information.

B. Schedule demonstration with at least 7 days' advance notice.

END OF SECTION 211000

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SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Escutcheons.
4. Equipment installation requirements common to equipment sections.
5. Supports and anchorages.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than plumbing and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and plumbing equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Plumbing Piping
B. Plumbing Fixtures & Equipment

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

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

2.3 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: Not allowed, make connections with brass nipple or ball valve.

D. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.4 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

2.5 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

C. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

2.6 WIRING METHODS

A. Where electrical wiring is required by this trade other than covered by Division 26, the contractor shall refer to the same wiring materials and methods as specified under Division 26. No Exceptions

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

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

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

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

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

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

F. Install piping to permit valve servicing.

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

L. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

M. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Fire Resistive Joint Systems" for materials.

N. Verify final equipment locations for roughing-in.

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

3.2 PIPING JOINT CONSTRUCTION

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

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

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

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.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

3.6 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 220500

SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze ball valves.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

A. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

B. NSF Compliance: NSF 61 for valve materials for potable-water service.

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. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller except plug valves.

E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:

1. 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. Solder Joint: With sockets according to ASME B16.18.

2. Threaded: With threads according to ASME B1.20.1.

2.2 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bonze Ball Valves with Bronze Trim:

1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions 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.

3.2 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.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service: Ball valves.
2. Throttling Service: ball valves.

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

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

3.4 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 1" and Smaller:

1. Quarter-turn bronze ball valves with soldered or threaded ends
2. Quarter-turn angled valves with soldered or threaded ends.

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

1. Quarter-turn brass ball valves with brazed ends

END OF SECTION 220523

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SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

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

1.2 DEFINITIONS

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

1.3 SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.
3. Powder-actuated fastener systems.

1.4 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 STEEL PIPE HANGERS AND SUPPORTS

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

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

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

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

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

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

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

2.4 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- (690-kPa-) minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Insulation-Insert Material for Cold Piping: Water-repellent treated, Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular with vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

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

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

F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

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

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

2.6 EQUIPMENT SUPPORTS

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

2.7 MISCELLANEOUS MATERIALS

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

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

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

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

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN 20 to DN 600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
3. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
4. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 1/2 to NPS 36 (DN 100 to DN 900)

5. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN 25 to DN 750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

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. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

   a. Light (MSS Type 31): 750 lb (340 kg).
   b. Medium (MSS Type 32): 1500 lb (680 kg).
   c. Heavy (MSS Type 33): 3000 lb (1360 kg).

8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
3. Variable-Spring 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.

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

E. Fastener System Installation:

1. Install powder-actuated fasteners 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. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

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

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

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

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65)] and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

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

M. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

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

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.

5. Pipes NPS 8 (DN 200) 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.

3.6 PAINTING

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

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

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

END OF SECTION 220529

SECTION 221116 - DOMESTIC WATER PIPING (POTABLE)

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. Specialty valves.
2. Flexible connectors.
3. Escutcheons.
4. Sleeves and sleeve seals.

1.3 SUBMITTALS

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

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

B. Comply with NSF 61 for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Type ‘L’ hard copper tubing with soldered joints for all piping 1¼” and smaller.

B. Type ‘L’ hard copper tubing with brazed joints for all pipes 1 ½” and larger.

C. Press fittings will not be accepted.

D. No galvanized piping or components will be accepted.

E. DCW piping serving flush valves shall be copper type ‘M’ piping.

F. 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.

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

1. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.2 PIPING JOINING MATERIALS

A. Brazed joints and fittings for copper piping larger than 1 ¼”

B. Soldered joints and fittings for copper piping 1 ¼” and smaller.

C. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.

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

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

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

2.3 SPECIALTY VALVES

A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.

B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.4 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

1. Not Allowed

C. Dielectric Nipples:

1. Description:

a. Electroplated steel nipple complying with ASTM F 1545.
b. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C.
c. End Connections: Male threaded or grooved.
d. Lining: Inert and non-corrosive, propylene.

2.5 FLEXIBLE CONNECTORS

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

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

B. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig (1380 kPa).
2. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.6 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.

C. One Piece, Stamped Steel: Chrome-plated finish with setscrew.

D. Split Casting, Cast Brass: Polished, chrome-plated finish with concealed hinge and setscrew.

2.7 SLEEVES

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

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

C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.8 SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.

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

2.9 GROUT

A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 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 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.

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

E. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

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

G. 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.

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

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

J. Install piping to permit valve servicing.

K. 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.

L. Install piping free of sags and bends.

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

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

3.2 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. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems. Use bronze nipples or ball valves.

3.3 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 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) 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.

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 (DN 50) and smaller. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.

3.4 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing. Arrange piping to minimize the occurrences of dielectric fittings.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples or bronze valves. Dielectric unions will not be accepted.

3.5 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump.

B. Install bronze-hose flexible connectors in copper domestic water tubing.

3.6 HANGER AND SUPPORT INSTALLATION

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

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.

B. Support vertical piping and tubing at base.

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

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 3: 108 inches (2700 mm) with 1/2-inch (13-mm) rod.

D. Install supports for vertical copper tubing every 10 feet (3 m).

E. 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 (DN 65) and larger.

3.8 ESCUTCHEON INSTALLATION

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

B. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish with set screw.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece or split casting, cast brass with polished chrome-plated finish with set screw.
4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with rough-brass finish with set screw.
5. Bare Piping in Equipment Rooms: One piece, cast brass with set screw.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.9 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

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

C. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

D. Install sleeves in new partitions, slabs, and walls as they are built.

E. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

F. Seal space outside of sleeves in concrete slabs and walls with grout.

G. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

H. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
2. Sleeves for Piping Passing through Gypsum-Board Partitions:

   a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
   b. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

I. 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 in Division 07 Section "Fire Resistive Joint Systems" for firestop materials and installations.

3.10 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.11 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.

3.12 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. Re-inspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for re-inspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit 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 static water pressure of 50 psig (345 kPa) above operating pressure, or 100psig whichever is greater, 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.
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.

3.13 CLEANING

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

1. Purge new piping before using.
2. Fill Line : After all prerequisites are met, fill the system slowly with water, at a velocity of approximately 1 foot per second, while necessary measures are taken to eliminate all air at the highest points of the system where air may collect in pockets. After filling, shut off system in order to prevent contaminated water from flowing back in the line supplying the water.
3. Pressure Test: A pressure test shall be performed. Piping shall be tested at 1.5 times working pressure for 24 hrs.
4. Flushing: Allow filled system to set undisturbed for a minimum of 24 hours, then begin flushing operations. The section of main to be disinfected shall be flushed through blow-off assemblies. Flushing shall be a velocity of not less than 2.5 feet per second to remove sediment and other foreign matter until the water runs clear. The Contractor shall be responsible for making adequate provisions for drainage of large volume of flushing water, including proper de-chlorination/disposal of chlorinated water. Any damages that may occur from this operation shall be the sole responsibility of the Contractor. In conjunction with beginning flushing, authorities having jurisdiction representative will perform a high range chlorine concentration test. Chlorine concentration of 50 mg/l minimum must be provided. Allow chlorinated water to set in the test section for 24 hours. The chlorine concentration shall not drop below 20 ppm within a minimum period of 24 hours.
5. Sampling – Day 1: Check chlorine and turbidity. After allowing the system to flush so that at least two volumes of water pass through the main, the first bacteria sample shall be collected at regular intervals not exceeding 1,200 feet, and tested for bacteriological quality. The contractor shall be responsible for making adequate provisions for drainage

of large volume of flushing water, including proper de-chlorination/disposal of heavily chlorinated water.

6. Sampling – Day 2: The water main shall not be flushed again. Inspector will check both chlorine concentration and turbidity. If within the acceptable limits, a second bacteriological test will be performed collecting from the same discharge points as on day one. If the second bacteria sample has passed, the system shall be left in service, provided a low range chlorine concentration test has been taken and approved by an OWASA representative. The chlorine concentration shall be less than 2 mg/l or no higher than that generally prevailing in the source system.
7. Certification of bacteriological testing for quality of the domestic water shall be conducted prior of and included in the request for Beneficial Occupancy

3.14 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. Aboveground domestic water piping, NPS 1 ¼" and smaller except for flush valves shall be the following:

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

D. Aboveground domestic water piping, NPS 1 ½" and larger and for all flush valves shall be the following:

1. Hard copper tube, ASTM B 88, Type L copper with brazed joints and fittings.

PART 4 - FINAL

4.1 After final flushing, flow all fixtures to confirm the valves are open.

END OF SECTION 221116

SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Sink Faucets

1.2 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. FRP: Fiberglass-reinforced plastic.

D. PMMA: Polymethyl methacrylate (acrylic) plastic.

E. PVC: Polyvinyl chloride plastic.

F. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.3 SUBMITTALS

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

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and maintenance data.

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. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

C. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

D. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

F. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
2. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
3. Vitreous-China Fixtures: ASME A112.19.2M.
4. Water-Closet, Flush Valve,: ASME A112.19.5.

G. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Faucets: ASME A112.18.1.
2. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
3. NSF Potable-Water Materials: NSF 61.
4. Pipe Threads: ASME B1.20.1.
5. Supply Fittings: ASME A112.18.1.
6. Brass Waste Fittings: ASME A112.18.2.

H. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Manual-Operation Flushometers: ASSE 1037.
4. Plastic Tubular Fittings: ASTM F 409.
5. Brass Waste Fittings: ASME A112.18.2.

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

1. Flexible Water Connectors: ASME A112.18.6.
2. Grab Bars: ASTM F 446.
3. Hose-Coupling Threads: ASME B1.20.7.
4. Pipe Threads: ASME B1.20.1.
5. Plastic Toilet Seats: ANSI Z124.5.

PART 2 - PRODUCTS

2.1 SINK FAUCETS

A. Sink Faucets:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:

   a. American Standard Companies, Inc.
   b. Delta Faucet Company.
   c. Elkay Manufacturing Co.
   d. Kohler Co.
   e. Moen, Inc.

2.2 FIXTURE SUPPORTS

A. Fixture Supports:

1. Manufacturers: Subject to compliance with requirements, use one of the following:

a. Josam Company.
b. MIFAB Manufacturing Inc.
c. Smith, Jay R. Mfg. Co.
d. Tyler Pipe; Wade Div.
e. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
f. Zurn Plumbing Products Group; Specification Drainage Operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Plumbing contractor shall coordinate all rough-in connections and make all final connections to specialty fixtures, appliances, beverage machines and equipment provided by the owner. Including final testing.

B. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

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.

D. Install fixtures level and plumb according to roughing-in drawings.

E. 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.

F. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

G. 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.

H. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

I. 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.

J. Install escutcheons at piping wall and 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 "Common Work Results for Plumbing."

K. 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."

3.2 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. Division 22 shall provide rough-ins and that make final connection to any equipment provided by others such as ice maker, and dish washer.

3.3 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.

3.4 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 230500 - COMMON WORK RESULTS 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 the following:

1. Sleeves.
2. Escutcheons.
3. Equipment installation requirements common to equipment sections.
4. Concrete bases.
5. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

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

B. Non-Destructive Inspection and Testing: A/E shall visually inspect pipe welds. Based on visual inspections, upon order of the A/E, non-destructive testing of selected pipe welds shall be performed by a qualified testing agency, at the expense of the Owner, using one of the following methods selected by the A/E. The welds inspected shall be selected randomly, but the selection shall include an examination of welds made by each welding operator or welder.

1. Radiographic testing in accordance with ASTM E 94:

   a. Make identification of defects by comparing radiographs to reference radiographs in ASTM E 390.
   b. Film shall positively and properly identify as to member being inspected, location of weld, and location of film on weld.
   c. Stamp identification on steel so film may be easily identified and matched to identification mark

2. Ultrasonic testing in accordance with ASTM E 164:

   a. Size of defects will be determined by relating amplitude of oscilloscope traces to hole in ASTM reference weldment.
   b. Diameter of reference holes shall be 3/32-inch.
   c. Weld defects which are cause for rejection include cracks, lack of fusion, incomplete penetration, porosity, or slag inclusions which produce reflections equal to or greater than 80 percent of reference hole reflection and have linear dimensions as indicated by transducer movement exceeding 1/4-inch for material thickness up to and including 3/4-inch.

C. Correction of Defective Welds: If random testing reveals that any welds fail to meet minimum quality requirements, an additional 10 percent of the welds in that same group shall be inspected at the Contractor's expense. If all of the additional welds inspected meet the quality requirements, the entire group of welds represented shall be accepted and the defective welds shall be repaired. If any of the additional welds inspected also fail to meet the quality requirements, that entire group of welds shall be rejected. At the Contractor's option, the rejected welds shall be removed and the joints rewelded or the rejected welds shall be 100 percent tested as hereinbefore specified and all defective weld areas removed and rewelded.

D. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements. No additional cost will be allowed for such changes and substitutions.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Use type L copper piping for all condensate drain piping

2.2 JOINING MATERIALS

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

B. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

2.3 SLEEVES

A. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

2.4 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated

2.5 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.2 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.5 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 230500

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 requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Provide with shaft grounding rings

2.2 MOTOR CHARACTERISTICS

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

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium Efficiency, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: 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. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F 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.

I. 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 Multi-speed 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.
5. Provide with shaft grounding rings.

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. Capacitor start, inductor run.
3. Capacitor start, capacitor run.

B. Multispeed Motors: Electronically Commutated (ECM).

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

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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. Flowmeters.

1.3 SUBMITTALS

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

B. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers:

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, 9 inches (229 mm)]long.

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

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

E. Window: Glass.

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: Same as manufacturer of thermometer being used.

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

2.3 PRESSURE GAGES

A. Manufacturers:

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

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

1. Case: Dry type, cast aluminum, 4-1/2-inch (114-mm) diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4 (DN 8), bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
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 (100 kPa of vacuum to 103 kPa of pressure).

11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 (DN 8) brass or stainless-steel needle type.
2. Syphons: NPS 1/4 (DN 8) coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

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.
4. Inlet and outlet of each hydronic heat exchanger.
5. Inlet and outlet of each hydronic heat-recovery unit.
6. Inlet and outlet of each thermal storage tank.
7. Outside-air, return-air, and mixed-air ducts.

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- and condenser-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 needle-valve and syphon fitting in piping for each pressure gage for steam.

F. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.

G. Install flowmeter elements in accessible positions in piping systems.

H. 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.

I. Install connection fittings for attachment to portable indicators in accessible locations.

J. Install flowmeters at discharge of hydronic system pumps and at inlet of hydronic air coils.

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.

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 ball valves.
2. Iron, single-flange butterfly valves.
3. Wafer disc check 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 SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller.
4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:

1. 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.
2. Butterfly Valves: With extended neck.

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.

2.2 BRONZE BALL VALVES

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

1. Manufacturers:

   a. Conbraco Industries, Inc.; Apollo Valves.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Hammond Valve.
   d. Lance Valves; a division of Advanced Thermal Systems, Inc.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig (1035 kPa).
   c. CWP Rating: 600 psig (4140 kPa).
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

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

1. Manufacturers:

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Conbraco Industries, Inc.; Apollo Valves.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Jenkins Valves.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Flo Fab Inc.
h. Hammond Valve.
i. Kitz Corporation.
j. Legend Valve.
k. Milwaukee Valve Company.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Red-White Valve Corporation.
o. Spence Strainers International; a division of CIRCOR International.
p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze.

2.4 WAFER DISC CHECK VALVES

A. Class 150, Wafer Disc Check Valves with Soft Seal Metal Seats, non slam, spring assisted:

1. Manufacturers:

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: AWWA C518.
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.

F. Valves installed over 8’ A.F.F shall have chain wheels fitted to allow operation from floor level.

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 (Above Ground): Butterfly or Ball valves.
2. Pump-Discharge Check Valves:

a. Wafer disk check valves with lever and weight or with 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 Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
2. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends.
3. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.5 HOT-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

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

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged.
2. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM seat, aluminum-bronze disc.
3. Iron Swing Check Valves: Class 250, nonmetallic-to-metal seats.

END OF SECTION 230523

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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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Fastener systems.
5. Equipment supports.

1.3 DEFINITIONS

A. 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 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. Retain a registered engineer to 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. Powder-actuated fastener systems.
3. Shop Drawings: Signed and sealed by a qualified professional engineer showing seismic-restraint hangers and supports for piping and equipment

B. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to 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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 EQUIPMENT SUPPORTS

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

2.3 MISCELLANEOUS MATERIALS

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

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

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

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

3.3 METAL FABRICATIONS

A. 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.

3.4 ADJUSTING

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

3.5 PAINTING

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

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

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

END OF SECTION 230529

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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. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.
2. Equipment markers.
3. Equipment signs.
4. Access panel and door markers.
5. Pipe markers.
6. Stencils.
7. Valve tags.
8. Valve schedules.
9. 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. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

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

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

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

a. Manufacturer, product name, model number, and serial number.
b. Capacity, operating and power characteristics, and essential data.
c. Labels of tested compliances.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved phenolic plates white background and black lettering securely fastened to the equipment with sheet metal screws.

1. Terminology: Match schedules as closely as possible.
2. Data:

a. Name and plan number.
b. Equipment service.
c. Design capacity.
d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches (64 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.

C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, Engraved phenolic plates white background and black lettering. .Provide holes for mechanical fastening.

1. Data: Instructions for operation of equipment and for safety procedures.
2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
3. Thickness: 1/16 inch (1.6 mm) for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) in length, and 1/8 inch (3.2 mm) for larger units.
4. Fasteners: Self-tapping, stainless-steel sheet-metal screws..

D. Access Panel and Door Markers: 1/16-inch- (1.6-mm-) thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch (3.2-mm) center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

A. Completely paint piping systems in mechanical rooms with the applicable colors listed below with appropriate self-sticking or strap-on identifications and arrows indicating direction of flow.

B. On straight runs of piping, space marking no further than 30 feet apart; and with pre-tentioned Plastic Pipe Markers near each valve, pressure reducing valve, heat exchanger, etc.

C. Where pipe passes through walls or floors, mark near the penetration on both sides. Provide markings at each directional change of all piping systems.

D. Mechanical room and outdoor pipe color and the colors of bands are as follows:

Service	Marker Wording	Lettering Color	Background Color	Pipe/Covering Color
Hot water systems	HEATING WATER RETURN	Black	Yellow	Lt. Red
	HEATING WATER SUPPLY	Black	Yellow	Lt. Red
Chilled water systems	CHILLED WATER RETURN	Black	Yellow	Lt. Blue
	CHILLED WATER SUPPLY	Black	Yellow	Lt. Blue
Fire Protection	SPRINKLER-FIRE	White	Red	Red
Natural gas	NATURAL GAS	Black	Yellow	Yellow
Domestic cold water	DOMESTIC COLD WATER	White	Green	Blue
Domestic hot water	DOMESTIC HOT WATER	Black	Yellow	Lt. Red
Domestic hot water recirculating	DOMESTIC HOT WATER RETURN	Black	Yellow	Orange
Domestic make-up water	MAKE-UP WATER	White	Green	Blue
Make-up water non-potable	NON-POTABLE MAKE-UP WATER	Black	Yellow	Purple
Sanitary drain	SANITARY DRAIN	White	Green	*
Storm drain, incl. roof drains	STORM DRAIN	White	Green	*
Plumbing vent	VENT	White	Green	*
Condensate drain	DRAIN	White	Green	*

* Pipe not painted unless exposed

Color	Sherwin Williams Industrial & Marine Coatings Paint Number	Sherwin Williams All Surface Enamel Paint Number
Yellow	Safety Yellow SW 4084	Safety Yellow 502
Orange	Safety Orange SW 4083	N/A
Green	Cedar Green SW 4072	Hunter Green 510
Light Green	Safety Green SW 4085	Safety Green 506
Blue	N/A	Navy Blue 509
Light Blue	Safety Blue SW 4086	Safety Blue 505
Red	N/A	Apple Red 511
Light Red	Safety Red SW 4081	Safety Red 507
White	Ultra White SW 4087	Extreme White 500
Black	Black SW 4090	Black 501
Purple	Plum SW 4080	N/A

E. Additional Labeling requirements

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length
3. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

F. Pre-tensioned Pipe Markers: Pre-coiled semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

G. Shaped Pipe Markers: Preformed semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

H. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

I. Plastic Tape: Continuously printed, vinyl tape at least 3 mils (0.08 mm) thick with pressure-sensitive, permanent-type, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

2.3 VALVE TAGS

A. Provide brass valve tags for all valves and a schedule under rigid plastic in the mechanical room.

2.4 WARNING TAGS

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

1. Size: Approximately 4 by 7 inches (100 by 178 mm)
2. Fasteners: Brass grommet and wire
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Pumps, compressors, chillers, condensers, and similar motor-driven units.
2. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
3. Fans.

3.3 PIPING AND DUCT IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Pre-tensioned pipe markers: color-coded.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed 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 nonaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 WARNING-TAG INSTALLATION

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

3.5 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.6 CLEANING

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

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. Air Systems:

a. Variable-air-volume systems.

2. Hydronic Piping Systems:

a. Constant-flow systems.
b. Variable-flow systems.

3. HVAC equipment quantitative-performance settings.
4. Verifying that automatic control devices are functioning properly.
5. Reporting results of activities and procedures specified in this Section.

1.3 SUBMITTALS

A. Strategies and Procedures Plan: Within 90 days from Contractor's Notice to Proceed, submit two (2) 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.

B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

C. Warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC or NEBB.

B. 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.

C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." Or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

1.5 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

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

1.6 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 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.

B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include 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. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine system pumps to ensure absence of entrained air in the suction piping.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.

7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings. Label circuit setters with final setting including flow and dP using a permanent metal tag.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

3.5 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.

3.6 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.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. 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.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

E. 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.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.7 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.

3.8 PROCEDURES FOR BOILERS

A. Measure entering- and leaving-water temperatures and water flow.

3.9 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.
8. Calculate BTU transfer on both air side and water side.

B. Electric-Heating Coils: Measure the following data for each coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. 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.

3.10 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.
2. Motor horsepower rating.
3. Motor rpm.
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.

3.11 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

D. Refrigerant Coils: Measure the following data for each coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.12 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.

3.13 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.

3.14 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Heating-Water Flow Rate: 0 to minus 10 percent.

3.15 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.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.

14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

3.16 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

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SECTION 230700 – HVAC PIPE 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:

1. Insulation Materials:

a. Mineral fiber.
b. Polyisocyanurate.
c. Flexible elastomeric

2. Insulating cements.
3. Adhesives.
4. Mastics.
5. Lagging adhesives.
6. Sealants.
7. Factory-applied jackets.
8. Field-applied fabric-reinforcing mesh.
9. Field-applied cloths.
10. Field-applied jackets.
11. Tapes.
12. Securements.
13. Corner angles.

1.3 SUBMITTALS

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

B. Shop Drawings:

1. 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.
8. 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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
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 size and location 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, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems 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 Part 3 schedule articles for where insulating materials shall be applied.

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

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

D. 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, 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 Pipe Insulation.
    d. Manson Insulation Inc.; Alley-K.
    e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

H. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

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

   a. Apache Products Company; ISO-25.
   b. Dow Chemical Company (The); Trymer.
   c. Duna USA Inc.; Corafoam.
   d. Elliott Company; Elfoam.

2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
3. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E 84.
4. Fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

   a. Pipe Applications: PVDC-SSL.
   b. Equipment Applications: ASJ.

I. Flexible Elastomeric: 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 the following:

   a. Aeroflex USA Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.2 INSULATING CEMENTS

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

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

   a. Insulco, Division of MFS, Inc.; SmoothKote.
   b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
   c. Rock Wool Manufacturing Company; Delta One Shot.

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. Polyisocyanurate: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).

C. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

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

a. Childers Products, Division of ITW; CP-97.
b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
c. Marathon Industries, Inc.; 290.
d. Mon-Eco Industries, Inc.; 22-30.
e. Vimasco Corporation; 760.

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:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.

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

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

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

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

a. Dow Chemical Company (The); 739, Dow Silicone.
b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Red Devil, Inc.; Celulon Ultra Clear.
e. Speedline Corporation; Speedline Vinyl Adhesive.

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

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

a. Aeroflex USA Inc.; Aeroseal.
b. Armacell LCC; 520 Adhesive.

c. Foster Products Corporation, H. B. Fuller Company; 85-75.
d. RBX Corporation; Rubatex Contact Adhesive.
e. MASTICS

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

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

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
2. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
4. Color: White.

J. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.

2.4 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Polyisocyanurate Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Products, Division of ITW; CP-76.
   b. Foster Products Corporation, H. B. Fuller Company; 30-45.
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
   f. Vimasco Corporation; 750.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
5. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: Aluminum.

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

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: White.

2.5 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.

2.6 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. (271 g/sq. m).

2.7 FIELD-APPLIED JACKETS

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

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

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

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. See Mechanical Identification Section for Color
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

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

a. Childers Products, Division of ITW; Metal Jacketing Systems.
b. PABCO Metals Corporation; Surefit.

c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
d. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

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

1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.9 SECUREMENTS

A. Bands:

1. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with closed seal.
2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.

2.10 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

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

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

B. 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 (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). 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 (0 and 149 deg C) 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, ducts and fittings, and piping including fittings, valves, and specialties.

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

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams between the 2 O’clock and 3 o’clock positions

E. All joints shall be sealed weathertight and with appropriate UV resistant sealant for all exterior applications.

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

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

H. Keep insulation materials dry during application and finishing.

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

J. Install insulation with least number of joints practical.

K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation 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.

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

M. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (50 mm) o.c.

   a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

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

P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

Q. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations 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 (50 mm).
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: Install insulation continuously through penetrations of fire-rated walls and partitions. 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 (50 mm).

E. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. 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 (50 mm).
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies.

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

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 (75 mm) from insulation end joints, and 16 inches (400 mm) 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 (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) 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 (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches (75 mm).
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 (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from galvanized steel, at 0.050 inch (1.3 mm) 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.

3.6 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

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

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place

with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) 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.

3.7 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), 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 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

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, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate 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.

3.9 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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.
   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

3.10 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 (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) 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 (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints. Horizontal seams must also be sealed.

3.11 FINISHES

A. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material:

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

a. Finish Coat Material: Interior, flat, latex-emulsion size.

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

C. Color: See Mechanical Identification Section for color. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or PVC jackets.

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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.

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

3.13 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 and outdoor equipment in paragraphs below that is not factory insulated.

C. Hot-water pump insulation shall be one of the following:

1. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. M) nominal density.
2. Polyisocyanurate: 1-1/2 inches (38 mm) thick.

3.14 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.
4. Condenser water piping.

3.15 INDOOR PIPING INSULATION SCHEDULE

A. Hot Water Piping, Except Mechanical Rooms below 8’0”

1. NPS 1-1/2” and Smaller: Insulation shall be one of the following:

a. Mineral-Fiber, Preformed Pipe, Type I, 2” thick.
b. Flexible elastomeric. 2” thick.
c. Cellular Glass. 2” thick.

2. NPS 2” and Larger: Insulation shall be one of the following:

a. Mineral-Fiber, Preformed Pipe, Type I, 2” thick.
b. Cellular Glass. 2” thick.

B. Chilled Water Piping, Except Mechanical Rooms below 8’0”

1. NPS 1-1/2” and Smaller: Insulation shall be one of the following:

a. Polyisocyanurate, 2” thick.
b. Flexible elastomeric. 2” thick.

2. NPS 2” and Larger: Insulation shall be one of the following:

a. Polyisocyanurate, 2” thick.

C. Refrigerant Suction and Hot-Gas Piping:

1. Insulation shall be one of the following:

a. Polyisocyanurate 2” (38 mm) thick.
b. Flexible elastomeric. 2” 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. Install removable jacketing for steam traps, PRVs, and all serviceable equipment.

D. Piping, Concealed:

1. None.

E. Piping, Exposed Finished Areas:

1. PVC, Color-Coded by System, 20 mils (0.5 mm) thick.

F. Piping, Exposed Main Mechanical Room shall be one the following.

1. PVC, Color-Coded by System, 20 mils (0.5 mm) thick.

G. Equipment, Exposed Main Mechanical Room shall be;

1. Woven Glass Cloth Jacket 8oz/sq. yd. Painted per System 2 Coats

a. Polyisocyanurate 2" (38 mm) thick.
b. Flexible elastomeric. 2" Thick.

3.17 MECHANICAL ROOM INSUALTION AND JACKETING

A. All piping in mechanical rooms, under 8'0" shall be insulated with cellular glass product, 2" thick with color coded 20 mil PVC jacket. Piping above 8'0 shall comply with sections above.

3.18 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. Aluminum Jacket.

END OF SECTION 230700

SECTION 230701 - HVAC 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:

1. Insulation Materials:

   a. Mineral fiber.

2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Factory-applied jackets.
7. Field-applied fabric-reinforcing mesh.
8. Tapes.
9. Securements.

1.3 SUBMITTALS

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

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
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.
8. Detail field application for each equipment type.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Lined ductwork shall not be accepted in any part of the system.

B. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

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

D. 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.

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

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

G. 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 the following:

a. CertainTeed Corp.; Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; All-Service Duct Wrap.

H. 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 ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide 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 INSULATING CEMENTS

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

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

   a. Insulco, Division of MFS, Inc.; SmoothKote.
   b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
   c. Rock Wool Manufacturing Company; Delta One Shot.

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

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

   a. Childers Products, Division of ITW; CP-82.
   b. Foster Products Corporation, H. B. Fuller Company; 85-20.
   c. ITW TACC, Division of Illinois Tool Works; S-90/80.
   d. Marathon Industries, Inc.; 225.
   e. Mon-Eco Industries, Inc.; 22-25.

2.4 MASTICS

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

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

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

a. Childers Products, Division of ITW; CP-35.
b. Foster Products Corporation, H. B. Fuller Company; 30-90.
c. ITW TACC, Division of Illinois Tool Works; CB-50.
d. Marathon Industries, Inc.; 590.
e. Mon-Eco Industries, Inc.; 55-40.
f. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

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

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

a. Childers Products, Division of ITW; CP-10.
b. Foster Products Corporation, H. B. Fuller Company; 35-00.
c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
d. Marathon Industries, Inc.; 550.
e. Mon-Eco Industries, Inc.; 55-50.
f. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
4. Solids Content: 63 percent by volume and 73 percent by weight.
5. Color: White.

2.5 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. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for duct, equipment, and pipe.

2.7 FIELD-APPLIED JACKETS

A. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Sheet and roll stock ready for shop or field sizing.
2. Finish and thickness are indicated in field-applied jacket schedules.
3. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

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 the following:

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

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

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

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

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.9 SECUREMENTS

A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 3/4 inch (19 mm) wide with wing or closed seal.

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

a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.

B. Insulation Pins and Hangers:

1. Capacitor-discharge weld-pins: 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 the following:

1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
2) GEMCO; Press and Peel.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Products: Subject to compliance with requirements, provide 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- (19-mm-) wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 PREPARATION

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

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

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

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

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (50 mm) o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and 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 (100 mm) 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.

3.3 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 (50 mm) 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 (50 mm).
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: Install insulation continuously through penetrations of fire-rated walls and partitions. 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 (50 mm).

E. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. 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 (50 mm).

3.4 SEAL PENETRATIONS THROUGH FIRE-RATED ASSEMBLIES.

3.5 MINERAL-FIBER INSULATION INSTALLATION

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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
   b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) 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 (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) 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 (10 deg C) at 18-foot (5.5-m) 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 2 times the insulation thickness but not less than 3 inches (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) 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- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) 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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
   b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) 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 (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) 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 (10 deg C) at 18-foot (5.5-m) 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 2 times the insulation thickness but not less than 3 inches (75 mm).

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- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.6 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Firestopping."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

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

3.8 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in nonconditioned space.
4. Indoor, exposed return located in nonconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Factory-insulated flexible ducts.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.
6. Exhaust Ducts

3.9 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket.

1. Thermal insulation R-Value: R-8
2. Factory FSK Jacket

B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket.

1. Thermal insulation R-Value: R-8
2. Factory FSK Jacket

C. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket.

1. Thermal insulation R-Value: R-8
2. Factory FSK Jacket

D. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber board.

1. Thermal insulation R-Value: R-8
2. Field-Applied Woven Fiber Jacket, painted.

E. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber board.

1. Thermal insulation R-Value: R-8
2. Field-Applied Woven Fiber Jacket, painted.

F. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber board.

1. Thermal insulation R-Value: R-8
2. Field-Applied Woven Fiber Jacket, painted.

3.10 CONCEALED, ROOF-MOUNTED DUCT

A. Supply duct

1. Thermal insulation R-Value: R-8
2. Double-walled construction with 2” mineral fiber preformed wrap.

END OF SECTION 230701

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SECTION 230900 - DIRECT DIGITAL CONTROL SYSTEMS AND BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Control equipment.
B. Software.
C. Graphic Standards
D. Sequences

1.2 RELATED DOCUMENTS

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

1.3 SUMMARY

A. This Section shall provide the Direct Digital Control (DDC), Energy Management and Building Automation System (BAS) for the air conditioning, heating and ventilating systems, lighting controls and shall interface with other microprocessor based building subsystems as shown on the drawings and as specified.

B. This controls specification includes hardware and software designed to control the building system with full graphical representation.

C. The controls vendor should ensure the building is operating independently of the graphics and has communication back to the GSA server housing the engineering or configuration software. All sequences should be fully functional and verified.

D. Related Section: Division 23 Section "Sequence of Operation" contains requirements that relate to this Section.

1.4 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Hydronic Piping: Installation of all wells, control valves, flow switches, temperature sensor sockets, gage taps, flow meters.

B. Ductwork Accessories: Installation of flow stations, automatic dampers, smoke detectors. Connection of damper end switches Gas Piping: Installation of natural gas flow meters.

C. Water Flow: Installation of water flow meters.

D. Electric Metering: Installation of voltage and current measurement devices in electrical cabinets and the power circuit to the support the measurement device.

1.5 REFERENCES

A. ASHRAE standard 135-2010.
B. ASME MC85.1.
C. NEMA EMC1.

1.6 DEFINITIONS

A. BACnet: An industry standard data communications protocol for Building Automation Control Networks. Refer to ASHRAE standard 135-2010.

B. SEC-WAN- Secure Engineered Controls Wide Area Network - Ethernet based network linking remote Wake Co. Facilities with a central location for the purpose of transmitting and receiving building control information. Traffic over this network will be TCP/IP packets.

C. High Tier- That portion of the Vendor System that connects to the SEC-WAN directly using Ethernet as the physical medium. This is an open, interconnected system that each vendor must be capable of connecting to using standard Ethernet.

D. Building Level Network (BLN)- That portion of the Vendor System that connects the network controller to the specific monitoring and control devices in the building. Physical medium is serial (RS-485, RS-232) or Ethernet. Traffic over this network shall be BACnet MS/TP or BACnet IP under vendor created subnetwork.

E. Server- Centrally located, at General Services Center, 401 Capital Blvd., LAN attached, Rack-mounted server computer running Windows Server operating system. High Tier communicate to Server via Ethernet, TCP/IP connection.

F. Building Controller- located in each facility, continually monitors field devices to ensure proper function. The controller is standalone. The controller serves as a gateway between the BLN and the SEC-WAN.

G. TEC or ASC (Device Controller)- Connected to the Network Controller via TCP/IP, MS/TP, or/RS-485/RS-232E. Directly regulates field devices.

H. Workstation: Operating on latest County approved version of Microsoft Windows Operating System. Device used to send configuration data to either the server or the network controller. Used to upload field panel program to server or download field panel program from server to field panel. Field Devices- Pump controller, chiller controller, actuator, etc.

1.7 SYSTEM DESCRIPTION

A. Building Automation System (BAS) Contractor shall provide.

1. A fully integrated building automation system (BAS), UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and lighting control capabilities; including interface by ethernet to the existing Wake County - Secure Engineered Controls Wide Area Network (SEC-WAN).

2. Complete temperature and lighting control system to be DDC as specified herein.
3. All wiring, conduit, panels, for all DDC temperature controls.
4. All final electrical connections to each stand-alone Application Specific Controller and DDC Controller.
5. BAS Contractor shall be responsible for all electrical work associated with the BAS control system and as called for on the Drawings.

   a. Perform all wiring in accordance with all local and national codes.
   b. Install all line voltage wiring, concealed or exposed, in accordance with Division 26.
   c. Electrical Contractor shall provide 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for direct digital control systems.
   d. BAS contractor to provide UPS power for Control Panel where indicated on drawings
   e. Surge transient protection and power conditioners shall be incorporated in design of system to protect electrical components in all DDC Controllers, Application Specific Controllers and operator's workstations.
   f. All low voltage electrical control wiring throughout the building shall be installed in accordance with Division 26. Except that digital control wiring and 24V power bus may be run without conduit in accessible ceiling spaces under the provision of NEC, Class 2 when approved.

B. General Product Description:

1. The building automation system (BAS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, lighting control and historical data collection. The Building Automation System shall be <u>fully</u> <u>compatible</u> and shall <u>be fully integrated</u> with the existing system presently owned and operated by Wake County.
2. The building automation system shall consist of the following:

   a. Connection of BAS by Ethernet to dedicated Wake County General Services Administration Building Controls Server. Additional software and programming for BAS Workstation, as specified.
   b. Stand-alone DDC Controllers compatible with those already installed by Wake County.
   c. Stand-alone Application Specific Controllers (ASCs.) (ie. Gateway to central building equipment).

3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, Application Specific Controllers and operator devices.
4. 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 control strategies at other operational devices.
5. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the

network without dependence upon on network communication outside the controlled building. DDC Controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

1.8 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections. A minimum of 1 PDF set of documents are required. Building Number verification: The building number should be confirmed with GSA through official written construction communication.

B. BACnet instance number submittal per the form included in this specification will be completed. BACnet instance numbers are managed by Wake County and are assigned to individual devices. See instance number naming convention for the starting point. Building number and acronym should be confirmed with the County.

C. BACnet point names should be submitted for all equipment and physical points planned in the project. These point names should adhere to the County naming convention attached. PDF or spreadsheet submission for this specific submittal are acceptable.

D. Manufacturer's Product Data for each and all types of products specified. Include manufacturer's technical Product Data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, installation instructions, and startup instructions.

1. Submit manufacturer's product information on all hardware items along with descriptive literature for all software programs to show compliance with specifications.

E. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Submit damper leakage and flow characteristics, plus size schedule for controlled dampers.

F. Shop Drawings, PDF, containing the following information for each control system:

1. Schematic flow diagram showing fans, pumps, coils, dampers, valves, and control devices.
2. Each control device labeled with setting or adjustable range of control.
3. Diagrams for all required electrical wiring. Clearly differentiate between factory-installed and field-installed wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
7. Listing of connected data points, including connected control unit and input device. Itemized list should include each point name per Wake County's point name convention, the control point name and description.

8. Devices with imported points which do not follow the County's point name convention should be converted in a field panel to follow the convention.
9. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
10. Software description and sequence of operation. This shall include both printed and electronic copies of the program. It shall also include a layman's description of the sequence and a flow chart for a non-programmers interpretation.
11. System configuration diagram showing all panel types and locations as well as communications network and workstations.

G. Graphics – Control graphics should be submitted to the county in PDF format. The graphics should be complete with point values populated or simulated to shot value font, size, color and unit of measure.

H. Wiring diagrams detailing wiring for power, signal, and control systems and differentiating clearly between manufacturer-installed and field-installed wiring.

I. Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Architect/Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

1.9 ADDITIONAL REQUIREMENTS

A. Correction of Work:

1. Contractor's Responsibility. The Contractor shall promptly correct all work the Owner finds defective or failing to conform to the Contract Documents. The Contractor shall bear all cost of correcting such work.
2. During Warranty. If, within the warranty period required by the Contract Documents, any of the work is found to be defective in material or workmanship or not in accordance with the Contract Documents, the Contractor shall correct it promptly after receipt of notice from Owner to do so. Owner shall give notice promptly after discovery of the condition. Contractor shall notify owner within 24 hours of proposed corrections and schedule.

B. Coordination of Work During Construction:

1. The Contractor shall protect the installed works by other trades.
2. The Contractor shall coordinate with other trades.
3. The Contractor shall repair any damage caused by his work to building(s) and equipment.
4. The contractor shall maintain functionality of all existing systems throughout project.

C. Warranty and Service:

1. Standard Warranty.

a. The Contractor shall warrant the system to be free from defects in material and workmanship for a period of one (1) years from the date of completion and acceptance of the work by the Owner. Any defects shall be repaired or replaced, including materials and labor at no cost to Wake County.

2. Wake County reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any such changes made by Wake County, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.
3. Service Response Requirements during the Warranty Period.

   a. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic, text, or email notification by the Owner to the Contractor. Emergency service shall be provided 24 hours per day, 7 days per week, and 365 days per year with no exceptions and at no cost to Wake County.
   b. Technician response by telephone, text, or email to any request for service shall be provided within two (2) hours of Wake County's initial request for service.
   c. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the Wake County site within four (4) hours of the Wake County initial request for such services, as specified.
   d. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic, text, or email notification by the Wake County to the Contractor.
   e. Response by telephone, text, or email to any request for service shall be provided within eight (8) working hours (Contractor specified 40 hours per week normal working period) of the Wake County initial request for service.
   f. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the Wake County site within three (3) working days of the Wake County initial request for such services, asspecified.
   g. At any time during the Warranty Period that Contractor is on Site for maintenance, emergency, or normal service, Contractor shall notify Wake County and the local building operating personnel. Contractor shall notify said personnel of all work anticipated being involved for the service work. In addition, no work affecting system operation shall commence until express permission is granted. After the work is completed a work order ticket describing in detail all work performed (i.e. hardware replaced or serviced, software or firmware modifications made, etc.), hours worked, follow-up work required, etc., must be signed by an authorized building operator.
   h. Wake County Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for Wake County to call in the event of a need for

service. At least one of the lines shall be attended at any given time at all times. Alternatively, text messaging can be used for technicians trained in system to be serviced. One of the three notified technicians shall respond to every call within 15 minutes.

i. Technical Support: Contractor shall provide technical support by telephone throughout the Warranty Period.

j. Preventive maintenance shall be provided throughout the Warranty Period in accordance with the hardware component manufacturer's requirements.

k. In the last month of the Warranty Period, all System software and controller firmware, software, drivers, etc. will be upgraded to the latest release (version) in effect at the end of the Warranty Period.

D. Post-warranty Service.

1. Contractor shall ensure accessibility to technical support and replacement parts for ten (10) years past the warranty period.

1.10 PROJECT RECORD DOCUMENTS

A. Submit under provision of Division 01.

B. Accurately record actual location of control components, including but not limited to, panels, thermostats, and sensors.

C. Revise shop drawings to reflect actual installation and operating sequences.

D. Include data specified in "Submittals" in final "Record Documents" form in hard copy form and in CAD. (DWG or DXF format).

E. Include a USB drive backup of all BAS control programs in addition to server backup.

1.11 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Division 01.

B. Maintenance instructions and spare parts list for each type of control device.

C. Interconnection wiring diagrams with identified and numbered system components and devices.

D. Final shop drawings should be printed and located in a document sleeve within each control panel.

E. Keyboard illustrations and step-by-step procedures indexed for each operator function.

F. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

G. Calibration records and list of set points.

H. Submit quotation for annual maintenance service for after the warranty period.

1.12 QUALIFICATIONS & QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

B. Install system using competent workmen who are fully trained in the installation of temperature control equipment.

C. Single source responsibility of supplier shall be the complete installation and proper operation of the BAS and control system and shall include debugging and proper calibration of each component in the entire system.

D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

E. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

F. BAS shall comply with UL 916 PAZX and 864 UDTZ and be so listed at the time of bid.

G. Design and build all system components to be fault-tolerant.

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus or minus 3 Hertz variation in line frequency.
2. Static, transient and short-circuit protection on all inputs and outputs.
3. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.
4. Network-connected devices to be A.C. coupled or equivalent so that any single device failure will not disrupt or halt network communication.
5. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and system low battery indication.
6. It must be possible to receive and print out alarms at a central location even when the Server/workstation at that location is nonoperational or taken out of service for periodic maintenance.

H. Supplier shall be either the authorized regional manufacturer's representative as such with Siemens Building Technologies, Inc., Schneider Electric, or the manufacturer's Authorized Controls Integrator as such with Honeywell International, Inc.

1.13 PRE-INSTALLATION CONFERENCE

A. Convene a conference two weeks prior to commencing work of this Section, under provisions of Division 01.

B. Require attendance of parties directly affecting the work of this Section. Controls technicians familiar with the controls wiring and programming are required to attend.

1.14 COORDINATION

A. The Control System contractor shall schedule and attend a pre-submittal (prior to submission of control diagrams) meeting with Owner for purposes of resolving any potential problems regarding the interface of the proposed system with those existing within General Services and present schedule for approval.

B. BACnet instance number submittal sheet must be submitted to GSA to obtain BACnet instance IDs. Equipment should not be connected to the network until configured with the Instance IDs provided.

C. The control system contractor shall adhere to the Wake County equipment and point naming convention. Controls system contractor shall schedule a nomenclature coordination meeting to occur after notice to proceed, but before contractor begins DDC work. Nomenclature must be approved by GSA. Incorrect point names will be required to be corrected by the completion of the project.

D. Programming of Control system modifications necessitated by this Project will be done at the General Services' terminal located at 401 Capital Blvd., Raleigh, NC or on-site as necessary. This programming will be complete by the authorized Programmer representing the Control System contractor. Coordination of Owner specified point designations and scheduling of the programming will be the responsibility of the Control System contractor (to be coordinated with Owner). Programming must be done prior to Wake County acceptance of system maintenance responsibility. Any option to perform remote programming or configuration is only allowed at the discretion of the County and is not guaranteed.

E. System Start-up and Acceptance: Upon completion of the installation, start-up the system and perform all necessary testing. When the system performance is deemed satisfactory in whole or part by Architect/Engineer and by the Wake County Representative, designated by Wake County officials, the system parts will be accepted for beneficial use and placed under warranty. Warranty shall not commence prior to receipt of certificate of completion from Architect/Engineer.

F. System Testing and Balancing: The Control System contractor shall participate in the Testing and Balancing of the HVAC System and Wake County GSA Representative. The control contractor shall support the Testing and Balancing contractor through the entirety of balancing.

1.15 INPUT/OUTPUT SUMMARY

A. Refer to end of this Section. DESIGNER SHALL INCLUDE I/O SUMMARY FOR EACH PROJECT.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Ecostruxure, by Schneider Electric.
B. Honeywell International, Inc. (ACI).
C. Siemens Building Technologies, Inc. APOGEE.

2.2 NETWORK

A. All networked control products 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. BAS Server shall be capable of simultaneous direct connection and communication with BACnet/IP corporate level networks without the use of interposing devices.

D. Any break in Ethernet communication from the PC to the controllers on the Primary Network shall result in a notification at the PC.

E. Any break in Ethernet communication between the standard client and server workstations on the Primary Network shall result in a notification at each workstation.

F. The network architecture shall consist of two levels of networks:

1. The High Tier level network shall be BACnet/IP over Ethernet. It shall network the Building Automation Server, Operator workstations, and Building level controllers. Provide network media converters, routers and switches as necessary for a complete network.

G. The Floor level network shall be BACnet over the native infrastructure (i.e. if BACnet MS/TP native, all devices should communicate over MS/TP. If BACnet IP native, all devices should communicate over IP to a dedicated BMS router placed inside a BMS enclosure). It shall network to all of the DDC controlled equipment on a floor or in a system and network to a router that connects to the Automaton level BAS backbone. Controllers for the central plant and large infrastructure air handlers shall reside on the backbone BACnet/IP network. 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. Modbus.
3. BACnet IP (On dedicated BMS sub-network).

H. Use fiber optic cabling for all Ethernet runs longer than 300 ft.

I. Where a smoke control application is required, provide UL 864 / UUKL listed network switches, and NFPA approved cabling, enclosures and installation methods.

J. The system shall be installed with a 10% spare capacity on each subnetwork for the addition of future controllers.

2.3 DISTRIBUTED CONTROL REQUIREMENTS

A. 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.

B. 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.

C. 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.

D. 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.

2.4 SERVER: Existing Server

A. Owner will provide specifications of existing server upon request.

B. OWNER will provide necessary hardware and software to ensure that the server is backed up fully on a daily basis and could be quickly restored if necessary.

C. Vendor will provide and install any add on software not native to the Network Operating System to ensure full functionality resulting from the addition of this contract in the area of reporting capability and database storage (SQL Server, Sybase, Crystal Reports, etc.). Vendor should verify the installation of the software is adequate to meeting the project requirements.

D. OWNER will ensure that the server is backed up by an UPS to prevent power outage.

E. If owner does not possess manufacturers' high-tier equipment, vendor must supply server per Wake County standards, 1 workstation, and all software necessary to connect and control building per this document. Specifications should be confirmed prior to bid.

2.5 BAS SOFTWARE

A. Overview.

1. The BAS Contractor shall provide system software capable of engineering level configuration. A thick client GUI shall provide comprehensive user interface and configuration tools to view and edit graphics, controller-level programming, points, schedules, trends, and alarms. Controller programming must be able to be viewed, edited, backed up and reloaded to the controller over the network.
2. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP\IP. Server shall be accessed using a web browser over Owner virtual private network.
3. Graphic software shall facilitate user-friendly interface to all aspects of the System Software. The intent of this Specification is to require a graphic package that provides for intuitive operation of the systems without extensive training and experience. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis. The Operator Interface shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. The system shall be capable of supporting an unlimited number of clients.
4. The number of network controllers required is dependent on the type and quantity of devices installed. It is the responsibility of the Contractor to determine the quantity and type of devices. The Contractor shall be responsible to properly install the correct number (increase if required) of network controllers from the designed minimum shown on the BAS documents. The Contractor shall confirm the designed network load and architecture with the capabilities of the selected Network Controller. If network communications issues arise as a result of a limited Network Controller resource count the Network Integrator shall furnish, install, and implement additional Network Controllers to reduce the network traffic on each Network Controllers Local Operating Network to less than 50% of maximum bandwidth as recommended by the manufacturer. The total capacity includes all imbedded applications as well as design specific applications.
5. The web browser GUI shall by HTML5 compatible and provide an interactive user interface and must offer and be configured with the following features as a minimum:

    a. Trending.
    b. Scheduling.
    c. Real time 'live' Graphic Programs.
    d. Tree Navigation.
    e. Parameter change of properties.
    f. Set-point Adjustments.
    g. Alarm / Event information.

6. Software Components: All software components of the BAS system software shall be provided and installed as part of this project. BAS software components shall include:

    a. System Configuration Utilities for future modifications to the system, and controllers shall include all software and programming not specifically itemized in these specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.
    b. Graphical Programming Tools.
    c. Direct Digital Control Software.
    d. Application Software.

B. General:

1. All necessary software to form a complete operating system as described in this specification shall be provided.
2. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
3. All digital points shall have user defined two-state status indication (descriptors with minimum of 8 characters allowed per state (i.e. summer/winter).
4. All subsystems that can stop or disrupt the program shall be graphically displayed as red/green status.
5. The software shall be provided with an interactive HELP function to assist operators with syntax, abbreviations, commands and saving programs.

C. Control Software Description:

1. The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:

    a. Two-position control.
    b. Proportional control.
    c. Proportional plus integral control.
    d. Proportional, integral, plus derivative control.
    e. Automatic tuning of control loops.

2. Control sequence shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
4. Upon the resumption of normal power, each DDC 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.

D. Scheduling:

1. Building controllers must store and use operating schedules. BACnet schedules are preferred.

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.

7. Schedule Categories: The system shall allow operators to define and edit scheduling categories (for example, lighting, HVAC occupancy, etc.). Unless otherwise defined in the project documents, separate schedules should be defined for:

   a. AHU Occupancy.
   b. VAV Occupancy.
   c. Exterior Lighting Schedule.
   d. Interior Lighting Schedule.

E. DDC Controllers shall have the ability to perform all the following energy management routines:

1. Time-of-day scheduling.
2. Calendar-based scheduling.
3. Holiday scheduling.
4. Temporary schedule overrides.
5. Start-Stop Time Optimization.
6. Automatic Daylight Savings Time Switchover.
7. Night setback control.
8. Enthalpy switchover (economizer).
9. Peak demand limiting.

10. Temperature-compensated duty cycling.
11. Fan speed/CFM control (reducing fan speed on CV AHU to save demand charges).
12. Heating/cooling interlock (to prevent system overlap).
13. Hot water reset.
14. Chilled water reset.
15. Condenser water reset.
16. Equipment sequencing.
17. Supply air reset.
18. Control Loop Algorithm.
19. Adaptive Loop Tuning.
20. Generator load shedding/starting sequence.

NOTE: FOR EXAMPLE, PUMP, AND CHILLER SEQUENCING TO REDUCE PEAK DEMAND. INCLUDE IN SEQUENCE OF OPERATIONS. PROVIDE FOR RAMPING DOWN CHILLERS WHEN ANOTHER CHILLER IS BROUGHT ONLINE TO REDUCE PEAK DEMAND

a. All programs shall be executed automatically without the need for operator intervention and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operations.

F. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. It shall be possible to use any of the following in a custom process:

a. Any system measured point data or status.
b. Any calculated data.
c. Any results from other processes.
d. User-defined constants.
e. Arithmetic functions (+, - * /, square root, exp, etc.).
f. Boolean logic operators (and/or, exclusive or, etc.).
g. On-delay/off-delay/one-shot timers.

2. Custom processes may be triggered based on any combination of the following:

a. Time interval.
b. Time-of-day.
c. Date.
d. Other processes.
e. Time programming.
f. Events (e.g., point alarms).

3. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network.

4. Processes shall be able to generate operator messages and advisories to operator I/0 devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
5. The custom control programming feature shall be documented via English language descriptors. The document shall include plain English version of programming for a clear understanding of code and the program. It shall also include a layman's description of the sequence and a flow chart for a non-programmers interpretation.
6. DDC and HVAC Mechanical Equipment Controller shall be capable of comment lines for sequence of operation explanation.
7. Programming shall provide owner with the ability to override reset schedules per point at all user interfaces.

G. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/0 summary.

1. DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

   a. 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 DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute for a 24-hour period shall be provided. Each DDC Controller shall have a dedicated RAM based buffer for trend data and shall be capable of storing a minimum of 25,000 data samples. Provide additional RAM capacity internal or external to the DDC Controller as necessary to meet this requirement.
   b. If buffer in each DDC Controller in a building over 100,000 square feet cannot store 25,000 data samples, provide additional Controllers in Mechanical Equipment Room to obtain required minimum data storage.

2. Trend data shall be stored at the DDC Controllers and uploaded to the server 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 3rd party personal computer applications.

H. DDC Controllers shall have the capability to automatically accumulate and store run-time hours for digital input and output points as specified in the point I/0 summary.

1. The totalization routine shall have a sampling resolution of one minute or less.
2. The user shall have the ability to define a warning limit for runtime totalization. Unique, user-specified messages shall be generated when the limit is reached.

I. DDC Controllers shall have the capability to automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/0 summary.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g., KWH, gallons, BTU, tons, etc.).

2. The totalization routine shall have a sampling resolution of one minute or less.
3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

J. DDC 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 points as specified in the point I/0 summary.

1. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.
2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

K. The network shall allow the DDC Controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC Mechanical Equipment Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC Mechanical Equipment Controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer-to-peer network shall also allow any DDC and HVAC Mechanical Equipment Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.

L. System Security: System shall be capable of multi-level access through Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:

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.

M. 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. Paged alarm messages shall be routed to user-defined list of phone numbers via SMS messages.
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. 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.

N. Trends: Trends shall both be displayed and user configurable through the Web Browser GUI or thick client. Trends shall be capable on all analog, digital, calculated, and integrated points. A trend log’s properties shall be editable using the Navigation Tree and Graphic Pane. Trends must be must user configurable from the thick/thin client including creating new trends on all connected items. Trends that must be set up with a separate configuration tool are NOT acceptable.

1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane located on every page. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
2. Local Trends: Trend data shall be collected locally by a Controller located in the building, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
3. Server/Long Term Trends: Trend data shall be collected periodically by the server and must have demonstrable capability of storing for a minimum of 2 years. Server must provide the ability to easily download at least 2 years’ worth of data for multiple points simultaneously to a .csv or Microsoft Excel file with one export.
4. Events: Events shall be logged for review by the operator, engineering or management personnel. The system shall log each new operator log-on, and whenever an operator changes a set-point or turns any device on or off. Each time the event log records an event, it will record the operator logged in and the type of action taken (set-point change, state change, etc.), along with a date and time stamp.
5. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are

selected for displays that have different trend intervals, the system will automatically scale the axis.

6. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
7. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
8. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
9. Copy/Paste. The operator must have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

O. Graphical User Interface.

1. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events and trends.
2. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator's role privileges.
3. Navigation: Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic.
4. Actions: The web interface shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

   a. Graphics: Using graphical format suitable for display in a web browser, graphics shall include, color building floor-plans, equipment drawings, active graphic set-point controls, web content and other valid HTML elements. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Webpage.
   b. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.
   c. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree). The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided

by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

d. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.

e. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling.

2.6 BUILDING CONTROLLER

A. 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. The controller Controllers shall combine both network routing functions, control functions, and server functions into a single unit. The controller shall be multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list. Schedules shall reside in the building controller and only rely on the central server for updates.

B. The Building controller shall be classified as a “native” BACnet device, supporting the BACnet Network Server Controller (B-BC) profile. NSCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Network Server Controllers (B-BC).

C. Each DDC controller shall have a manual override point present on the controller so that the equipment may be operated directly from the controller.

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. Air handlers.
6. Systems with over 24 input/output points.

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 for primary network communications.
2. Secondary Network communication module for secondary network communications.
3. RJ45 port: Minimum 10/100Mbaud.
4. RS485 ports for subnetworks and point expansion.
5. Human Machine Interface port (HMI).
6. USB Port.

G. Input and Output Points Hardware:

1. Input/output point modules as required including spare capacity.
2. Monitoring of the status of all hand-off-auto switches.
3. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
4. 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.
5. Graduated intensity LEDs or analog indication of value for each analog output.

H. Each DDC Controller shall support:

1. Monitoring of the following types of inputs, without the addition of equipment outside the DDC Controller cabinet:

    a. Analog inputs.

        1) 4-20 mA.
        2) 0-10 Vdc.
        3) Thermistors.
        4) 1000 ohm RTDs.

    b. Digital inputs.

        1) Dry contact closure.
        2) Pulse Accumulator.
        3) Voltage Sensing.

2. Direct control of electronic actuators and control devices. Each DDC Controller shall be capable of providing the following control outputs without the addition of equipment outside the DDC Controller cabinet:

a. Digital outputs (contact closure).

1) Contact closure (motor starters, sizes 1-4).

b. Analog outputs.

1) 4-20 mA.
2) 0-10 Vdc.

I. Each DDC Controller / network router shall have a minimum of 10%spare capacity for future point connection. The type of spares shall be in the same proportion as the implemented I/0 functions of the panel, but in no case shall there be less than two spares of each implemented I/0 type. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

1. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

J. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

K. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC 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 60 days. Controls Contractor shall provide external battery back-up, if necessary to meet this requirement.

1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.

L. Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and BACnet objects. Provide software, drives and programming.

M. 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.

N. Code compliance:

1. Approvals and standards: UL916; CE; FCC.
2. Provide UL864-UUKL where called for in the sequences of operations.

O. Accessories:

1. Appropriate NEMA rated metal enclosure.
2. Power supplies as required for all associated modules, sensors, actuators, etc.

P. 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.

Q. 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).

R. 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 (RFCI) 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:

a. IEEE Standard 587 1980.
b. UL 864 Supply Line Transients.
c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11).

S. Provide a separate DDC Controller for each HVAC system as indicated on the drawings and in the input/output summary, Section 1.15. It is intended that each unique system be provided with its own point resident DDC Controller.

2.7 APPLICATION SPECIFIC CONTROLLERS (ASC)

A. Each Application Level Control Panel 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 be a microprocessor-based, multi-tasking, real-time digital control processor.

B. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs).

C. The 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. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network.

D. Communication:

1. BAS Network: The Advanced Application Controller shall support the following Data Link Layers.

a. BACnet MS/TP Master or slave.
b. Modbus.
c. BACnet IP (On dedicated BMS sub-network).

E. Provide an Application Specific Control Panel for each of the following types of equipment (if applicable):

1. Constant Air Volume (CAV) boxes.
2. Duct mounted reheat coils.
3. Fan coil Units.
4. Fan Powered Variable Air Volume (VAV) Boxes.
5. Reheat Coils.
6. Supplemental AC units.
7. Variable Air Volume (VAV) Boxes.
8. Other terminal equipment.

F. Terminal Equipment Controllers (VAV Controllers):

1. Provide for control of each piece of equipment, including, but not limited to, the following:

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs (except for unit ventilator controllers) shall be of the Universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of Universal outputs, provide a minimum of 50% spare outputs of each type via additional point termination boards or controllers. Analog outputs to field devices shall be either 4 to 20 ma or 1 to 10 volt. Tri-state signals (floating control) shall not be acceptable. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable. As an alternative, provide DDC Controllers or other ASCs with industry standard outputs for control of all terminal equipment.
3. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:

a. Accuracy: ±1°F
b. Operating Range: 0° to 115°F
c. Set Point Adjustment Range: 55° to 95°F
d. Set Point Modes

1) Independent Heating, Cooling,
2) Night Setback Heating, Night Setback Cooling

e. Calibration Adjustments: None required.
f. Installation: Up to 150 ft. from Controller.
g. 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. In lieu of an internal jack, provide a method for local communications to controller without the need for outside network or provide a separate terminal jack mounted on a stainless steel wall plate adjacent to the sensor to facilitate direct access to the controller via the terminal.
h. Each room sensor shall also include the following auxiliary devices:

1) Setpoint Adjustment Dial.
2) Temperature Indicator.
3) Override Switch.

i. The setpoint adjustment dial shall allow for modification of the temperature by the occupant Setpoint adjustment may be locked out overridden or limited as to time or temperature through software by an authorized operator at the central workstation, DDC Controller, or via the portable operator's terminal. In lieu of an integral adjustment dial, provide a separate dial mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.
j. The temperature indicator shall be a digital readout and have the ability to indicate at minimum current temperature and temperature setpoint.
k. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, DDC Controller or via the portable operator's terminal. In lieu of an integral switch, provide a separate momentary contact switch mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.

4. Each controller shall perform its primary control function independent of other DDC Controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the DDC Controller time clock to ensure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

5. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.
6. Programming and/or configurations should be editable over the network from the standard thin or thick client software.
7. Variable Air Volume (VAV) Box Controllers: shall support the following types of pressure independent terminal boxes as a minimum:

    a. VAV cooling only.
    b. VAV with hot water reheat.

8. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.
9. The VAV box controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller. The controllers shall also function normally under ambient conditions of 32° to 122°F and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
10. The controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual airflow. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm and measurement accuracy of 5% at 400 to 4000 fpm, ensuring primary air flow conditions shall be controlled and maintained to within 5% of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.
11. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

12. Damper actuator should provide indication of damper position. Active proportional feedback or calculated position shall be available. Specific damper position shall be controllable. If calculated position is used, this controller must self-calibrate on a daily basis and be set up for off-hours calibration. Floating point damper actuators which do not allow position control are not acceptable.
13. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within 1.5°F of setpoint at the room sensor location.
14. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve as required to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.
15. Each controller shall have a discharge air temperature sensor on the VAV box for system operator to use for diagnostics.

2.8 BUILDING SYSTEMS INTEGRATION

A. The BAS System shall establish a seamless interconnection with other building, electrical and/or mechanical subsystems that employ BACnet protocol (Chillers, Variable frequency drives, etc.). These systems shall be controlled, monitored and graphically programmed with the same Graphical Programming Language (GPL) used for all other control modules.

B. VARIABLE FREQUENCY DRIVE INTEGRATION

1. VFDs should be controlled via hardwired operation including Enable, speed, alarm points.
2. Unless specifically noted on the drawings, the motor/fan/pump status should be monitored separately through a current transducer.
3. VFDs shall have modbus/BACnet capabilities - the drives should be integrated into the control system and points should be available on the controls system.
4. At a minimum the following BACnet points shall be integrated: Actual drive speed (hz), Motor Current (A-avg), Motor Voltage (V-rms), Driver Power (kW), Drive Energy (kWh) Alarms. Drive Power should be converted to kW if not available as BACnet point.

C. CHILLERS AND BOILER INTEGRATION

1. Chillers and Boilers should be controlled via hardwired operation including Enable, setpoint, status and alarm points.
2. Chillers and Boilers shall have modbus/BACnet capabilities - the chiller/boilers should be integrated into the control system and points should be available on the controls system.
3. At a minimum, the following Boiler points shall be integrated: Setpoint (F), Inlet Temp (F), Outlet Temp (F), Flue Temp (F), Firing Rate (%), Boiler Pump Status, Boiler Pump Speed (%), Alarm, Alarm Code

4. At a minimum, the following Chiller points shall be integrated: Setpoint (F), Chiller Status, Chiller Operating Mode, Operating Capacity (%), Compressor Speed (%), Compressor Status (each), Inlet Temp (F), Outlet Temp (F).

D. LIGHTING CONTROL SYSTEM INTEGRATION

1. Where lighting controllers are to be integrated through a dry-contact, the relay should have hand/on/auto switch for local override
2. Where lighting controllers are to be integrated through modbus/BACnet – the lighting control panel should be integrated into the control system and points should be available on the controls system.

2.9 CONTROL PANELS

A. Controllers in mechanical rooms shall be mounted in a minimum of NEMA 1 enclosures. Exterior controllers shall be mounted in a NEMA 4X Stainless Steel enclosure.

B. Mount on walls at an approved location or provide a free standing rack built of unistrut or hot dipped galvanized of sufficient strength to maintain rigidity.

C. 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.

D. Provide power supplies for control voltage power.

E. 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.

F. Power supplies for controllers shall be a transformer with a fuse or circuit breaker. Power supplies for other devices can be plain transformers.

G. 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.

H. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator’s workstations.

I. All devices in a panel shall be permanently mounted, including network switches, modems, media converters, etc.

J. Provide a pocket to hold documentation.

K. Wire management should be completed using covered, slotted wireway (Panduit) in the control panels. Panels should be sized to accommodate wireways and DIN rail mounted equipment as necessary. Wires should not be left hanging.

2.10 INPUT/OUTPUT SENSORS

A. Temperature:

1. Unless otherwise stated in this specification temperature sensors to be platinum RTD type.
2. Resistance tolerance at calibration point to be no more than 0.2% Calibration point 0 degrees F.
3. Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements where larger or prone to stratification, sensor length 18" to 25 ft as required.
4. Insertion elements for liquids shall be brass or stainless steel with minimum insertion length of 2-1/2 inches.
5. Room temperature sensors used with terminal equipment controllers to be either thermistor or RTD type with set-point adjustment, temperature indicator, terminal jack and over-ride switch. Refer to Terminal Equipment Controller Specification for detailed requirements.
6. Provide outside air sensors with watertight inlet fitting, shielded from direct rays of sun.

B. Humidity Sensor:

1. Duct type shall include a dew point probe with an adjustable/removable draft shield and a transmitter mounted to the sensor probe case.
2. Outside Air type shall include a probe in a weather-proof housing and a transmitter for indoor mounting.
3. Dew Point monitoring range -40 to +115 degrees F, dewpoint.
4. Room Sensors: Range of 0-99 percent RH.
5. Elements: Accurate within 5 percent over 20-95% RH range with linear output.
6. Output signal 0-10V or 4-20MA DC.
7. Accuracy at Calibration Point.

   a. Dewpoint Element +-1.1 degrees F, dewpoint.
   b. Dewpoint Sensor +- 1.5 degrees F, dewpoint.

8. Voltage, probe heater - 120 Vac.
9. Voltage, transmitter - 26 Vdc.

C. Static Pressure Sensors:

1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.
2. Temperature compensated with typical thermal error of .015 percent of full scale per degree F. in temperature range of 35 to 135 degrees F.
3. Accuracy: One percent of full scale with repeatability 0.3 percent.
4. Output: 0-10 Vdc or 4-20ma with power at 13 to 36 vdc.

D. Equipment Operation Sensors:

1. Status Inputs for Fans: Current sensitive relay with current transformers, adjustable and set to 175 percent of rated motor current.

2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi and on the pump side from any check valve or triple duty valve.
3. Status Inputs where differential pressure sensing is impractical: Current sensitive relay with current transformers, adjustable and set to 175 percent of rated motor current.

E. Low Temperature Protection Thermostats:

1. Low temperature protection thermostats shall be the manual reset type and shall have sensing elements not less than 20 feet in length. The thermostat shall operate in response to the coldest temperature at other parts of the element. The element shall be properly supported to cover the entire duct width. Separate thermostats shall be provided for each 25 sq. ft. of coil face areas of fraction thereof.
2. Low temperature protection thermostats shall be installed such that freezestats do not trip during normal operation of the system.
3. Controls should be programmed such that freezestats do not trip during normal winter operation.
4. Controls should be programmed such that freezestats do not trip during smoke evacuation operation. This is usually accomplished by automatically opening the hot water valves on the hot water coils during operation of the smoke evacuation system.

F. Air Flow Monitoring Stations:

1. Unless otherwise noted, monitor outdoor air volumes from duct mounted thermal dispersion air flow measurement systems.

    a. System shall employ bead in glass thermistor technology. Sensors shall be installed using an equal area sensor distribution.
    b. Thermistor signals shall be process by a 12 bit microprocessor based transmitter. Transmitter shall be 24vac powered.
    c. System shall be capable of processing any air flow rate from 0 to 5000FPM.
    d. Sensor accuracy shall be +/- 2% of reading with a +/- .25% repeatability.
    e. Sensors shall operate in conditions of -20˚ F to 160˚ F and 0 to 90% RH, non-condensing.
    f. Where indicated provide Air Flow Monitoring Station equal to Ebtron with remote indicating readout transmitter. Remote transmitter shall be mounted in a location protected from moisture.
    g. Install readout panels a maximum of 6’-0” above the finished floor in the closest Mechanical Room.

G. Fan Inlet Airflow Traverse Probes:

1. Provide on the indicated fans, airflow traverse probes mounted in the fan inlets capable of continuously measuring the air handling capacity (air volume) of the respective centrifugal fan(s). The fan inlet airflow traverse probes shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.

2. The fan inlet airflow traverse probes (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings, and shall be of aluminum construction with hard anodized finish.
3. The fan inlet airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level within the system be amplified by its presence in the fan inlet bell. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 3% of actual flow over a fan operating range of 6 to 1 capacity turndown.
4. The fan inlet airflow traverse probes shall be the Kele, Model KIP2 or engineer approved equal.

H. Carbon Dioxide Sensor

1. CO2 sensor shall utilize Non-dispersive infrared technology (NDIR) repeatable.
2. Sensor repeatability shall be +/- 20 ppm, 0-2000.
3. Sensor accuracy shall be <= 75 ppm over 0-1500 ppm range.
4. Field selectable 4-20MA/0-5V/0-10V output with LCD display

I. Hydronic Water Flow Meter

1. Flow meters shall be Insertion Electromagnetic. Basis of design is Onicon F-3500.
2. Flow meter shall have an analog output for flow rate and a pulse output for totalized flow.
3. Connection: 1” Male NPT Hot Tap Adapter fitting. Installation through 1” full port isolation valve, minimum.
4. Flow Range: Flow-measuring element and transmitter shall cover operating range of equipment or system served.
5. Wetted components shall be constructed of 316L stainless steel with attached tag indicating calibration information.
6. Electromagnetic sensing element shall utilize two sets of diametrically opposed electrodes to measure the average flow rate velocity.
7. Accuracy: Flowmeter shall provide calibrated outputs directly from the integral transmitter, throughout the operating range with the accuracy stated as follows:

   a. Plus or minus 1.0% of rate from 2.0 to 20.0 ft/sec velocity (10:1 turndown).
   b. Plus or minus 0.02 ft/sec below 2 ft / sec

2.11 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class indicated. Where type or body material is not indicated, make selection as determined by manufacturer. For installation requirements and pressure class, based on maximum pressure and temperature rating of piping system.

B. Globe Pattern: As follows:

1. Up to 2 inches (DN 50): Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.

2. Over 2 inches (DN 50): Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
3. Hydronic Systems: As follows:

   a. Rating: Service at 125 psi WSP (862 kPa) and 250 deg F (121 deg C).
   b. Internal Construction: Replaceable plugs and seats of stainless steel or brass.

      1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
      2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

   c. Sizing: 3-psi (21-kPa) maximum pressure drop at design flow rate.
   d. Flow Characteristics: 2-way valves have equal percentage characteristics; 3-way valves have linear characteristics. Select operators to close valves against pump shutoff head.

4. Butterfly Pattern: Iron body; bronze, aluminum-bronze, or stainless-steel disc; resilient, replaceable seat for service to 200 deg F (93 deg C) wafer or lug ends; extended neck.

   a. Rating: Service at 125 psi WSP (862 kPa) and 250 deg F (121 deg C).
   b. Sizing: 1-psi (7-kPa) maximum pressure drop at design flow rate.

5. Terminal Unit Control Valves: Bronze body, bronze trim, 2 or 3 port as indicated, replaceable plugs and seats, union and threaded ends.

   a. Rating: Service at 125 psi WSP (862 kPa) and 250 deg F (121 deg C).
   b. Sizing: 3-psi (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.
   c. Flow Characteristics: 2-way valves have equal percentage characteristics; 3-way valves have linear characteristics.
   d. Actuator : Proportional, modulating, self-contained – see VALVE AND DAMPER ACTUATORS

2.12 DAMPERS

A. Dampers: AMCA-rated, opposed blade design; form frames from not less than 0.1084-inch (2.8-mm) galvanized steel with mounting holes for duct mounting; damper blades not less than 0.0635-inch (1.6-mm) galvanized steel, with maximum blade width of 8 inches (203 mm).

   1. Blades secured to 1/2-inch (13-mm) diameter, zinc-plated axles keyed, hexagonal square or other shape solid shaft that has positive (no slip) engagement with the provided actuator. Provided with zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass. Ends sealed against spring-stainless-steel blade bearings. Thrust bearings at each end of every blade.
   2. Operating Temperature Range: From -40 to 200 deg F (-40 to 93 deg C).
   3. For standard applications as indicated, (as selected by manufacturer's sizing techniques) with optional closed-cell neoprene edging.

4. For low-leakage applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm/sq. ft. (51 L/s/sq. m) of damper area, at differential pressure of 4 inches wg (995 Pa) when damper is being held by torque of 50 inch-pounds (5.6 N x m); test in accordance with AMCA 500.
5. Dampers shall be provided with mechanical end switches independent of the actuator position sensor to indicate a positive open or closed position of the damper blade itself.
6. Parallel dampers only allowed for non-modulating (on/off) operation.
7. Damper/Actuator combination shall be capable of modulating at maximum static pressure rating.

2.13 VALVE AND DAMPER ACTUATORS

A. Basis of design: Belimo.

B. Electronic Direct-Coupled. Electronic direct-coupled actuation shall be provided.

C. Actuator Mounting. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft. Where a shaft extension is required a manufactured option accessory shall be used. Field fabricated extensions and couplers will not be allowed. The actuator shall employ a V-bolt and toothed V-clamp fastening technique. Single point bolt or screw type fastener for circular valve and damper shafts is unacceptable.

D. Electronic Overload Sensing. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.

E. Power Failure/Safety Applications. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non- mechanical forms of fail-safe operation are not acceptable.

F. Spring Return Actuators. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.

G. Proportional Actuators. Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA control input and provide a 2 to 10VDC or 4 to 20mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is not acceptable.

H. 24 Volts (AC/DC) actuators. All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 20VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 20VA. Actuators operating on 230VAC shall not be acceptable.

I. Non-Spring Return Actuators. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators shall have a manual crank for this purpose.

J. Modulating Actuators. All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.

K. Conduit Fitting. Actuators shall be provided with a conduit fitting.

L. U.L. Listing. Actuators shall be Underwriters Laboratories Standard 873 listed.

M. Warranty. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a minimum 5-year manufacturer's warranty.

N. Actuators shall be selected utilizing no more than 80% of the cataloged torque rating.

O. Actuators shall be electronic, low voltage (24 VAC/VDC), NEMA 2 rated for all applications. Two- position may utilize 120 VAC actuators. Actuators shall have UL, CSA and ISO 9001 certification and approvals. Actuators shall have a minimum operating range of –22□ to 122□F. Optional auxiliary switches shall be available if required by the sequence. Actuators shall be fully modulating/proportional, floating/tri-state, or two- position as required. Pulse width modulation is unacceptable. Actuators shall have visual position indicators. Proportional actuators shall be field programmable to operate in sequence with other devices without additional transducers. All actuators except two- position shall be capable of providing a constant rotation rate independent of the load. Actuators used on dampers or valves shall be designed to directly couple to a stem, shaft or ISO style-mounting pad. Damper actuators or damper actuators adapted for use with control valves shall utilize V-bolt toothed V-clamp shaft fastening technique. Single point, bolt, or single screw type shaft fastening techniques for circular or round damper or valve shafts is unacceptable.

P. Ganged actuators must allow for single point manual operation.

2.14 MISCELLANEOUS CONTROLS

A. The control manufacturer shall furnish all two-position relays, current transformers, NEMA rated enclosures, thermostats and all other controls necessary to meet the specifications and provide for a properly operating automatic control system. All control devices connected in line-voltage circuits shall be U.L. listed and of a type to meet the current and voltage requirements of the particular application.

B. If a device or piece of equipment is provided with the ability to communicate directly with the controls system through any form of communication protocol (such as BACnet or lon) and the device is indicated to be connected to the BAS the controls contractor shall integrate their controls to that device.

C. All low voltage communication and network wiring shall have orange jackets.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation. Verify that field end devices and wiring are installed before proceeding with installation.

3.2 INSTALLATION

A. Install equipment as indicated to comply with manufacturer's written instructions.

B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and appropriate to sequence of operation.

C. The DDC control panel shall be mounted in the same mechanical room as the equipment being controlled, or an adjacent utility room. Exact locations shall be coordinated in the field with the owner and engineer.

D. Where Ethernet is used for building level communication, a dedicated switch should be located in a BMS enclosure with the other DDC control panels and be configured on a private sub-network separate from the Wake County network.

E. 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.

F. 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.

G. Chiller, pump & cooling tower shall be wired to the same controller, not across network.

H. Remote sensors shall be wired to the control panel of the equipment it is controlling, not across the network.

I. Signals to remote motor control centers shall be hard wired to the control panel, not across the network.

J. Terminal units shall each have their own controller. Only exceptions are:

1. Groups of reheat coils.
2. Groups of exhaust fans.

K. Connect and configure equipment and software to achieve the sequence of operation specified.

L. Verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate 60 inches (1524 mm) above floor.

M. Any required ethernet cable not already identified in the scope of the project shall be the responsibility of the vendor to coordinate and install.

N. Install damper actuators on outside of duct in warm areas, not where exposed to outdoor temperatures.

O. Install labels and nameplates to identify control components.

P. Install white vinyl label on each sensor/actuator indicating installation date of sensors/actuators (vinyl handheld label maker).

Q. Install labels to VAV and terminal boxes on ceiling grid below device. Provide ceiling grid labels to identify sensors and devices above ceiling outside of mechanical rooms. (white vinyl handheld label maker).

R. Wires shall be labeled at every final and intermediate termination. Labels should identify point, panel and equipment number.

S. Actuators with line voltage shall be fed from a circuit dedicated to actuators only for a single piece of equipment.

T. Install electrical work in accordance with Division 26. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

U. Conduits for control wiring shall not exceed 40% fill.

V. Graphics should be completed and active prior to the commissioning process and prior to substantial completion.

W. Point Structuring and Naming:

1. The intent of this Section is to require a consistent means of naming points across Wake County WAN. Configure the systems from the perspective of Wake County WAN, not solely the local Project. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, and the like. The convention is tailored towards Wake County WAN and as such, the interface shall always use this naming convention. BACnet systems shall also use this naming convention. For non- BACnet systems, the naming convention shall be implemented as much as practical, and any deviations from this naming convention shall be approved by Wake County.
2. Each Network Controller shall have English language descriptors for all system points, variables, parameters etc. located and accessible from the NC memory. All point naming shall match between all system files and record documents.
3. Point Summary Table: The term ‘Point’ is a generic description for the class of object represented by analog and binary inputs, outputs, and values. With each schematic, Network Integrator shall provide a Point Summary Table listing:

    a. Equipment type.
    b. Equipment number.

c. Equipment code.
d. Full point name (see Point Naming Convention paragraph).
e. Point description.
f. Object type.
g. Engineering units.
h. Network variable.

4. Additional fields for non- BACnet systems shall be appended to each row. Point Summary Table shall be provided in in electronic format (ODBC-compliant).
5. Point Summary Table shall also illustrate Network Variable Data Links.
6. The System Integrator shall coordinate with Wake County representative to compile and submit a proposed Point Summary Table for review (see point naming submittal) prior to any object programming or Project startup. Wake County shall grant approval of final point names to be verified through Commissioning by issuing the approved alarms to the System Integrator.
7. All points shall be identified per Wake County's point naming convention.
8. System Enable Points – Each AHU, hot water system, chilled water system should indicate a system enable point to allow for taking the unit offline manually.
9. Adjustable points – Temperature associated with a temperature reset, pressure reset, outdoor air lock out or other variable indicated as adjustable should be created as a point and be indicated on a graphic for adjustment.
10. All functional variables with in the code such as mode, Temperature Bands, Average Temperature, Cooling Loop Outputs and other points used within the programming should be created as virtual points for the purposes of troubleshooting.
11. Actuators should be programmed and displayed as 0% = closed and 100% = open.
12. Comment lines should be included in the code which is active on the controller. Comments should be complete enough to determine what is included within the code without reading the programming language.

X. Trend Point Naming. The naming convention for points shall be in plain English and separate the data using the underscore (_) and include the building number, building acronym, equipment, point and time interval or COV.

Trend Name Examples:

- 232FVL_AHU01_SupplyAirTemp_15min
- 232FVL_Vav01_15_SpaceTemp
- 232_FVL_ChilledWater_ChillerEnable_COV
- 232FVL_HotWater_Boiler02_FireRate_15min

1. Trends shall be as follows: Unless otherwise noted on the construction drawings, 15 minute interval trends should be set up for

a. All points, physical and virtual associated with AHUs
b. All points, physical and virtual associated with DX Systems
c. VAV, terminal - space temperature, humidity, temperature setpoint, valve position, discharge temp, air flow and damper position
d. Chiller/Boiler Plants – Chiller/Boiler enable, supply temp, return temp, secondary supply temp, secondary return temp, primary and secondary pump – enable, status, speed, and all flow readings

e. Chiller BACnet values – enable, supply temperature, temp set point, capacity, power, compressor status
f. Boiler BACnet values – enable, supply temperature, temperature set point, firing rate
g. Water Submeters – Total volume, year to date volume, flow rate
h. Natural Gas Submeter – Total Volume, year to date Volume, flow rate
i. Electrical Submeter – Circuit total power (kW), Circuit energy (kwh) total, Circuit energy (kWh) year to date

Y. Alarm Setup: Unless otherwise noted on the construction drawings, alarm should be set up via hard wired points or other software-type alarms for a minimum of:

1. Fire Alarm Active Alarm
2. Chiller Alarm
3. Boiler Alarm
4. VFD Alarm
5. Dirty Filter Alarm
6. High Limit Alarm
7. Low Temp Alarm (Freezestat)
8. Pump/Fan Status Alarm

a. Unless otherwise noted on the construction drawings, alarms should be page for a minimum of the following:

1) Chiller Alarm
2) Boiler Alarm
3) VFD Alarm
4) Fire Alarm

3.3 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Division 01.

B. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

C. Provide service engineer to instruct Owner's representatives in operation of systems plant and equipment, for one 8 hour period.

3.4 SCHEDULING OF TRAINING SHALL BE COORDINATED WITH OWNER

A. Provide basic operator training for a minimum of 4 persons on sequence of operations data display, alarm and status descriptions, requesting data, execution of commands and request of logs. Include a minimum of (12) hour’s dedicated instructor time. Provide as-built documents and O & M manuals for each person. A portion of the instruction time shall be specifically dedicated to the building life safety systems. As built drawings on paper and cad. As built drawings shall have a link to them shown on the controls front-end.

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 three (3) visits to Project during other than normal occupancy hours for this purpose.

3.5 COMMISSIONING

A. Manufacturer's Field Services: Provide the services of a factory-authorized service representative to start control systems. Shall be scheduled with owner. Test and adjust controls and safeties.

B. System Equipment: Upon completion of installation of each piece of equipment, field- inspect and mechanically and electrically test equipment for proper function.

C. Field Materials: Upon completion of installation of each piece of equipment, field-inspect and mechanically and electrically test equipment for proper function.

D. Acceptance Testing. Upon completion of the installation, the Contractor shall start up the system and perform all necessary trending, scheduling calibration, testing, and debugging operations. The Contractor in the presence of the Owners' representative shall perform an acceptance test. Acceptance test procedure to be submitted, for approval no later than 4 weeks prior to testing. Submission of test procedure shall imply that systems are complete, functional and that contractor has verified performance. Successful completion of acceptance testing shall be required prior to substantial completion.

E. 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 unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of controllers inputs, outputs, and sensors.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

F. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.

7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

12. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.
13. Calibrating and Adjusting:

    a. Calibrate instruments.
    b. Make three-point calibration test for both linearity and accuracy for each analog instrument.
    c. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
    d. Control System Inputs and Outputs:

        1) Check analog inputs at 0, 50, and 100 percent of span.
        2) Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
        3) Check digital inputs using jumper wire.
        4) Check digital outputs using ohmmeter to test for contact making or breaking.
        5) Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

    e. Flow:

        1) Calibrate the input sensors to the specified accuracy.
        2) Manually operate flow switches to verify that they make or break contact.

    f. Pressure:

        1) Calibrate pressure transmitters at 0, 50, and 100 percent of span.
        2) Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

    g. Temperature:

1) Calibrate the input sensors to the specified accuracy.
2) Calibrate temperature switches to make or break contacts.

h. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.

1) Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
2) Provide diagnostic and test instruments for calibration and adjustment of system.
3) Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures. Document all tests and provide to Wake County.

i. Adjust initial temperature and humidity set points.
j. 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 three (3) visits to Project during other than normal occupancy hours for this purpose.
k. Carbon Dioxide: Verify CO_2 readings with a calibration kit or against a known accurate device.

G. Replace damaged or malfunctioning controls and equipment.

H. Start, test, and adjust control systems.

I. Demonstrate compliance with requirements.

J. Adjust, calibrate, and fine tune circuits and equipment to achieve the sequence of operation specified without fault or failure.

3.6 DEMONSTRATION

A. Demonstrate a complete and fully operational system to Owner as required by contract documents near completion of project.

3.7 GRAPHICS

A. See Graphic standards.

B. Contractor shall submit graphics via a submittal and correct any deficiencies prior to project acceptance

C. Contractor shall allow four (4) hours of additional graphic design/modify time to adjust, develop, modify, and install the graphics after the DDC controls are installed and operational. The owner will provide marked up graphics illustrating the work.

PART 4 - GRAPHICS AND POINT NAMING

4.1 COORDINATION

A. Graphics should be developed and submitted to the County via a project submittal.

B. Graphics should be completed and active prior to the commissioning process.

4.2 GRAPHIC GUIDELINES

A. Standard units of measure should be used and labeled as follows:

Value	Unit
Temperature	ºF
Water Flow	gpm
Air Flow	CFM
Relative Humidity	%RH
Water Differential Pressure	psi
Gas Volume	CCF
Gas Flow	CFH

Value	Unit
Enthalpy	BTU/lbºF
Carbon Dioxide	ppm
Static Pressure	“WC
Filter Differential Pressure	“WC
Power	kW
Electrical Energy	kWh

B. Setpoints – should be located beneath each point controlled to a set point. Points in override shall have a visual indication they have been overridden.

C. System Enable Points – Each AHU, hot water system, chilled water system should indicate a system enable point to allow for taking the unit offline manually.

D. Adjustable points – Temperature associated with a temperature reset, pressure reset, outdoor air lock out or other variable indicated as adjustable should be created as a point and be indicated on a graphic for adjustment.

E. Actuators/Damper/Valves should be programmed and displayed as 0% = closed and 100% = open.

F. Control and monitoring points of equipment should be located beneath the item being controlled.

4.3 GRAPHIC EXAMPLES

A. To the extent technically possible all graphics shall be based upon the examples shown below. All features of the graphics, such as title block, navigation buttons, etc., shall always be located in the same general area on each Graphic.

B. Navigation – Buildings should be organized in a navigation tree and include the three-digit building identification number.

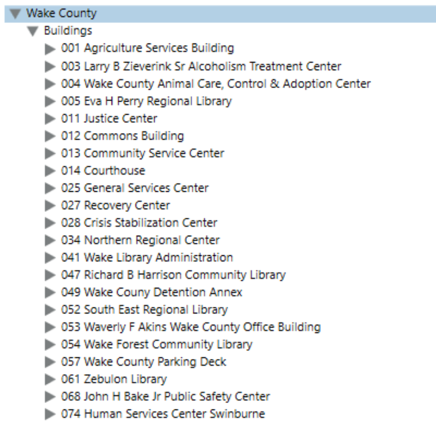


Figure 1: Navigation Tree, Example 1

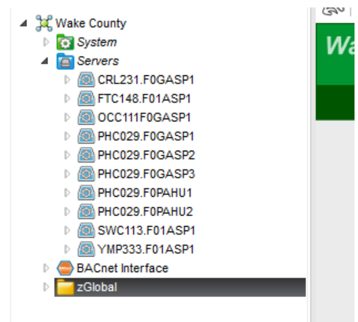


Figure 2: Navigation Tree, Example 2

C. Navigation – A top navigation bar should include site-specific graphics for the main mechanical and control systems, and the outdoor conditions for that site.

Figure 3: Navigation Bar, Example 1

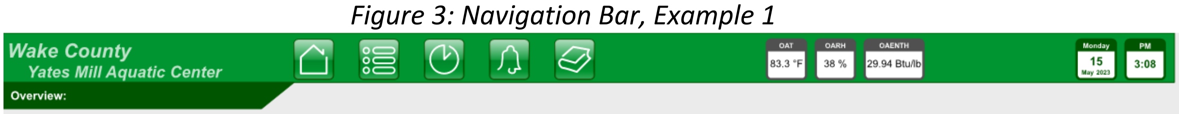


Figure 4: Navigation Bar, Example 2

D. Building Home Page – A building-specific home page should be created to provide an overview of the main systems status. The home page should include the navigation bar, building photo, and readings for the main systems such as AHU supply temperatures, hot water and chiller water supply temperatures and average building temperature.

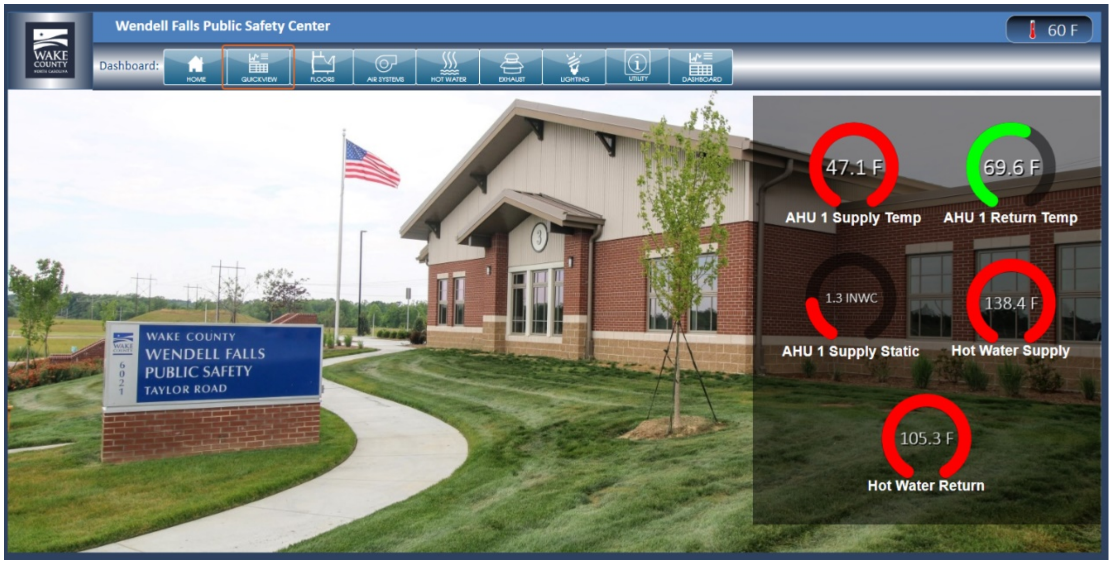


Figure 5: Building Home Page, Example 1

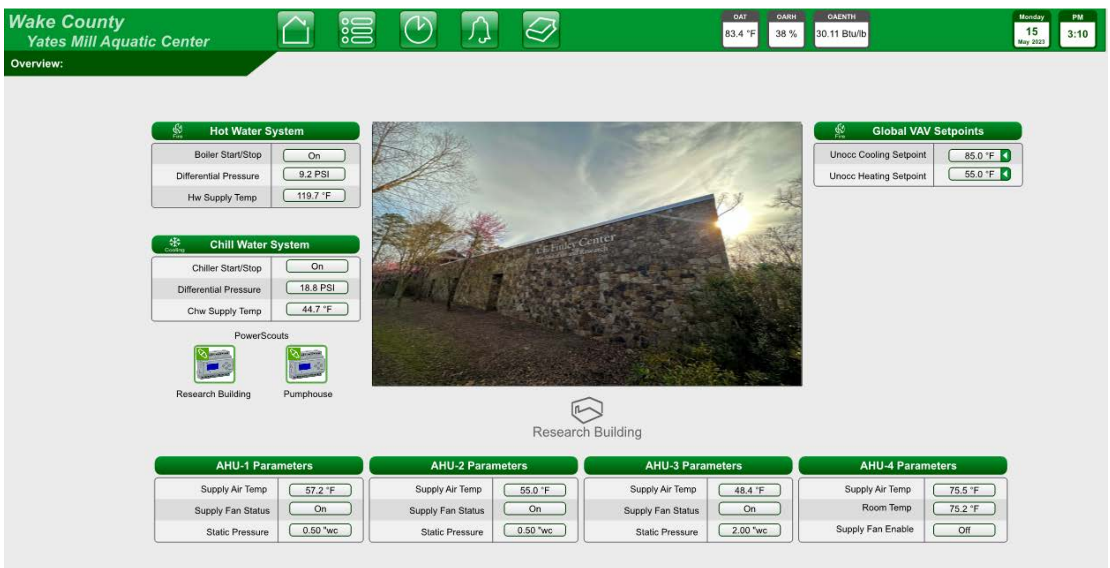


Figure 6: Building Home Page, Example 2

E. AHU Graphics – Air handling unit graphics should represent the ductwork and airflow as accurately as possible. Where multiple ducts or paths are present, the graphics should represent this. Sensor locations should be accurately represented.

1. Content, top right –

a. "AHU Parameters" shall be located in a box and include major control points such as AHU Enable, Occupancy Modes, Dehumidification Enable, Economizer Enable points shall be displayed

b. Dehumidification Enable, Economizer Enable points shall be displayed

c. "AHU Setpoints" under the parameters, if an air handler has space setpoints, there shall be displayed in a box and include room temperature, occupied cooling/heating setpoints, unoccupied cooling/heating setpoints.

Figure 7: AHU Graphic, Example 1

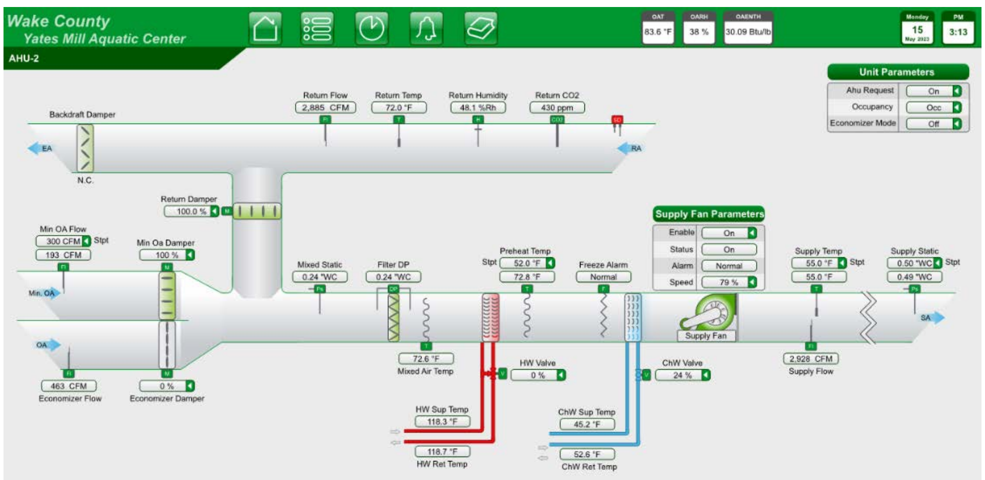


Figure 8: AHU Graphic, Example 2

F. Floor Navigation – A floor plan should be created from the architectural floor plans and include inside walls, doorways and room numbers. Duct work shall include colored main duct as well as diffusers - one color per AHU. A legend should indicate AHU number and color. VAV boxes should be indicated and the zone ductwork and zone should be identifiable. Main equipment should be indicated and labeled. Ductwork should be a layer that can be toggled on/off. Floor color per zone that can be toggled on/off is preffered, but optional.

Figure 9: Floor Navigation - Example 1

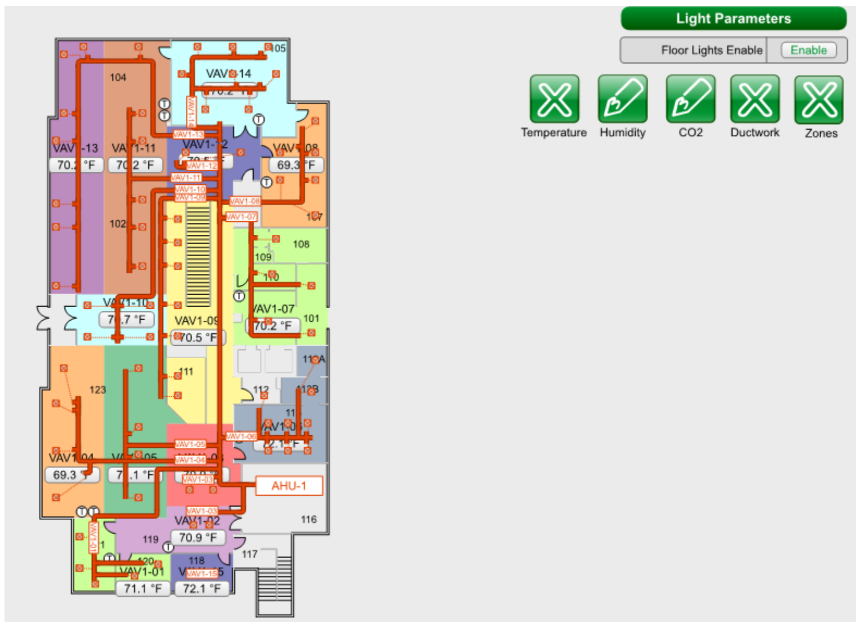


Figure 10: Floor Navigation - Example 2

G. VAV Table – A table of all VAV associated with an air handler should be placed on a graphic. Tables should be separated per AHU.

VAV Tec	Room Served	Space Temp	Ctl Stpt	Stpt Dial	Room Min Stpt	Room Max Stpt	Fan	Airflow	Max CFM	Min CFM	Dmpr Pos	AUX Temp	Heat Cool
TEC 01	Womens RR 112	71.8 °F	71.0 °F	YES	68.0 °F	76.0 °F	ON	152.0 ft3/min	596.0 ft3/min	120.0 ft3/min	100.0 %	71.0 °F	COOL
TEC 02	AS. Manager 118	69.75 DEG F	71.0 °F	YES	68.0 °F	76.0 °F	ON	144.0 ft3/min	744.0 ft3/min	148.0 ft3/min	13.6 %	71.0 °F	HEAT
TEC 03	Lockers 120	71.00 DEG F	71.0 °F	YES	68.0 °F	76.0 °F	ON	108.0 ft3/min	540.0 ft3/min	108.0 ft3/min	11.2 %	74.5 °F	HEAT
TEC 04	Periodicals Room	72.5 °F	74.0 °F	YES	68.0 °F	76.0 °F	ON	316.0 ft3/min	1,600.0 ft3/min	320.0 ft3/min	28.8 %	75.0 °F	HEAT
TEC 05	Workroom 110	70.8 °F	71.0 °F	YES	68.0 °F	76.0 °F	ON	544.0 ft3/min	992.0 ft3/min	200.0 ft3/min	63.6 %	71.0 °F	COOL
TEC 06	Program Rm 108	70.3 °F	20.0 %	YES	68.0 °F	76.0 °F	ON	740.0 ft3/min	2,132.0 ft3/min	428.0 ft3/min	0.0 %	71.5 °F	COOL

Figure 11: VAV Table - Example 1

Unit Name	Area Served	Occupancy	Space Temp	Base Clg Stpt	Base Htg Stpt	Effective Stpt	Supply Temp	Flow	Flow Stpt	Damper Pos	Terminal Load	Reheat Pos	Space RH%
F01VAV1-01	Offices 120&121	Occupied	71.1 °F	72.0 °F	68.0 °F	72.0 °F	61.2 °F	286 CFM	240 CFM	98 %	0 %	0 %	---
F01VAV1-02	1-01 stat/Self Check 119	Occupied	70.9 °F	72.0 °F	68.0 °F	72.0 °F	61.5 °F	94 CFM	90 CFM	27 %	0 %	0 %	---
F01VAV1-03	1-06 stat/Computer/Printing	Occupied	70.9 °F	72.0 °F	68.0 °F	72.0 °F	60.7 °F	139 CFM	150 CFM	25 %	0 %	0 %	---
F01VAV1-04	1-06 stat/Perimeter 122&123	Occupied	69.3 °F	72.0 °F	68.0 °F	72.0 °F	60.6 °F	280 CFM	270 CFM	25 %	0 %	0 %	---
F01VAV1-05	1-06 stat/Interior 122&123	Occupied	71.1 °F	72.0 °F	68.0 °F	72.0 °F	62.6 °F	162 CFM	195 CFM	18 %	0 %	0 %	---
F01VAV1-06	Interior 122&123	Occupied	72.1 °F	72.0 °F	68.0 °F	72.0 °F	60.5 °F	194 CFM	216 CFM	24 %	0 %	0 %	---
F01VAV1-07	1-08 stat/Workroom 113	Occupied	70.2 °F	72.0 °F	68.0 °F	68.0 °F	60.5 °F	898 CFM	900 CFM	60 %	100 %	0 %	---
F01VAV1-08	Central East	Occupied	69.3 °F	72.0 °F	68.0 °F	68.0 °F	72.7 °F	542 CFM	540 CFM	41 %	0 %	2 %	---
F01VAV1-09	1-10 stat/Workroom 107	Occupied	70.5 °F	72.0 °F	68.0 °F	72.0 °F	62.3 °F	271 CFM	315 CFM	14 %	0 %	0 %	---
F01VAV1-10	Core/Circulation	Occupied	70.7 °F	72.0 °F	68.0 °F	72.0 °F	60.9 °F	302 CFM	300 CFM	29 %	0 %	0 %	---
F01VAV1-11	1-14 stat/Interior 102&104	Occupied	70.2 °F	72.0 °F	68.0 °F	72.0 °F	61.0 °F	266 CFM	270 CFM	26 %	0 %	0 %	---
F01VAV1-12	1-14 stat/Youth Svr 103	Occupied	70.5 °F	72.0 °F	68.0 °F	72.0 °F	61.0 °F	127 CFM	135 CFM	25 %	0 %	0 %	---
F01VAV1-13	1-14 stat/Perimeter 102.104	Occupied	70.2 °F	72.0 °F	63.0 °F	72.0 °F	60.8 °F	519 CFM	540 CFM	31 %	0 %	0 %	---
F01VAV1-14	Child Program 105	Occupied	70.2 °F	72.0 °F	68.0 °F	72.0 °F	70.3 °F	349 CFM	200 CFM	0 %	0 %	0 %	---
F01VAV1-15	Telecom 1st Floor	Occupied	72.1 °F	72.0 °F	68.0 °F	72.0 °F	60.8 °F	89 CFM	90 CFM	36 %	0 %	0 %	---

Figure 12: VAV Table - Example 2

H. VAV Graphic – An individual VAV graphic should include all relevant status and setpoints

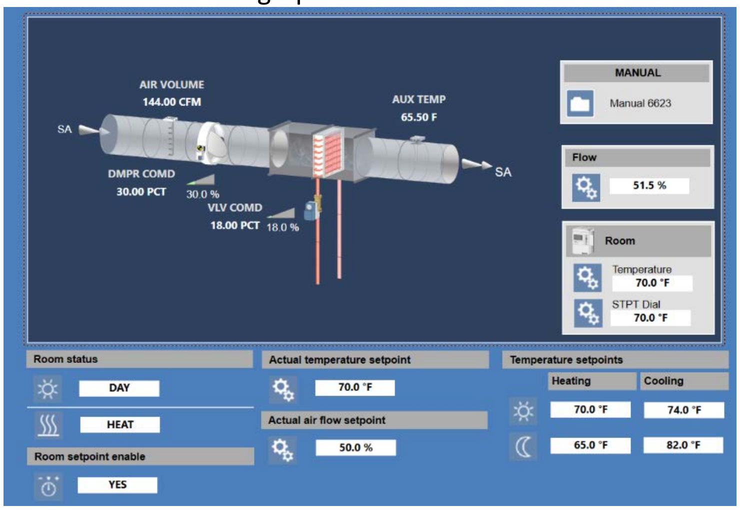


Figure 13: VAV Graphic

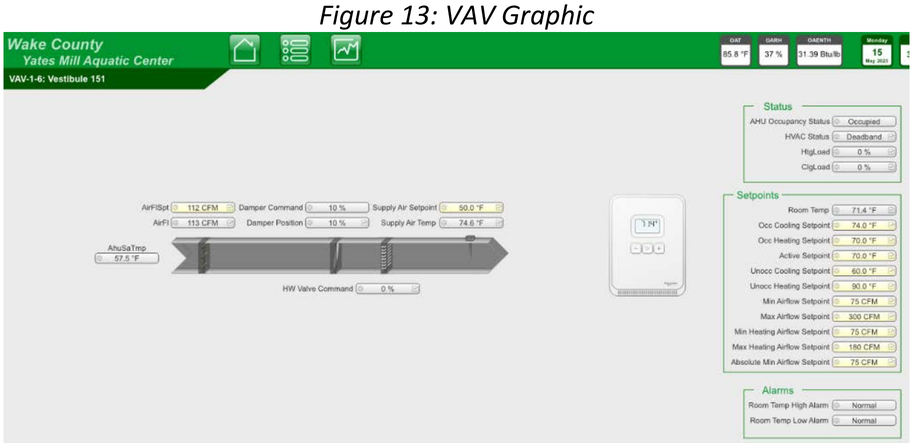


Figure 14: VAV Graphic, Example 2

I. VFD Graphics – A separate graphic should be created for each VFD in addition to the information presented as part of the AHU or system. The separate graphic should show BACnet values to the extent possible.

J. VFD Graphic within in other pages: The VFD on the equipment (AHU/Hot Water Plant/etc) page should show enable, status, alarm, command speed and power.

Figure 15: VFD points in Equipment Graphic

K. Chiller and Boilers plants
   1. Content, top right
      a. System Enable point, lockout temps, VAV call, AHU call, Dehum call should be located in a "System" box.
      b. Beside each Chiller/Boiler: Chiller/Boiler Enable, Status, Temp Setpoint and alarm should be located in a box. BACnet points for the chiller/boiler should be included such as firing rate, current capacity/compressor status.
      c. Temperature resets based on outside air should be indicated in a table.
      d. Flow diagram may not fit on a single Graphic for large or complex Central Plants. If this happens, the condenser water system and the chilled water system shall be broken out into separate Graphics.

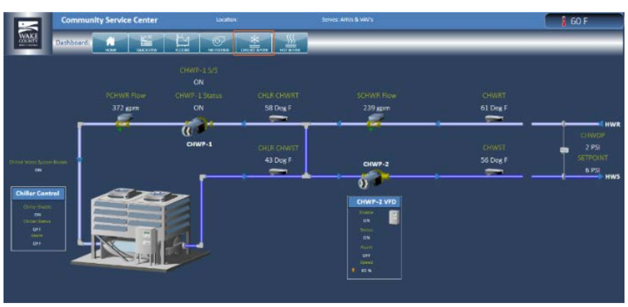


Figure 16: Chiller Plant Graphic, Example 1

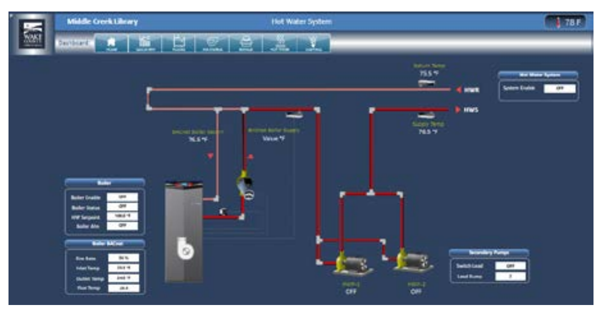


Figure 17: Boiler Plant Graphic, Example 1

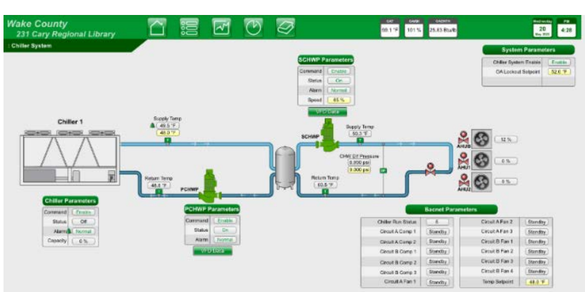


Figure 18: Chiller Plant Graphic, Example 2

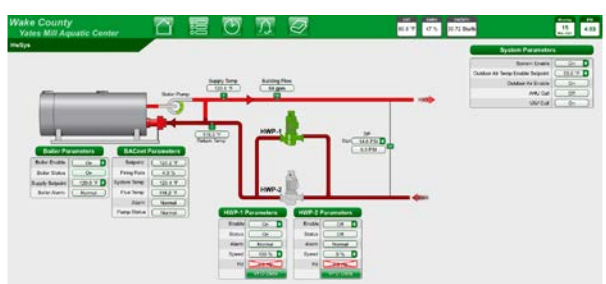


Figure 19: Boiler Plant Graphic, Example 2

L. Temperature Reset: Temperature resets which are dependent on two other variables should be included on the graphic in a table format.

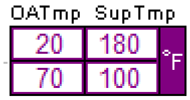
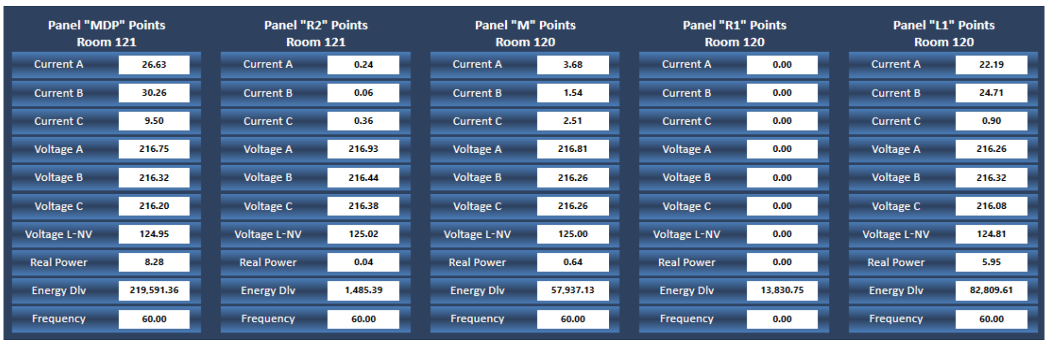


Figure 20: Temperature Reset Table in Plant Graphic - Example

M. Power meters – Pertinent values for each power meter should be displayed in a table. The table should display at minimum phase voltage, total power, and total energy for each channel measured. Where multiple circuits are metered within a building, one-line riser or tree shall display the kW and kWh of each circuit with descriptions of each circuit displayed.



	Panel "MDP" Points Room 121	Panel "R2" Points Room 121	Panel "M" Points Room 120	Panel "R1" Points Room 120	Panel "L1" Points Room 120
Current A	26.63	0.24	3.68	0.00	22.19
Current B	30.26	0.06	1.54	0.00	24.71
Current C	9.50	0.36	2.51	0.00	0.90
Voltage A	216.75	216.93	216.81	0.00	216.26
Voltage B	216.32	216.44	216.26	0.00	216.32
Voltage C	216.20	216.38	216.26	0.00	216.08
Voltage L-NV	124.95	125.02	125.00	0.00	124.81
Real Power	8.28	0.04	0.64	0.00	5.95
Energy Dlv	219,591.36	1,485.39	57,937.13	13,830.75	82,809.61
Frequency	60.00	60.00	60.00	0.00	60.00

*Figure 21: Power Meter Graphic Exam*ple

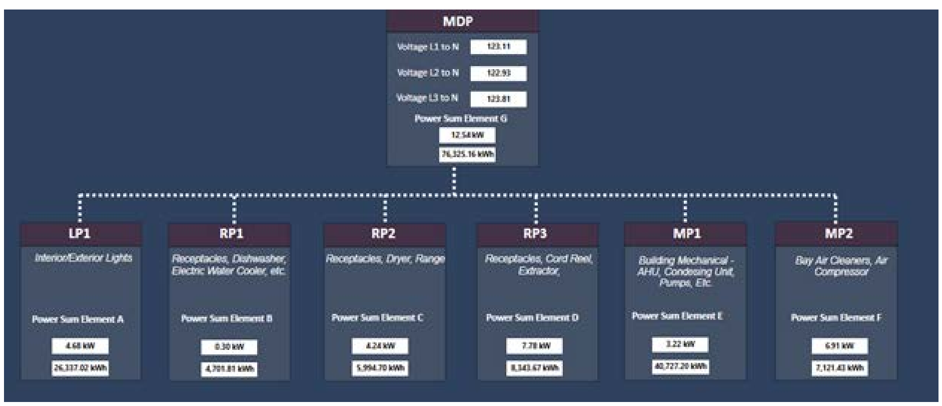


Figure 22: Power Meter - Riser/Tree Example

4.4 Wake County GSA BMS Naming Convention

A. All physical and virtual points as well as equipment should follow the point naming convention. Both name and description should be completed to allow for quick identification of point, location and purpose. Where possible, points should be case sensitive to follow the naming convention.

B. Single Equipment Points

Example:
BACnet Name: 149ERL.01.AHU01.SAFanEnbl
BACnet Description: 149ERL – AHU01 Supply Fan Enable
Where: 149 = Building Number;
ERL = Building Acronym;
01 = Floor Number
AHU = Equipment Type; See Table
01 = Equipment Number
SAFan = Component;
Enbl = Measurement/Control

C. Terminal Box / VAV Points

Examples:
BACnet Name: 149ERL.02.AHU02.TBP15.FanEnbl
BACnet Description:149ERL – Terminal Box 15 – Fan Enable
Where: 149 = Building Number; see key
ERL = Building Acronym; see key
02 = Floor Number
AHU02 = Air Handler Number
TBP = Terminal Box: Parallel
15 = Terminal Box Number
FanEnbl = Measurement/Control (TEC fan control)

BACnet Name: 149ERL.03.AHU01.VAV08.DmprCtl
BACnet Description:149ERL – VAV08 – Damper Control
Where: 149 = Building Number; see key
ERL = Building Acronym; see key
03 = Floor Number
AHU01 = Air Handler Number
VAV = VAV Box
08 = VAV Box Number
DmprCtl = Measurement/Control (TEC Damper control)

D. Building floor level designations for BMS points:

PD	Pod
DM	Dorm
0B	Basement
0G	Ground
0M	Main
1	First
MZ	Mezzanine
2	Second
3	Third
4	Fourth

5	Fifth
6	Sixth
7	Seventh
8	Eighth
9	Ninth
10	Tenth
11	Eleventh and so on

E. Acronyms for Equipment Type

Equipment Type	Equipment Description
AHU	Air Handling Unit
Blr	Boiler
Dmpr	Control Damper
CU	Condensing Unit
Chem	Chemical Feeder
Chlr	Chiller
CT	Cooling Tower
DctHtr	Duct Heater, Electric
FireDoor	Fire Door
Gen	Emergency Generator
Evap	Evaporator Coil
DX	Direct Expansion Cooling Circuit
ExFan	Exhaust Fan
EXH	Exhaust Hood
ExtLgt	Exterior Lighting
IntLgt	Interior Lighting
FACP	Fire Alarm Panel
FCU	Fan Coil Unit
FDmpr	Fire Damper
HP	Heat Pump
HX	Heat Exchanger

Equipment Type	Equipment Description
HVAC	Heating Vent. /Ac System
SumpLvl	Sump Level Sensor
Pmp	Pump
StairFan	Stair Pressurization Fan
PRV	Pressure Reducing Valve
RAFan	Return Air Fan
RTU	Roof Top Unit
SAFan	Supply Air Fan
SmkDmpr	Smoke Damper
SumpPmp	Sump Pump
FPBP	Fan Powered Box / Terminal Box (Parallel)
FPBS	Fan Powered Box / Terminal Box (Series)
Tnk	Tank
ATS	Automatic Transfer Switch
UH	Unit Heater
UPS	Uninterrubtable Power Supply
VAV	Vav Box
VFD	Variable Frequency Drive
PTAC	Wall A/C
WH	Water Heater
Smk	Smoke Detector

F. Acronyms for Components & Measurement/Control

Component Name	Component Description
Econ	Economizer
C02	Carbon Dioxide
CdW	Condenser Water
Chlr	Chiller
ChW	Chilled Water
ChWS	Chilled Water System
Coil	Coil
SA	Supply Air
RA	Return Air
MA	Mixed Air
EA	Exhaust Air
OA	Outside Air
Pht	Preheat
S	Supply (Water)
R	Return (Water)
DX	DX Cooling Stage
CT	Cooling Tower
CoolCoil	Cooling Coil
EOL	End of Line
FrzStat	Freezestat
Flm	Flame
Fltr	Filter
Gas	Natural Gas
Elec	Electric
Heat	Heating
Vib	Vibration
IsoVlv	Isolation Valve
MkUp	Make Up (Water)
HeatCoil	Heating Coil
Hum	Humidity
HW	Hot Water
HWS	Hot Water System
Rht	Reheat
Rm	Room
Spc	Space
Stm	Steam
Smk	Smoke
LPStm	Low Pressure Steam

Measurement/Control	Measurement/Control Description
Cap	Capacity
Tmp	Temperature
SP	Setpoint
TmpSP	Temperature Setpoint
STmp	Supply Temp
RTmp	Return Temp
STmpSP	Supply Temp Setpoint
Enbl	Enable
Stat	Status
Alm	Alarm
Amp	Amps
Flow	Air/Water Flow
RFlow	Return Flow
SFlow	Supply Flow
PosFdBck	Position Feedback
Ctl	Control Signal
OnSP	On Setpoint
Req	System Request/Enable (AHU/Chilled Water System/Hot Water System)
DP	Differential Pressure
Enth	Enthalpy
FireRate	Boiler Flame Control
DewPt	Dew Point
Prs	Pressure
Spd	Speed - Control
SpdFdBck	Speed - Feedback from VFD
Hi	High Speed
Lo	Low Speed
StaticPrs	Static Pressure
StaticPrsSP	Static Pressure Set point
kW	Kilowatts
kWh	Kilowatt Hours

G. Acronyms for Subcomponents

Component Name	Component Description
Vlv	Valve
Byp	Bypass
Pmp	Pump
Dmpr	Damper
Dmd	Demand
Fan	Fan
Dehum	Dehumification Equip-ment/Sequence
EndSwitch	End Switch
Lo	Low
Hi	High
Pre	Pre (before)
Pwr	Power

4.5 Combined Examples of Components, Subcomponents and Measurement/Control

ChWVlv	Chiller Water Valve
ChWRFlow	Chiller Water Return Flow
ChWRTmp	Chilled Water Return Temp
ChWSPump	Chiller Water Supply Pump
ChWSTmp	Chilled Water Supply Temp
ChWSTmpSP	Chiller Water Supply Temp Setpoint
CTBypVlv	Cooling Tower Bypass Valve
CoolCoilTmp	Cooling Coil Temperature
DmprCtl	Damper Control
DmprPosFdBck	Damper Position Feedback
EconDmpr	Economizer Damper
EOLPrs	End of Line Pressure
FltrStat	Filter DP (Clean/Dirty) Status
FltrDP	Filter DP (Measurement)
GasFlow	Natural Gas Flow Rate
CTVibAlm	Cooling Tower Vibration Alarm
PreFltrDP	Pre Filter Differential Pressure
MkUpVlv	Make Up Water Valve
HiLvlAlm	High Level Alarm
SAHiTmpAlm	Supply Air High Temperature Alarm
LPStmVlv	Low Pressure Steam Valve
HiStatPrsAlm	High Static Pressure Alarm
OATmp	Outside Air Temp

A. Controller Device Name

1. Equipment named after primary control purpose. Where multiple systems are served, the controller model can be referenced. BACnet Descriptions must be assigned.

Example:
BACnet Name: 149ERL.01.AHU01
BACnet Description:149ERL – AHU 1 Controller

Where: 149 = Building Number;
ERL = Building Acronym;
01 = Floor Number
AHU = Primary Equipment Served
01 = Equipment Number

Example: Variable Frequency Drive
BACnet Name: 149ERL.01.AHU01.SAFan_VFD
BACnet Description:149ERL – AHU1 Supply Fan VFD

BACnet Name:076ORL.01.ChWS.CdWPmp_VFD
BACnet Description:076ORL – Chilled Water System Cond. Pump VFD

Example: VAV
BACnet Name: 149ERL.01.AHU01.VAV08

Example: Controlling two AHUs
BACnet Name: 149ERL.01.AHU01_AHU02

Example: Controlling Multiple Systems:

Example: Schneider ASP
BACnet Name: 149ERL.01.ASP01

Example: Siemens PXCM
BACnet Name: 149ERL.01.PXCM01

Example: JACE
BACnet Name: 149ERL.01.JACE01

Example: Terminal Box
Equipment Name: 149ERL.02.TBP15

Where: 149 = Building Number; see key
ERL = Building Identifier; see key
02 = Floor Number
TBP = Terminal Box: Parallel
15 = Terminal Box Number

B. Wake County GSA BMS BACnet Instance Naming Convention

1. BACnet Instance Numbers 1 to 4194302 (7 digits)

<u>XXXXXXX – BACnet Instance Number, where:</u>
XXX - Three Digit Building Number
XX - Field Panel Controller (11-99 w/ 00 reserved for the server[1]
XX - Device MAC address (00-99 w/ 00 reserved for the Field Panel Controller)[2]

[1] *Examples include Network Controllers, AHU controller, Chiller Plant Controller, etc.*
[2] *Equipment connected or associated with the controller. Example: VAV controllers, VFDs, Chiller BACnet connection, etc.*

<u>Example</u>: First AHU (or Network Level Controller) in Building 156
Point Name: 1561100

Where: 156 = Three Digit Building Number
11 = Field Panel Controller (11-99 w/ 00 reserved for the server)
00 = Device MAC address (00-99 w/ 00 reserved for the Field Panel Controller)

<u>Example</u>: Second AHU in Building 156
Point Name: 1561200

Where: 156 = Three Digit Building Number
12 = Field Panel Controller (11-99 w/ 00 reserved for the server)
00 = Device MAC address (00-99 w/ 00 reserved for the Field Panel Controller)

<u>Example</u>: First VAV associated with the Second AHU controller in Building 156
Point Name: 1561201

Where: 156 = Three Digit Building Number
12 = Field Panel Controller (11-99 w/ 00 reserved for the server)
01 = Device MAC address (00-99 w/ 00 reserved for the Field Panel Controller)

Wake County – Building Name and Number Submittal

Controls Contractor		GSA
Building Name		
Building Number		

Wake County BACnet Instance Number Submittal

Controls Contractor	
Building Name	
Building Number	

Graphics Contractor

Device Description	Device Model	BACnet Name	BACnet Description	BACnet Instance Number
Example: AHU1 Controller	*PXCM*	*149ERL.01.AHU01*	*149ERL – AHU 1*	*1491100*
Example: VAV1 Served by AHU1	*DXR*	*149ERL.01.AHU01.VAV01*	*149ERL – AHU1 – VAV1*	*1491101*

END OF SECTION 230900

SECTION 230975 – ADJUSTABLE FREQUENCY DRIVE 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 MECHANICAL GENERAL PROVISIONS

A. The Contractor shall conform to the General Conditions.

1.3 WORK INCLUDED

A. Adjustable frequency drive units

1.4 QUALITY ASSURANCE

A. All components to be UL listed or labeled.

B. All wiring to conform to the NEC.

C. All enclosures to be NEMA rated.

D. All drives exposed to weather or wet situations shall be enclosed in a NEMA 3R enclosure.

E. All units shall conform to Part 15 of the FCC regulations on RFI/EMI emissions.

F. The power converter section of every VFD shall be tested with an actual AC induction motor while loaded and temperature cycled within an environment chamber at 40° C (104° F).

G. After installation the manufacturer's representative of the equipment provided in this section shall certify in writing to the Owner's representative that the equipment has been assembled and installed within the guidelines of the manufacturer's written installation instructions and that its performance meets or exceeds the operating characteristics specified and/or scheduled and that its emissions are within the limits set by the aforementioned regulations.

H. A Field Service Engineer is to be provided for start up assistance for the drive and its related motor. Start up assistance shall consist of verifying factory performance standards for the drive and aiding in establishing reference speed points for control of the motor.

I. Provide warranty period for VFDs and any bypass for 36 months minimum, inclusive of parts, travel, labor and shipping required for repair from date of shipment.

1.5 SUBMITTALS

A. Submit complete performance and dimensional data along with construction details and wiring diagrams.

B. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Adjustable Frequency Drive Units:

1. Schneider Electric
2. Square D
3. Danfoss-Graham

2.2 EQUIPMENT REQUIREMENTS

A. The inverters are to be selected for operation with the motors provided for this project. The drive system shall provide an input power factor of 95% throughout the entire speed range. The inverter shall not contribute 5th or 7th harmonic current to the power distribution system or contain the appropriate filter network to limit those harmonics to not more than 5% of the theoretical value.

B. The input power section of the power converter shall utilize a full wave bridge frequency AC line power to fixed DC voltage. This power section shall be insensitive to phase rotation of the AC line. The output power section of the power converter shall change fixed DC voltage to adjustable frequency AC voltage, utilizing insulated gate bipolar transistors (IGBTs).

C. The inverter shall be a 6-pulse width modulating type for maximum reliability and provide inherent short circuit protection. The inverter shall be capable of withstanding an output phase to phase, phase to ground short circuit and inverter semi-conductor short circuit, without causing a failure to the inverter. The drive system shall provide a near unity power factor. It is to provide operation of the fan motors as scheduled. Units shall be mounted in a NEMA 1 or better enclosure, and shall be rated for installation in a plenum environment. The following equipment and features are to be incorporated:

1. Fully range minimum and maximum speed adjustment with ability to automatically select speeds.
2. Adjustable linear acceleration and deceleration, each separately adjustable.
3. Field adjustable or automatic current limit.
4. Inherent short circuit protection.
5. All units shall operate from 4-20 ma signal in automatic mode.
6. Under voltage and over voltage protection.
7. Provide with three bypass line contactors.
8. Over temperature protection.
9. Be rated to provide 100% of rated current, minimum 110% break away current.
10. Inverter is to be rated for an input line voltage variation of +10% and -5%.
11. Inverter is to include a door interlocked disconnect switch or circuit breaker. If integral disconnect is not supplied, the manufacturer shall furnish a separate disconnect with inverter. Manufacturer shall also furnish all step-up/step-down transformers required if inverter and motor are not ground voltage. Current limiting fuses shall be wired to the power converter input, and shall be installed in the combination enclosure.
12. The following are to be included in the inverter cabinet:

a. Filtered ventilation louvers or heat sinks.
b. Door mounted analog or digital speed indicator calibrated 0-100%.
c. Power on light.
d. Fault light.
e. Fault reset button.
f. Manual speed potentiometer for operation in the manual mode.
g. Manual-off-automatic switch.
h. Manually switched bypass circuit to bypass power feed around the inverter.
i. Temperature controlled cooling fan.
j. Manual reset safeties
k. (Min) three auxiliary contacts

D. Unit to include automatic restart circuitry in the event of a power outage, with no more than a 60 second delay after power is reapplied. Unit shall try at least three re-starts before shut-down and alarm.

E. Environmental Ratings

1. The VFD shall be designed to operate in a pollution Degree-2 environment. The VFD shall meet IEC 664-1 and NEMA ICS 1 Standards.
2. The storage temperature range shall be -25° C to 70° C (-13° F to 158° F).
3. The maximum relative humidity shall be 95% at 40° C (104° F), non-condensing.
4. The VFD shall be rated to operate at altitudes less than or equal to 3,300 ft (1000m). For altitudes above 3,300 ft (1,000 m), de-rate the VFD by 1.2% for every 330 ft (100m).
5. The VFD shall meet the IEC 68-2 operational vibration specification.

F. Performance Ratings

1. The VFD shall be designed to operate (±) 10% of rated voltage
2. The VFD shall operate from an input frequency range of 47.5 to 63-Hz.
3. The displacement power factor shall not be less than 0.95 lagging under any speed or load condition.
4. The efficiency of the VFD at 100% speed and load shall not be less than 96%.
5. The variable torque rated VFD over current capacity shall be not less than 110 % for 1-minute.
6. The output carrier frequency of the VFD shall be programmable at 2, 4 or 10-kHz. In addition, the output carrier frequency shall be randomly modulated about the selected frequency. VFDs with an operable carrier frequency above 10-kHz shall not be allowed.
7. Provide with temperature controlled cooling fans.

G. Protection

1. Upon power-up, the VFD shall automatically test for valid operation of memory, loss of analog reference input, loss of communication, DC-to-DC power supply, control power and pre-charge circuit.
2. The VFD shall be UL 508A or 508C listed for the available fault as determined available by the designer, but no less than 22,000-A rms fault current for 460 V drives. For 208-VAC distribution systems, the UL508C listing shall be for 8,800-A rms of minimum

available fault current. The Power Converter shall meet the short circuit specifications defined by NEMA ICS 7.1.09, and have the value listed on the VFD nameplate.

3. The VFD shall be protected against short circuits between output phases and to ground.
4. The VFD shall have a minimum AC under voltage power loss ride-through of 200 milliseconds (12 cycles).
5. The VFD shall have a programmable ride through function which will allow the logic to maintain control for a minimum of one second (60 cycles) without faulting.
6. For a fault condition other than a ground fault, short circuit or internal fault, an auto restart function will provide up to 5 programmable restart attempts. The programmable time delay before restart attempts will range from 1 second to 600 seconds.
7. Upon loss of the analog input speed reference signal, the VFD shall fault and / or operate at a user-defined speed set between programmed low- and high-speed settings.
8. The VFD shall include solid-state protection that is UL listed and that meets UL 508 C as a Class 10 overload protective device and meets IEC 947. The minimum adjustment range shall be from .45 to 1.05% of the current output of the VFD.
9. The output frequency shall be software -controlled to reduce frequency (fold back) when the motor is overloaded.
10. There shall be three skip frequency ranges that can each be programmed to a bandwidth of 2 or 5 Hz. The skip frequencies shall be programmed independently, back to back, or overlapping.
11. For motors 5 hp and larger provide Shaft Grounding Rings, to protect the motors against VFD induced damage such as motor bearing failure.
12. The VFD shall include ‘output phase imbalance’ fault indication.
13. The VFD shall include DC link reactors to minimize power line harmonics and to provide near unity power factor.

H. Adjustments & Configurations

1. The VFD will be factory programmed to operate all specified optional devices.
2. The acceleration and deceleration ramp times shall be adjustable from 1 to 999 seconds.
3. The memory shall retain and record run status and fault type of the past 8 faults.
4. The software shall have a no load function that, when selected, will reduce the voltage to the motor for variable torque loads. A constant volts/Hz ratio will be maintained during acceleration. The output voltage will then automatically adjust to meet the torque requirement of the load.
5. Provide a programmable Automatic Energy Optimization (AEO) selection feature to optimize motor magnetization voltage and minimize energy consumption in variable torque applications. This feature should dynamically and continuously adjust output voltage in response to load, independent of speed.
6. Provide An Automatic Motor Adaptation (AMA) function measuring motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to spin the motor shaft or decouple the motor from the load to accomplish this optimization. Additionally, the parameters for motor resistance and motor reactance shall be user-programmable.

I. Keypad Display Interface

1. The keypad display interface shall enable adjustments to the VFD via a touch keypad. All electrical values, configuration parameters, I/O assignments, application and activity

function access, faults, local control, adjustment storage, self-test and diagnostics shall be in plain English.

2. The display will be a high resolution, LCD back-lit screen capable of displaying graphics such as bar graphs as well as six lines of 21 alphanumeric characters.
3. The VFD model number, torque type, software revision number, horsepower, output current, motor frequency and motor voltage shall be listed on the drive identification portion of the LCD display.
4. The keypad display shall be configured to display one or two bar graphs with numeric data that are programmable by the operator. As a minimum the programmable outputs shall consist of speed reference, output frequency, output current, motor torque, output power, output voltage, line voltage, DC voltage, motor thermal state, drive thermal state, elapsed time, motor speed, machine speed reference and machine speed.
5. The keypad display shall consist of programmable function keys that allow both operating commands and programming options to be preset by the operator. A hardware selector switch shall allow the terminal keypad to be locked out from unauthorized personnel.
6. A RUN key and a STOP key will command a normal starting and stopping as programmed when the VFD is in keypad control mode. The STOP key must be active in all control modes.
7. The VFD shall have three LEDs mounted on the front panel to indicate functional status. A green LED will verify that the VFD power supply is on. A red LED indicator will indicate an VFD fault. A yellow LED indicator will designate a pending fault condition.

J. Operator Control Interface

1. The control power for the digital inputs and outputs shall be 24 VDC.
2. The internal power supply shall incorporate automatic current fold-back that protects the internal power supply if incorrectly connected or shorted. The transistor logic outputs will be current limited and will not be damaged if shorted.
3. Pull-apart terminal strips shall be used on all logic and analog signal connections in the power converter.
4. Input requirements; four isolated digital logic inputs and two isolated analog inputs (one 0 - 10VDC speed potentiometer and one 4-20mA speed reference).
5. Output requirements; two digital logic outputs, two voltage-free relay output contacts (fault status and a programmable drive run), and two isolated 4 – 20 mA analog outputs that can be selected and assigned in the software (and be proportional to the following motor characteristics: frequency, current, power torque, voltage and thermal state).
6. The combination enclosure shall have the following dedicated operator controls:
   a. Hand-Off-Auto switch
   b. Manual Speed Potentiometer
   c. VFD-Off-Bypass switch
7. The hands-off-auto function which provides seamless transfer from EMCS control to hand control and back, without interruption of motor speed on transfer. The optional 120 VAC smoke purge relay shall be installed in the combination enclosure, and shall enable the VFD to be sequenced in accordance with local fire protection codes. A user-supplied 120 VAC signal will switch the VFD to 60 Hz operation for maximum fan motor

speed. If drive bypass is supplied, the smoke purge relay will isolate the VFD and run the fan motor full speed on bypass

8. The combination enclosure shall also include terminal point connection for fire /freeze stat interlock, to prevent drive or bypass (if supplied) operation.
9. VFDS shall be furnished with a LonTalk compatible FTT-10A compatible transceiver Drive / Bypass Contractors
10. VFS with bypass mode shall a drive disconnect, a two contactor bypass for full speed operation, and isolation barriers between the VFD and bypass. Specify VFD’s with bypass when installed on fan motors.
11. The combination enclosure shall include a pair of IEC rated bypass contactors (complete with thermal overload relays) to isolate the VFD output during the bypass mode and to coincidentally provide line power directly to the motor. It shall also include fuses on the line side of the VFD to enable isolation, a circuit breaker disconnect, control circuit transformer, motor flux decay timer and VFD/OFF/BYPASS switch. The operator shall have full control of the bypass contactors by operation of the combination enclosure mounted selector switch.
12. Disconnects shall be capable of being pad-locked in the “off” position.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's written installation instructions.

B. Install line filters where required by manufacturer’s recommendations.

C. Cabling from the drive to the motor shall consist of three (3) stranded copper TC circuit conductors with XLPE insulation. Shielding shall be provided consisting of two spiral copper tape shields (100% coverage). Provide with three (3) full size bare copper grounds.

D. The contractor shall assume the responsibility for coordinating the purchased equipment with the motor served and with the automatic temperature control system, paying specific attention to the signal sent and received the ground source and the required speed range.

E. Start-up shall be by a factory trained field service engineer representing the manufacturer of the equipment purchased. Start-up shall be done in the presence of the controls contractor and the engineer.

F. Training: A one-day on-site training course shall be provided by a representative of the VFD manufacturer to plant and/or maintenance personnel.

G. Documentation: The VFD manufacturer shall supply a comprehensive 8-1/2" x 11" spiral bound instruction-installation manual that includes wiring diagrams and layout.

END OF SECTION 230975

SECTION 230993 SEQUENCE OF OPERATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General
B. Air Handling Units
C. Terminal Units
D. Chilled Water Systems
E. Exhaust Fans
F. Lighting controls

1.02 RELATED DOCUMENTS:

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

B. Section 230500 COMMON WORK RESULTS FOR HVAC

C. Section 230900 - Building Automation System (BAS) General

1.03 SYSTEM DESCRIPTION

A. The systems to be controlled under work of this section basically comprise of the reinstallation and control of two central station variable speed air handlers serving 32 pinch-down VAV boxes with reheat coils. The system will integrate into an existing BAS installed recently to manage the Hot Water System and Boilers. The scope of this project also includes the control of a new variable speed primary chilled water system.

B. This Section defines the manner and method by which controls function.

1.04 SUBMITTALS

A. Refer to Section 230900 and Division 1 for requirements for control shop drawings, product data, Users Manual, etc.

B. Programming Manual: Provide DDC system programming manual as well as documentation of site-specific programming prior to the start of construction.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 GENERAL

A. Sequences specified herein indicate the functional intent of the systems operation and may not fully detail every aspect of the programming that may be required to obtain the indicated operation. Contractor shall provide all programming necessary to obtain the sequences/system operation indicated.

B. Except as specified otherwise, throttling ranges, proportional bands, and cycle differentials shall be centered on the associated setpoint. All modulating feedback control loops shall include the capability of having proportional, integral, and derivative action. Unless the loop is specified “proportional only” or “P+I”, Contractor shall apply appropriate elements of integral and derivative gain to each control loop which shall result in stable operation, minimum settling time, and shall maintain the primary variable within the specified maximum allowable variance.

C. Provide a real time clock and schedule controller with sufficient scheduling capability to schedule all required controllers and sequences. Set up initial schedules in coordination with Wake County.

D. Wherever a value is indicated as adjustable (adj.), it shall be modifiable, with the proper password level, from the Operator interface. For these points, it is unacceptable to have to modify programming statements to change the setpoint.

E. Where “prove operation” of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS shall, after an adjustable time delay after the device is commanded to operate (feedback delay) , confirm that the device is operational via the status input. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (debounce delay) while the device is commanded to run, an alarm shall be enunciated audibly. Upon failure, run command shall be removed and the device shall be locked out until the alarm is manually acknowledged unless specified otherwise.

F. BAS shall provide for adjustable maximum rates of change for increasing and decreasing output from the following analog output points:

1. Speed control of variable speed drives
2. Control Reset Loop
3. Valve Travel Limit

G. Wherever a value is indicated to be dependent on another value (i.e.: setpoint plus 5°F) BAS shall use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points shall be provided. One to store the parameter (5°F), one to store the setpoint, and one to store the value which is the result of the equation.

H. VFD Interface: BAS shall monitor the VFD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system’s graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

I. All actuators for valves and dampers should be scaled within the controller to operate 0% = closed and 100% = open.

J. All programming timers should be assigned variables for real-time troubleshooting.

K. Programming should include adequate comments in order to understand which sections of code perform specific functions.

L. AHU shall be programming with a separate “AHU Enable” and “Occupancy Mode” points. AHU Enable points shall shut the AHU down without the possibility of operation except life safety operation.

M. AHU controller should send occupancy points to VAV controllers. AHU should receive schedule command. While in unoccupied mode, AHU should either poll VAV boxes or receive call from VAV boxes to start and maintain setpoints.

3.02 SINGLE DUCT VAV AHU WITH PRE-HEAT & CHILLED WATER COILS, RETURN FAN

A. AHU Enable: AHU shall have an “AHU Enable” point

1. When the system enable point is on, the AHU shall be able to operate in any of the occupancy modes.
2. When the system enable point if off, all fans will be off, OA dampers shall close, and return air dampers shall open. Cooling coil valves should be closed. Heating coil shall be controlling.

B. Scheduled Occupancy: BAS shall determine the occupancy modes (occupied, unoccupied, preoccupancy, and setback) as defined. The following details the common control aspects related to the scheduled occupancy. The BAS shall display the applicable mode on the AHU graphics Reference the BAS control specifications (graphics) for more information on how this should be displayed.

a. Occupied Period: [Determined by Schedule] BAS shall energize the AHU during all occupied periods. Minimum OA flow set-point shall be as scheduled on the drawings. Occupied space setpoints shall apply for the connected terminal units.
b. Unoccupied Period: [Determined by Schedule] BAS shall deenergize the unit. OA damper position shall be 0% and OA flow setpoint shall be 0 CFM. If during the unoccupied period if there is a request for occupancy override, the occupancy mode shall become active for an adjustable period. Unoccupied space setpoints shall apply for the connected terminal units.
c. Setback Period (Night Heating / Night Cooling): [Determined by Temperatures in Unoccupied] During unoccupied period, the BAS shall deenergize the unit except as required to maintain a setback tempera-

ture. The AHU controller shall poll the temperature of associated VAVs every 5 minutes to determine: If [10%] of the VAV boxes are above the Cooling Setback Setpoint plus half Setback Deadband, or are below the Heating Setback Setpoint minus half Setback Deadband, the AHU shall be energized until all VAV boxes meet the temperature setpoints associated plus/minus half of the setback deadband (Setback Deadband shall be assigned a value of 3°F initially). Variables should be setup for "Boxes above Cooling Setback", "Boxes below Heating Setback", "Average VAV space temp", and "Min VAV space temp", "Max VAV space temp." If during the setback period if there is a request for occupancy override, the occupancy mode shall be-come active for 2 hr (adj).

d. Preoccupancy (Morning Warm Up / Cool Down): BAS shall energize the AHU continuously during the preoccupancy period. OA flow setpoint shall be 0 CFM. Occupied space setpoints shall apply for the connected terminal units.

C. Supply Fan: BAS shall control the starting and stopping of the supply fan as follows:

1. Start/Stop: BAS shall command the operation of the supply fan and it shall run continuously whenever the AHU is "energized" as specified in the occupancy modes.
2. Proof: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. VFD Control: Whenever the fan is energized, BAS shall control the speed of the VFD to maintain the supply duct static pressure setpoint. On start and stop, the VFD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. [Optional] Supply Air Static Pressure Setpoint (Reset Control): Reset duct static pressure set point(s) higher or lower between maximum and minimum set points based on BAS optimization logic that uses the terminal unit air damper positions.

   a. When the AHU is first energized, the initial static pressure setpoint shall be [1.25"]. The final setpoints shall be recommended by the TAB Contractor and approved by the Engineer.
   b. Setpoint shall be reset between the limits of [0.5"] (adj) to [2"] (adj). The final setpoints shall be recommended by the TAB Contractor and approved by the Engineer.
   c. BAS shall utilize a Sample and Bump output strategy or other similar loop output or logic to reset the static setpoint. The set point(s) shall be increased/decreased to maintain all terminal damper positions between 90% (adj.) and 95% (adj.). The set points(s) shall be adjusted every 10 minutes (adj.) by a 0.05 "WC (adj.) increment/decrement.

5. VFD Interface: BAS shall monitor the VFD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic

that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

6. Freeze Safety: The freezestat shall be manual reset. Upon a signal from the freezestat, the supply air fan shall stop.
7. VFD Interface: BAS shall monitor the VFD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
8. Freeze Safety: The freezestat shall be manual reset. Upon a signal from the freezestat, the return air fan shall stop.

D. Outside Air Damper, Single Damper:

1. When AHU is in Unoccupied or Setback modes the outside air dampers position shall be commanded closed. The outside air flow setpoint shall be set to (and display) 0 CFM.
2. When AHU is in Occupied or Preoccupancy modes the outside air damper position shall be controlled to meet an airflow setpoint unless economizer is available.

    a. Preoccupancy: OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
    b. Occupied: OA flow setpoint will be determined by demand control ventilation logic unless economizer is available or the preheat temperature low limits are reached.

        1) Demand Control Ventilation: The OA flow setpoint shall be set to "Minimum OA flow setpoint" and "Reduced minimum OA flow setpoint" based on RA CO2 reading.

            a) When the RA CO2 sensor value is below the RA CO2 low setpoint (600 ppm-adj.) for 30 min. (adj), the OA flow setpoint shall be set to the "Reduced Minimum OA flow setpoint".
            b) When the RA CO2 sensor value is above the RA CO2 high setpoint (1000 ppm-adj.) for 15 min. (adj.), the OA flow setpoint shall be set to the "Minimum OA flow setpoint."
            c) The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer, damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced mini-

mum damper position setpoints are adequate to maintain building pressure slightly positive at all times.

c. Airside Economizer: When economizer is enabled, it shall have priority over the damper position and CO2 control shall not be active. Economizer mode shall remain typical as a PI or PID Loop and be controlled as follows:

1) Economizer mode shall be enabled while:

a) The unit is energized, and supply air fan status has been proven for at least 15 seconds (adj.).
b) AND, when outside air temperature falls below 60°F (adj.) for 15 minutes
c) AND, when outside air temperatures are above 45°F (adj.)
d) AND, when outside air enthalpy is less than 26 BTU/lb

2) Economizer mode shall be disabled when:

a) when outside air temperature rises above 60°F for 15 minutes
b) OR, when outside air temperatures are below 45°F (adj.)
c) OR, when outside air enthalpy is greater than 27 BTU/lb

3) Economizer shall modulate the outside damper shall modulate per the higher of

a) A direct acting PID loop maintaining the mixed air temperature setpoint. The mixed air setpoint shall be equal to the discharge air temperature setpoint (specified herein) minus 3°F (adj.)
b) Minimum outside air flow using the Reduced Minimum OA flow setpoint.

d. Preheat Air Low Limit: BAS shall override the signal to the OA damper via a proportional only loop to maintain a minimum preheat temperature. The maximum allowed output of the OA dampers shall drop from 100% to 0% as the preheat air temperature drops from 47°F to 42°F (all values being adjustable).

3. Freeze Safety: Upon a signal from the freezestat, the OA dampers will close.

E. Outside Air Dampers (Economizer Damper and Minimum OA Damper):

1. Economizer Damper:

a. When AHU is in Unoccupied or Setback modes Minimum OA damper position shall be commanded closed. The minimum outside air flow set-point shall be set to (and display) 0 CFM.

b. When AHU is in Occupied or Preoccupancy modes the Economizer damper position shall be controlled to meet a mixed air temperature setpoint as follows:

1) Airside Economizer: Economizer mode shall remain typical as a PI or PID Loop and be controlled as follows:

a) Economizer mode shall be enabled while:

(1) The unit is energized, and supply air fan status has been proven for at least 15 seconds (adj.).

(2) AND, when outside air temperature falls below 60°F (adj.) for 15 minutes

(3) AND, when outside air temperatures are above 45°F (adj.)

(4) AND, when outside air enthalpy is less than 26 BTU/lb

b) Economizer mode shall be disabled when:

(1) when outside air temperature rises above 60°F for 15 minutes

(2) OR, when outside air temperatures are below 45°F (adj.)

(3) OR, when outside air enthalpy is greater than 27 BTU/lb

c) Economizer damper shall modulate per a direct acting PID loop maintaining the mixed air temperature set-point. The mixed air setpoint shall be equal to the dis-charge air temperature setpoint (specified herein) mi-nus 3°F (adj.)

2. Minimum OA Damper:

a. When AHU is in Unoccupied or Setback modes Minimum OA damper position shall be commanded closed. The minimum outside air flow set-point shall be set to (and display) 0 CFM.

b. When AHU is in Occupied or Preoccupancy modes the minimum OA damper position shall be controlled to meet an airflow setpoint unless economizer is available.

1) Preoccupancy: OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.

2) Occupied: OA flow setpoint will be determined by demand control ventilation logic unless economizer is available or the preheat temperature low limits are reached.

a) Demand Control Ventilation: The OA flow setpoint shall be set to "Minimum OA flow setpoint" and "Reduced minimum OA flow setpoint" based on RA CO2 reading.

(1) When the RA CO2 sensor value is below the RA CO2 low setpoint (600 ppm-adj.) for 30 min. (adj), the OA flow setpoint shall be set to the "Reduced Minimum OA flow setpoint".

(2) When the RA CO2 sensor value is above the RA CO2 high setpoint (1000 ppm-adj.) for 15 min. (adj.), the OA flow setpoint shall be set to the "Minimum OA flow setpoint."

(3) The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer, damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced minimum damper position setpoints are adequate to maintain building pressure slightly positive at all times.

b) Economizer: When economizer is enabled, the Minimum OA damper shall modulate per the higher of

(1) Economizer Damper Control position

(2) Minimum outside air flow using the Reduced Minimum OA flow setpoint.

c) Preheat Air Low Limit: BAS shall override the signal to the OA damper via a proportional only loop to maintain a minimum preheat temperature. The maximum allowed output of the OA dampers shall drop from 100% to 0% as the preheat air temperature drops from 47°F to 42°F (all values being adjustable).

3. Freeze Safety: Upon a signal from the freezestat, the OA dampers will close.

F. Return Air Damper: BAS shall modulate the Return damper inversely proportional to the Outside Air damper

G. Discharge Temperature: The discharge temperature setpoint shall be set to the lower of the following:

1. The BAS shall utilize one of the two following methods of reset:

   a. Outside air temperature reset: The upper and lower limits of this reset setpoint shall be 62°F and 55ºF (both adjustable), respectively. Based on outside air temperature, the discharge air setpoint shall be linearly reset to the indicated values (all adjustable).

Outside Air Temperature	Discharge Air Temperature
50 F	62 F
70 F	55 F

   b. BAS shall utilize a Sample and Bump output strategy or other similar loop output or logic to reset the discharge air temp setpoint. The upper and lower limits of this reset setpoint shall be 62°F and 55ºF (both adjustable), respectively. The initial setpoint shall be 55 F. The set point(s) shall be increased/decreased to maintain the average terminal box cooling demand loop to between 80 [adj] and 90 [adj]. The set points(s) shall be adjusted every 10 minutes [adj] at a 0.1 °F [adj] increment. This feature shall be able to be enabled/disabled with a GUI toggle.

2. A dehumidification loop shall be a Proportional only loop output reset from 62 °F to 55°F (adj.) as the return air humidity rises from 55% to 65% (both adjustable).

Return Air Humidity	Discharge Air Temperature
55% RH	62 F
65% RH	55 F

3. The resultant temperature output after passing through the two loops (as described above) shall be the effective discharge temperature setpoint. Both loop outputs shall be assigned to a point. Discharge temp setpoint value shall be trended, alarmed (vs actual temperature) and shown on the BAS graphic

H. Preheating Section:

1. HW Heating Valve: Valve shall modulate per the higher of

   a. a PID loop to maintain a leaving coil temperature at 52ºF (adj.), and
   b. a proportional only loop that is reset from 0 to 100% as the preheat air temperature drops from 48°F (adj.) to 40°F (adj.).

   Heating Loops shall remain active even when the AHU is not enabled.

2. Freeze Condition: The freezestat shall be manual reset. Upon a signal from the freezestat, the HW valve shall be commanded to 100% open (adj.)

I. Cooling Section:

1. Cooling Coil Valve: Whenever the AHU is energized and status is proven ON, N.C. cooling coil valve shall modulate via a direct acting PID loop to maintain discharge temperature at setpoint.
2. During setback or morning warm-up modes, the ChW valve shall remain closed.
3. Whenever the unit is energized and the economizer mode is active, the chilled water valve shall remain closed unless the economizer dampers have been commanded to full open.
4. Freeze Condition: The freezestat shall be manual reset. Upon a signal from the freezestat the ChW valve shall be commanded to 100% open (adj.)

J. Occupancy Override: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 120 min. (adj.)

K. Freeze Safety: The freezestat shall be manual reset. Upon a signal from the freezestat, the supply air and return air fans shall stop, the OA & EA dampers will close, the RA damper will open and the heating water and chilled water control valves at the air handling unit shall open fully.

L. Smoke/Fire Safety: Upon indication of smoke or fire by the Fire Alarm system (via a relay provided by the FAS contractor), the BAS shall deenergize the AH via a hard wired interlock. All dampers shall revert to their normal “Off” positions unless specifically indicated otherwise. The BAS shall enunciate the appropriate alarm; then remove and lock out the unit start command until the alarm condition is cleared.

M. High or Low Pressure Safety: Upon activation of a high or low pressure safety switch, AH shall be deenergized via a hard wired interlock and an indication of the operation shall be indicated at the BAS. The BAS shall enunciate the appropriate alarm; then remove and lock out the unit start command until the alarm condition is cleared.

3.03 SINGLE DUCT VAV BOX WITH REHEAT CONTROL

A. General: Control shall be pressure independent with minimum, maximum and heating maximum flow setpoints, scheduled occupancy with optimum preoccupancy.

B. Space Temperature Control: Four setpoints shall apply. Normal Heating (70°F adj.)), Normal Cooling (74°F adj.)), Setback Heating (68°F (adj.)), and setback cooling (78°F). These three values shall be the only values changed by the operator to adjust space temperature setpoint. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input).

C. Zone Damper: Zone damper shall modulate in a PI loop to maintain zone volume setpoint.

1. Cooling: The zone volume setpoint shall be reset between the minimum and the cooling maximum volume settings to maintain the space temperature at the cooling space temperature setpoint via a PID loop output. The zone volume setpoint shall be reset linearly between the minimum and cooling maximum volume setpoints as the loop output increases from 0 to 100%.
2. Heating: The zone volume setpoint shall be reset between the minimum and the heating maximum volume settings to maintain the space temperature at the heating space temperature setpoint via a PID loop output. Note that a common space heating PID loop output will be used to reset the zone volume setpoint (in the heating mode) and the HW reheat valve (see below). The zone volume setpoint shall be reset linearly between the minimum and heating maximum volume setpoints as the loop output increases from 25 to 100% (adj.).
3. Dead band: When the space temperature is between the effective space temperature heating and cooling setpoints (heating and cooling PID outputs are both at 0%), the zone volume setpoint shall remain at the minimum flow setpoint.
4. Zone Volume flow setpoints shall be as scheduled on the drawings.

D. Hydronic Reheat: Zone reheat coil valve shall modulate in a PID loop output (same loop output that resets the volume setpoint in the heating mode) to maintain the space temperature at the heating setpoint as defined above. The valve shall modulate from 0 to 100% on a PID loop output of 0-75% (adj.). The valve shall be closed whenever ALL the parent air units is off.

E. Reports:

1. Configure a tabular report using real-time data with the following column headings: VAV TERMINAL DESCRIPTION, ZONE TEMPERATURE, ZONE TEMPERATURE SETPOINT, PRIMARY AIR FLOW, PRIMARY AIR FLOW SETPOINT, DAMPER POSITION (0 to 100% open), REHEAT OUTPUT (0 to 100% heating), DISCHARGE AIR TEMPERATURE.
2. At the top of the table, list building number, floor or area description if applicable, parent air handling unit designation, air handling unit downduct static pressure and air handler discharge air temperature.
3. Reference the requirements for summary service screens in the Controls (graphics section) specification for additional information.

3.04 AIR COOLED CHILLER WITH VARIABLE PRIMARY PUMP

A. General: BAS shall fully control the chilled water systems and equipment and provide monitoring and diagnostic information for management purposes. BAS shall interface directly with the chiller and all available points shall be monitored and displayed via the operator interface. Refer to the control diagram for additional information.

1. Chilled Water System Enable: Cooling shall be enabled when

a. Any chilled water valve opens more than 20% continuously for 5 min. (adj.)
b. AND, the outside air temperature is above 60°F (adj.).

Once enabled, the chilled water system will operate for a minimum of 30 minutes. The chilled water system shall also be enabled whenever manually enabled by the operator at the operator interface.

2. Chilled Water System Disable: Cooling shall be disabled when all chilled water valves are less than 5% open continuously for 10 min. (adj.) or the outside air temperature is below 60°F. The chilled water system shall also be disabled whenever manually disabled by the operator at the operator interface.

B. Primary CHW Pump

1. The primary pump shall be started via an output from the internal chiller controls whenever the associated chiller is enabled.
2. BAS shall monitor the pump status.
3. VFD Control: Whenever a pump is energized the BAS shall control the speed of the VFD to maintain the a 12 deg temperature differential between chilled water supply and chilled water return temperatures.

C. Chiller Control

1. Enable/Disable: Whenever the Chilled Water System is enabled, AND Either Secondary pump is proven the Chiller shall be enabled after a 1 minute delay (adj.).
2. Proof/ Failure assessment: Whenever the chiller is in alarm, the BAS shall enunciate an alarm. BAS shall assess the chiller to be in alarm if:

a. chiller status is not proven ON in the first 10 minutes after the chiller is initially enabled.
b. OR, any time the chiller alarm point is ON.

3. Chilled Water Supply Temperature Reset

a. The chiller water supply temperature setpoint via an analog output from the building automation system to boiler.
b. The reset shall be as follows:

Outside Air Temperature	Chilled Water Supply Temperature
60 F	55 F
75 F	44 F
Dehum Mode	44 F

3.05 EXHAUST FANS

A. Restroom exhaust fans:

1. Enable/Disable: Exhaust fans should be set up on the AHU schedule and shall be enabled while the building is occupied and disabled when the building is unoccupied, in setback or in preoccupancy.

3.06 LIGHTING SEQUENCE OF OPERATION

A. Interior

1. The interior lights will be set up on a separate schedule.
2. Unless otherwise specified, the schedule will be set up for 2 hours before and 2 hours after scheduled public hours. Confirm schedule with County.

B. Exterior

1. The exterior lights (those that are attached to the building – ie: sconce-type located above entranceways) will be energized at sundown.
2. The lights will be de-energized at sunrise.

END OF SECTION 230993

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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 piping
2. Chilled water piping
3. Condenser water piping

B. See Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Hot Water Piping: 250 psig at 200 deg F.
2. Chilled Water Piping: 250 psig at 100 deg F.
3. Condenser Water Piping: 250 psig at 180 deg F.

1.4 SUBMITTALS

A. Product Data: For each type of the following:

1. Pressure-seal fittings.
2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
3. Air control devices.
4. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 (1:50) 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. Field quality-control test reports.

D. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. 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 1.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).

B. 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. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

C. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

D. Slip-On flanges are not permitted.

E. All piping shall comply with ASTM A105.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless 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: ASTM A307A bolts or studs only.

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. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

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

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

H. Dielectric Unions:

1. Not Permitted; use Dielectric nipples or bronze ball valve to connect dissimilar metals.

I. Dielectric Couplings:

1. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.4 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:

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. 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.
   g. Tour & Andersson; available through Victaulic Company of America

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig (860 kPa).

10. Maximum Operating Temperature: 250 deg F (121 deg C).

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing 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. 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: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig (860 kPa).
11. Maximum Operating Temperature: 250 deg F (121 deg C).

2.5 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:

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

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

C. Manual Air Vents:

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

D. Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. (379-L) unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig (860-kPa) working pressure and 250 deg F (121 deg C) maximum operating temperature.
3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig (860-kPa) working pressure and 240 deg F (116 deg C) maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.

E. In-Line Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig (1207 kPa).
3. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

F. Hydraulic and Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig (1207 kPa).
3. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

2.6 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

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 (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; Class 250, malleable-iron fittings; malleable-iron flanges and flange fittings; and threaded joints.

B. Chilled-water piping, aboveground, NPS 2-1/2 and larger shall be the following:

1. Schedule 40 steel pipe; Class 250, malleable-iron fittings; malleable-iron flanges and flange fittings; and threaded joints.

C. Hot-water piping, aboveground, NPS 1 (DN 50) and smaller, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; Class 250, malleable-iron fittings; malleable-iron flanges and flange fittings; and threaded joints.

D. Hot-water piping, aboveground, NPS 1 to NPS 2, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe; Class 250, malleable-iron fittings; malleable-iron flanges and flange fittings and threaded joints.

E. Hot-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be the following:

1. Schedule 40 steel pipe; Class 250, malleable-iron fittings; malleable-iron flanges and flange fittings.

3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating terminal as indicated.

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.

G. Brazed fittings for copper pipes.

3.3 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. Use ASTM A307 A Bolds and nuts.

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

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

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

L. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

M. Install drains, consisting of a tee fitting or thread-o-let, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage. Piping nipple shall be long enough to clear insulation.

N. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

O. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

P. 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.

Q. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."

R. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

S. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

T. 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 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

V. Arrange piping to minimize the occurrences of dielectric connections.

3.4 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. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.5 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. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

D. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches (1200 mm) above the floor. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 (DN 20) pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

E. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.8 CHEMICAL TREATMENT

A. 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.

B. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.9 FLUSHING & CLEANING PIPING SYSTEMS GENERAL

A. All water used during the hydrostatic pressure tests, cleaning, flushing and filling of piping systems shall be provided by the contractor and included in the project cost unless specifically agreed upon by the Director of Utilities and Engineering Services. This water is to be metered from project beginning until the piping system is cleared to be connected to the campus utility systems and/or at project close-out

B. Flush all water systems thoroughly for a minimum of 1 hour or longer, as required, to ensure removal of all dirt and foreign matter from piping system. Flushing shall continue until water draining from the pipe is clear and clean of any dirt and debris as determined by the Engineer or Owner. Bypass all pumps and equipment and remove all strainers from strainer bodies. Provide circulation by Contractor supplied pumping apparatus

C. Contractor shall be responsible for phasing and scheduling piping installation work such that all sections of the new piping will be cleaned and flushed as specified. Contractor shall provide temporary access tapping at all high points and low points through valves, tees, flanges, etc. to facilitate the cleaning and flushing process.

D. Contractor shall provide all water for flushing.

E. Contractor shall provide all temporary piping from water source to piping system and shall provide means for conducting testing and cleaning water from underground piping system to the appropriate sewer; i.e. pumps, piping, hoses, etc. Contractor to remove all temporary piping, pumps, hoses, etc. from the site after flushing has been completed.

F. Provide temporary piping or hose to bypass coils, control valves, heat exchangers, other factory cleaned equipment, and any component which may be damaged, unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place.

G. Sectionalize system to obtain minimum velocity of 6 fps. Provide temporary piping to connect dead-end supply and return headers as necessary. Flush bottom of risers.

H. Add chemical inhibitor Nalco 8338 or equivalent to closed loop water systems. (see below)

I. Contractor shall be responsible for filling and treating water for final fill.

3.10 FLUSHING & CLEANING PIPING SYSTEMS FINAL

A. Flush all water thoroughly for a minimum of 1 hour or longer, as required, to ensure removal of all dirt and foreign matter from piping system. Flushing shall continue until water draining from the pipe is clear and clean of any dirt and debris as determined by the Engineer or Owner. Bypass all pumps and equipment and remove all strainers from strainer bodies. Provide circulation by Contractor supplied pumping apparatus.

B. After initial flushing of system discussed in paragraph A above, use portable pumping apparatus for continuous 24 hour minimum circulation of cold water detergent similar to Nalco 2567 cleaner. Flush detergent clear with continuous draining and raw water fill for additional 12 to 24 hours or until all cleaner is removed from system and conductivity, pH, and iron concentrations are within guidelines. Replace strainers and reconnect permanent pumping apparatus and all apparatus bypassed.

3.11 WATER ANALYSIS REQUIREMENTS

A. Specific numbers will be determined at the time of construction as city water and system values can vary from location to location within the project site.

B. Hot Water Piping:

1. Conductivity: Approximate existing system conditions
2. pH: Approximate existing system conditions
3. Target inhibitor PPM level: Approximate existing system conditions
4. Iron concentration: Approximate existing City of Raleigh water conditions

3.12 SYSTEM PRESSURE AND LEAK TEST

A. Length of test, unless otherwise approved, shall be a minimum of 4 hours. Contractor shall have conducted a preliminary pressure test prior to final acceptance test to locate and correct any pipe leaks.

B. Water piping shall be leakage rate tested. Leakage rate test shall be conducted at the same time as the hydrostatic pressure test. Leakage rate is defined as the quantity of water that must be supplied into respective underground piping system to maintain pressure within 5 psig of the specified hydrostatic test pressure after system has been vented and filled. Contractor shall document test results and sign/date each test.

C. The maximum allowable leakage is determined by the following formula

1. L= N*D*(P) 2 /1 / 7,400

   where:
   L = allowable leakage (GPH)
   N = number of joints in length of pipe line tested
   D = nominal pipe diameter (inches)
   P = average test pressure during leakage test (psig)

2. If measure leakage rate exceeds maximum leakage rate, repair with new materials and repeat test until satisfactory results have been obtained

3.13 FIELD QUALITY CONTROL

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

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 16 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

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

END OF SECTION 232113

SECTION 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:

1. Separately coupled, base-mounted, end-suction centrifugal pumps.
2. Separately coupled, base-mounted, double-suction centrifugal pumps.
3. Closed-Coupled inline 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.

1. Wiring Diagrams: Power, signal, and control wiring.

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.

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 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: Two sets of mechanical seals for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers:

1. Bell & Gossett; Div. of ITT Industries.
2. Patterson
3. Taco, Inc.

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 250-psig (1720-kPa) minimum working pressure and a continuous water temperature of 225 deg F (93 deg C).

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.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket.
5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings. With minimum life of 200,000hrs.
7. Provide braided stainless steel flexible connectors.

D. Shaft Coupling: 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: Variable speed, with permanently lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

H. Nameplate shall be stainless steel, suitably secured to the pump.

I. Capacities and Characteristics:

1. See Schedule

2.3 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers:

1. Patterson
2. Bell & Gossett; Div. of ITT Industries.
3. Taco.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

C. Pump Construction:

1. The pumps shall be single stage end suction rear pull out design. The seal shall be serviceable without disturbing the piping connections. The capacities and characteristics shall be as called for in the plans/schedules.
2. Pump casing shall be constructed of ASTM A48 class 30 cast iron. The pump casing/volute shall be rated for 250 psi working pressure for all jobs. The pump flanges shall be matched to suit the working pressure of the piping components on the job, with either ANSI Class 125 flanges or ANSI class 250 flanges. The pump casing shall be drilled and tapped for gauge ports on both the suction and discharge connections and for a drain port at the bottom of the casing. The casing shall have an additional tapping on the discharge connection to allow for the installation of a seal flush line. The pump cover shall be drilled and tapped to accommodate a seal flush line which can be connected to the corresponding tapping on the discharge connection, or to an external source to facilitate cooling and flushing of the seal faces.
3. All casings shall be flanged. Threaded casings not allowed unless extra unions and fittings are provided with that pump to allow servicing. Flanges shall comply with ASTM A105M.
4. The pump shall have a factory installed vent/flush line to insure removal of trapped air from the casing and mechanical seal cooling. The vent/flush line shall run from the seal chamber to the pump discharge.
5. The impeller shall be ASTM B584-836/875 bronze and hydraulically balanced. The impeller shall be dynamically balanced to ANSI Grade G6.3 and shall be fitted to the shaft with a key. The impeller shall be cast by the hydraulically efficient lost foam technique to ensure repeatability of high quality.
6. The pump shall incorporate a dry shaft design to prevent the circulating fluid from contacting the shaft. The pump shaft shall be AISI 1045 carbon steel with field replaceable bronze SAE 660 shaft sleeve. In order to improve serviceability and reduce the cost of ownership the shaft sleeve must be slip on (press on not allowable) and must be easily replaced in the field.
7. The pump shall be fitted with a single mechanical seal, with EPT elastomers and Carbon/Ceramic faces, rated up to 250ºF. This seal must be capable of being flushed externally via a tapping in the pump cover adjacent to the seal cavity. The entire pump line shall use no more than three different sizes of seals.
8. The pump shall be close coupled to a NEMA standard JM frame motor.
9. In order to both simplify and reduce the total cost of ownership, the manufacturer shall standardize on no more than three sizes of mechanical seals through out the entire range of the family of pumps. The manufacturer shall not use multiple part numbers for the same part.

D. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing.

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. Refer to Division 23 Section "Common Work Results for HVAC."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. All concrete pads shall have 1-1/2” beveled edges.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 PUMP INSTALLATION

A. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches (19 to 38 mm) between pump base and foundation for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

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. Engage factory representative to laser align pumps in field.

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.

E. Contractor to provide copy of alignment report to owner with before and after measurement readings.

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 isolation valve on discharge side of pumps.

F. Install Y-type strainer and shutoff valve on suction side of pumps. Tie-wrap start-up strainer to strainer body when replaced with final strainer.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install single pressure gage with multiple input selector valve.

I. Install electrical connections for power, controls, and devices.

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.
6. Start motor.
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.

END OF SECTION 232123

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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 water-treatment systems for the following:

1. Heating, hot-water piping (closed-loop system).

1.3 CHEMICAL FEED SYSTEM DESCRIPTION

A. Closed-Loop System: One bypass feeder on each system with isolating and drain valves downstream from circulating pumps, unless otherwise indicated.

1. Introduce chemical treatment through bypass feeder when required or indicated by test.

1.4 PERFORMANCE REQUIREMENTS

A. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of installed equipment without posing a hazard to operating personnel or the environment.

B. Contractor shall coordinate with Wake County GSA, and their current chemical provider to ensure that all chemical treatment equipment is compatible with their contract with the County.

C. Base chemical treatment performance requirements 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.

1. Closed System: Maintain system essentially free of scale, corrosion, and fouling.

1.5 SUBMITTALS

A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:

1. Chemical solution tanks.
2. Agitators.
3. Control equipment and devices.
4. Test equipment.

5. Chemicals.
6. Filters.
7. Chemical feeders.

B. Shop Drawings: Detail equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For pumps, agitators, filters, system controls, and accessories to include in maintenance manuals specified in Division 1.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is an authorized representative of the chemical treatment manufacturer for both installation and maintenance of chemical treatment equipment required for this Project.

1.7 MAINTENANCE

A. Scope of Service: Provide chemicals and service program for maintaining optimum conditions in the circulating water for inhibiting corrosion, scale, and organic growths in the cooling, chilled-water piping and heating, hot-water piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, including the following:

1. Initial water analysis and recommendations.
2. Startup assistance.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical assistance.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

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. Chemicals: Furnish quantity equal to 100 percent of amount initially installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. HVAC Water-Treatment Products:

a. Ampion Corp.
b. Anderson Chemical Co., Inc.
c. Aqua-Chem, Inc.; Cleaver-Brooks Div.
d. Barclay Chemical Co., Water Management, Inc.
e. Betz Dearborn, Inc.
f. Calgon Corp., ECC International.
g. Diversey Water Technologies, Inc.
h. DuBois Chemicals, Inc.; DuBois USA Subsidiary.
i. Fluids Pumps & Controllers, Inc.
j. Harmsco Industrial Filters.
k. Metro Group., Inc.; Metropolitan Refining Div.
l. Nalco Chemical Co.
m. Selick & Bird, Inc.
n. Stewart-Hall, Div. of the Rectorseal Corp.
o. Trane Boland Services; Water Treatment.
p. Watcon, Inc.

2.2 CHEMICAL FEEDING EQUIPMENT

A. Bypass Feeders: Cast iron or steel, for introducing chemicals into system; with funnel shutoff valve on top, air-release valve on top, drain valve on bottom, and recirculating shutoff valves on sides.

1. Capacity: 5 gal.
2. Working Pressure: 125 psig.

B. Plastic-Body Strainer: Rigid PVC or CPVC with cleanable stainless-steel strainer element.

C. Additional requirements include balancing valve, flow indicator, and air vent at tank with isolation valves and drains: see detail.

2.3 CHEMICAL TREATMENT TEST EQUIPMENT

1. Provided by Owner

2.4 CHEMICALS

1. Provided by Owner.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. By Owner

3.2 INSTALLATION

A. Install treatment equipment level and plumb.

B. Add cleaning chemicals as recommended by manufacturer.

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 equipment to allow service and maintenance.

C. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.

3.4 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to perform startup service.

1. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
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. Owner shall place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.

B. Test chemical feed piping as follows:

1. By Owner

3.5 ADJUSTING

A. Occupancy Adjustments: Within 12 months of Substantial Completion, perform two separate water analyses to prove that automatic chemical feed systems are maintaining water quality within performance requirements specified in this Section. Perform analyses at least 60 days apart. Submit written reports of water analysis.

END OF SECTION 232500

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. Double-wall ducts and fittings in inaccessible locations.
3. Double-wall ducts and fittings for sound attenuation
4. Single-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner (not permitted)
7. Sealants and gaskets.
8. Hangers and supports.
9. Seismic-restraint devices.

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 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. 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. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated.

1. Static-Pressure Classes:

a. Supply Ducts (except in Mechanical Rooms): 1-inch wg (250 Pa)
b. Supply Ducts (Upstream from Air Terminal Units): 2-inch wg (500 Pa)
c. Supply Ducts (Downstream from Air Terminal Units): 1-inch wg (250 Pa)
d. Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg (500 Pa)

e. Return Ducts (Negative Pressure): 1-inch wg (250 Pa)
f. Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa)

2. Leakage Class:

a. Round Supply-Air Duct: 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa)
b. Rectangular Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg (0.29 L/s per sq. m at 250 Pa)
c. Flexible Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg (0.29 L/s per sq. m at 250 Pa) Retain seismic options and design criteria in paragraph below that are approved by authorities having jurisdiction.

1.4 SUBMITTALS

A. Product Data: For each type of the following products:

1. 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

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.
g. Other requirements for coordination drawings provided in SECTION 230010 – COORDINATION DRAWINGS

D. Welding certificates.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

1. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Mockups:

1. Before installing duct systems, build mockups representing roof chase enclosed ductwork. Build mockup to comply with the following requirements, using materials indicated for the completed Work:

a. Two transverse joints.
b. One typical branch connection, each with at least one elbow.
c. One 90-degree turn with turning vanes.
d. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

C. Duct performance shall be demonstrated to engineer and owner for all new ductwork installed to be in compliance with requirements above.

1. Leakage test shall be a dual-manometer type.
2. Leakage rates shall be calculated by contractor based upon fan curves
3. No new ductwork may be insulated until leakage test has been performed and approved by engineer.

PART 2 - PRODUCTS

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 DOUBLE-WALL DUCTS AND FITTINGS IN INACCESIBLE LOCATIONS:

A. Fabricate ducts with indicated dimensions for the inner duct.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

C. Transverse Joints: Welded Joints

D. Longitudinal Seams: Welded Joints

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)] at 75 deg F (24 deg C) mean temperature.
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.

F. Inner Duct – In-accessible applications: solid sheet steel.

2.3 DOUBLE-WALL DUCTS AND FITTINGS FOR SOUND ATTENUATION

A. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

C. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Traverse

(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."

D. 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."

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)] at 75 deg F (24 deg C) mean temperature.
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.

F. Inner Duct – Sound Attenuation Applications: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent

2.4 SINGLE-WALL ROUND AND FLAT-OVAL 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.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter (diameter of the round sides connecting the flat portions of the duct).

C. 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 (1524 mm) in Diameter: Flanged.

D. 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 (2286 mm) in diameter with butt-welded longitudinal seams.

2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

E. 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."

2.5 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.

1. Galvanized Coating Designation: G60 (Z180)
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

E. 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.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.6 DUCT LINER

1. Duct liner will not be accepted in any part of the system for this project.

2.7 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 (102 mm).
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), 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. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.8 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 (Table 4-1M), "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:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
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 and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

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 SEAM AND JOINT SEALING

A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.

B. Seal Classes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements."

3.3 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 (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) 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 (Table 4-1M), "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 (610 mm) of each elbow and within 48 inches (1200 mm) 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 (5 m).

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.

3.4 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.

3.5 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.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual."
2. Test the following systems:

a. Supply air.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before insulation application.
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 entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. 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.

3.7 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel.

B. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

C. 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 (5 m/s) 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 (5 to 7.6 m/s):

      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, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

   c. Velocity 1500 fpm (7.6 m/s) 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. 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 (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam.

D. 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: 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 (5 m/s) or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233130 – AIR DISTRIBUTION SYSTEM CLEANING

PART 1 - GENERAL

1.1 SUMMARY

1. All ductwork to be reused in this project shall be cleaned by the standards listed in this section.

B. Section includes:

1. Clean HVAC system from point where air enters system to each point where air is discharged from system.

1.2 REFERENCES

A. Abbreviations and Acronyms: See ACR, The NADCA Standard.

B. Reference Standards:

1. Following current standards and publications of issues currently in effect form part of this specification to extent specified:

a. American National Standards Institute/Institute of Inspection Cleaning and Restoration Certification (ANSI/IICRC).

1) ANSI/IICRC S520 - Standard for Professional Mold Remediation.

b. National Air Duct Cleaners Association (NADCA):

1) ACR, The NADCA Standard - Assessment, Cleaning & Restoration of HVAC Systems (Current Version).

c. National Fire Protection Association (NFPA):

1) NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
2) NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

d. North American Insulation Manufacturers Association (NAIMA):

1) Cleaning Fibrous Glass Insulated Air Duct Systems.

e. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

1) HVAC Duct Construction Standards - Metal and Flexible.

f. Underwriters' Laboratories (UL):

1) UL Standard 181 - UL Standard for Safety Factory-Made Air Ducts and Connectors.
2) UL Standard 181A - UL Standard for Safety Closure Systems for Use with Rigid Air Ducts.

g. US Green Building Council (USGBC):

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the Work of this section with the work of other trades, and the work of different contractors.

B. Precleaning Meeting:

1. Conduct precleaning meeting with representatives of Owner, Contractor, and facility occupants affected by cleaning work.

C. Sequencing:

1. Perform duct cleaning work after HVAC system but before new diffusers are installed.

D. Scheduling:

1. Prepare and submit HVAC system cleaning activities schedule in according with Division 01 section describing project scheduling requirements.

1.4 SUBMITTALS

A. Action Submittals:

1. Product Data: Submit data for each product.

B. Informational Submittals:

1. Duct cleaning plan: Before commencing cleaning work, submit written work

plan including following information:

a. Scope of Work identifying HVAC components are to be cleaned, as well as those components not to be cleaned.
b. Itemize specific environmental engineering controls required for workspace, and special work requirements.
c. Detail cleaning work means and methods.
d. Name, contact information, and functional tasks performed by each representative of each firm and contractor involved with the work.

2. Manufacturer’s Instructions: Submit cleaning agent product installation instructions.
3. Field Quality Control Submittals:

a. Submit laboratory analysis results, if NADCA Vacuum Test is used for cleanliness verification.
b. Submit documentation detailing chain of custody for test samples, if outside laboratories or testing agencies performed sample analysis or testing.

4. Qualification Statements: Show membership status, project experience, and certifications for:

a. HVAC Cleaning Contractor.

1.5 QUALIFICATIONS

A. HVAC System Cleaning Contractor: Current member of NADCA experienced in HVAC cleaning projects of similar size and complexity.

1. Supervisor: Employ NADCA-certified Air Systems Cleaning Specialist (ASCS) responsible for project.
2. Inspector: Employ NADCA-Certified ASCS, or NADCA-Certified Ventilation Inspector (CVI) to perform site inspections.

B. Licensing:

1. Submit copy of proper licenses, required to legally perform work in which work is located.
2. Comply with applicable federal, state, provincial, and local, rules, regulations, and licensing requirements.
3. Comply with requirements of Authorities Having Jurisdiction.

PART 2 - PRODUCTS

2.1 CLEANING MATERIALS

A. Cleaning Agents:

B. Water: Potable.

2.2 TREATMENT MATERIALS

A. Antimicrobial Agents: Type recommended by [Owner's] Certified Industrial Hygienist (CIH), determined from biological contamination test results.

B. Sealants:

PART 3 - EXECUTION

3.1 HVAC DUCT CLEANING CONTRACTORS

A. NADCA Member Contractors:

3.2 EXAMINATION

A. HVAC System Assessment and Site Survey:
   1. Before commencing work, assess HVAC system condition to determine appropriate engineering controls, safety measures, tools, equipment and cleaning products and methods required to complete the work.
   2. Perform HVAC system assessment by ASCS, Certified Ventilation Inspector (CVI), or equivalent.
   3. If microbial testing or sampling are required, [engage] [Owner will engage] services of technicians trained and acceptable to authorities having jurisdiction.

B. Work Plans:

   1. Project Schedule: Outline starting date, dates and times when work will take place, and completion date.

      a. Determine sequence of cleaning each system or portion of the work and coordinate with work of other trades and activities.

   2. Product Data and Safety Data Sheets: Product data submittals listing general use and specific chemical cleaning products and coatings used while performing the work, along with Safety Data Sheets for chemical products used to perform the

work.

3. Safety Plan: Define responsibilities of each organization’s designated representative involved with executing work plan throughout project.

   a. Include disclaimers identifying items not covered under project warranty or guarantee.

3.3 PROTECTION OF IN-PLACE CONDITIONS

A. Protect existing structures, surfaces, and systems from damage resulting from duct cleaning work.

B. Report damage caused by this work to Owner and Architect Project Manager.

3.4 HVAC SYSTEM PREPARATION

A. Service Openings:

1. Access duct cleaning work through existing or new service openings, allowing safe access and thorough cleaning throughout specified components.
2. Work through service openings sized to allow mechanical tool entry and visual inspection, as required for cleaning activities.
3. Where possible, work through existing service openings.
4. Where new service openings are required, install openings as follows:

   a. Do not degrade structural, thermal, or functional system integrity, and comply with applicable SMACNA duct construction methods.
   b. Install service openings complying with UL and NFPA standards, federal, state, and local code requirements, and requirements of Authorities Having Jurisdiction.
   c. Where required, install duct access doors complying with UL Standard 181, and fabricated with materials classified for flammability and smoke developed.
   d. Where required, install tapes complying with UL 181A.
   e. Where required, install closure panels fabricated from equivalent material and same or heavier gage.
   f. Mechanically fasten closure panels over service openings with screws or rivets at perimeter, maximum [4 inches] [100 mm] spacing.
   g. Fabricate closure panel to overlap duct opening perimeter, minimum [1 inch] [25 mm] .
   h. Insulate closure panels to match adjacent duct interior and exterior surfaces.
   i. Seal rigid fibrous glass duct systems in accordance with NAIMA recommended practices.

      1) Install closure techniques: UL Standard 181 or UL Standard 181A.

j. Close service openings installed in rigid fibrous glass ductwork and metal ductwork with fibrous glass liner with no exposed fibrous glass edges exposed to airstream.

5. Install service openings that can be reopened for future inspection or remediation.

   a. Mark outside of duct and report service opening locations to Owner in project closeout documents.

6. Do not cut service openings into flexible duct.

   a. Disconnect flexible duct at both ends as required for inspection and cleaning.
   b. Reconnect flexible duct ends in accordance with SMACNA standards.

3.5 CLEANING EQUIPMENT MAINTENANCE AND USE

A. Maintain equipment employed in work performance in good working order, consistent with equipment manufacturer's written instructions and applicable jurisdictional requirements.

B. Clean and inspect equipment before bringing to work site.

C. Do not introduce contaminants from cleaning equipment into indoor environment or HVAC system.

D. Service equipment to limit possible HVAC system contamination from insufficient service equipment cleaning, and unsafe operating conditions for service personnel and building occupants.

E. Perform activities requiring opening contaminated vacuum collection equipment on-site, including servicing or filter maintenance, in appropriate containment area or outside building.

F. Clean and seal collection devices, vacuums and other tools and devices before relocating to different building areas, moving equipment through occupied spaces, and before removing equipment from building.

G. Locate fuel-powered equipment to prevent combustion emissions and air exhaust emissions from entering building envelope.

   1. Monitor and manage equipment operation and location to prevent introduction of combustion emissions into occupied space.

3.6 CLEANING - GENERAL

A. Perform HVAC system cleaning in accordance with ACR, The NADCA Standard.

B. Remove visible non-adhered particulates.

1. Clean HVAC components employing agitation device to dislodge contaminants from HVAC component surface, and then capturing contaminants with vacuum collection device.

a. Acceptable methods include those that do not damage integrity of ductwork and other system components, and does not damage porous surface materials including internal insulation and duct lining.

2. Clean HVAC components using source removal mechanical cleaning methods designed to extract contaminants from within HVAC system and safely remove contaminants from facility.
3. Select source removal methods rendering HVAC system visibly clean and capable of passing cleanliness verification methods as described in ACR, The NADCA Standard.
4. Do not employ cleaning method, or combination of methods, that can damage HVAC system components or negatively alter system integrity.
5. Do not damage HVAC system and components with wet cleaning, power washing, steam cleaning and other wet process cleaning.

C. Apply cleaning materials in accordance with manufacturer's instructions.

1. Do not apply cleaning agents or water to electrical, fibrous glass or other porous HVAC system components.

D. Capture removed contamination and cleaning materials and legally dispose.

E. Verify HVAC system surface and component cleanliness in accordance NADCA Standard.

F. Particulate Collection:

1. Employ contaminant removal methods incorporating vacuum collection devices operated continuously during cleaning.

a. Connect vacuum collection device to component being cleaned through service opening.
b. Employ vacuum collection device of sufficient capacity to maintain areas being cleaned under negative pressure, containing debris is contained and preventing contaminant migration to adjacent areas.

2. When possible, discharge ducted exhaust air from vacuum collection devices outdoors, keeping discharge air clear of outdoor air intakes, operable windows,

and other locations allowing outdoor air entry.

a. Do not violate outdoor environmental standards, codes or regulations.
b. Do not discharge unfiltered air from vacuum collection devices outdoors.

3. When necessary to exhaust vacuum collection devices indoors, including hand-held and wet-vacuum machines, keep discharge air in work area, and provide machine air discharge HEPA filtration, rated at 99.97 percent collection efficiency for 0.3 micron particles and larger.

3.7 AIR HANDLING UNIT (AHU) CLEANING

A. Clean fans and blowers.

1. Clean blowers, fan housings, ducted plenums, scrolls, blades, or vanes, shafts, baffles, dampers and drive assemblies.
2. Remove visible non-adhered particulate deposits in accordance with ACR, The NADCA Standard.

B. Clean air handling unit (AHU) internal surfaces, components and condensate pans, and drains.

C. Clean heat transfer coils, fans, condensate pans, drains and similar non-porous surfaces in conjunction with mechanical methods as described in ACR, The NADCA Standard.

D. Control water spray and extraction are sufficient to collect debris and prevent water damage to HVAC components and surrounding equipment.

E. Capture, contain, test and dispose of waste water generated while performing wet cleaning in accordance with applicable federal, state, and local regulations, and requirements of Authorities Having Jurisdiction.

F. After cleaning, verify HVAC system surface and component cleanliness in accordance ACR, The NADCA Standard.

3.8 AIR DUCT SYSTEMS:

A. Clean air ducts to remove non-adhered substances.
B. Access air duct interiors through service openings in system that are large enough to accommodate mechanical cleaning procedures and allow for cleanliness verification.

C. Use mechanical agitation methods to remove particulate, debris, and non-adhered particulate.

D. Capture dislodged substances with vacuum collection device.

E. Do not employ cleaning methods that damage HVAC components.

F. Mark position of dampers and air-directional mechanical devices inside HVAC system prior to cleaning.

G. When cleaning is complete, restore dampers and devices to their marked positions.

H. After cleaning, verify cleanliness of HVAC system surfaces and components in accordance ACR, The NADCA Standard.

3.9 AHU COILS

A. Perform visual coil and drain pan inspection to determine whether Type 1 dry cleaning, or Type 2 wet cleaning is required.

B. Employ cleaning methods rendering coil visibly clean in accordance with ACR, The NADCA Standard.

C. Isolate coil from duct system during cleaning process. Do not allow removed particles to migrate to, or redeposit on, unintended areas.

D. Apply coil cleaning products in accordance with manufacturer’s published data and labeling.

E. Clean and flush condensate drain pan and drain line. Verify proper drainage operation before and after cleaning.

F. Apply cleaning methods and products that do not cause damage to, or erosion of, coil surface or fins.

3.10 TYPE 1 DRY CLEANING METHOD

A. Operate HEPA-filtered negative air machines that discharge continuously during Type 1 cleaning process.

B. Mechanically remove adhered dirt and contaminants in accordance with ACR, The NADCA Standard.

3.11 TYPE 2 WET CLEANING METHOD

A. Employ Type 2 wet cleaning method when visual inspection reveals suspect microbial matter on coil or drain pan. Access both upstream and downstream sides of each coil section for cleaning.

B. Employ engineering controls required for coil cleaning in accordance with ACR, The NADCA Standard.

C. Verify cleanliness after cleaning has been performed as described in ACR, The NADCA Standard.

D. Perform Type 2 cleaning if debris still remains on the coil or the coil is impacted after Type 1 cleaning has been completed and post-cleaning inspection has been performed.

E. After cleaning, verify cleanliness of HVAC coils in accordance ACR, The NADCA Standard.

3.12 SPECIAL TECHNIQUES

A. Engineering Controls:

1. Employ engineering controls to maintain worker and building occupant safety, and prevent contaminating surfaces outside work area.

    a. Comply with government regulations, and industry standards and guidelines relevant to working in the facility environment in which the work is located.
    b. Control odors, mists, and aromatic vapors during cleaning process.

B. Controlling Product Emissions:

1. Apply cleaning agents and other chemicals in accordance with manufacturer’s recommended procedures and product application instructions, including exhaust ventilation.

C. Negative Duct Pressurization:

1. Throughout cleaning process, keep HVAC system and associated air ducts at negative differential pressure, relative to indoor non-work area.
2. Maintain negative pressure differential between portion of HVAC duct system being cleaned and surrounding indoor occupant spaces.
3. Continuously monitor and verify correct pressure differential.
4. When performing vacuum collection, employ negative air machine drawing air from equipment being cleaned.
5. When negative air machine is not fitted with HEPA filtration, duct exhaust air from negative air machine to outdoor location, keeping discharge air clear of outdoor air intakes, operable windows, and other locations where outdoor air enters building.

    a. Do not violate outdoor environmental standards, codes or regulations by releasing debris.

b. Do not discharge unfiltered air from vacuum collection devices outdoors.

D. Microbial Agents:

1. Apply antimicrobial agents only when active biological growth is reasonably suspected, or where unacceptable levels of biological contamination have been verified through testing.
2. Apply antimicrobial agents after removal of surface deposits and debris.
3. Apply antimicrobial agents in accordance with antimicrobial agent manufacturer's written recommendations and associated EPA registration listing.

3.13 FIELD QUALITY CONTROL

A. Inspect work to verify cleanliness immediately after HVAC system component cleaning and prior to placing system in operation.

B. Do not apply treatment, coating, or antimicrobial agent to cleaned HVAC system or components until the work has been inspected and determined to be acceptable.

C. Visual Inspection:

1. When cleaning is complete, perform final inspection in presence of Engineer and Owner.
2. Perform visual inspection of porous and non-porous HVAC system component surfaces. Verify HVAC system is visibly clean as defined in ACR, The NADCA Standard.
3. If no contaminants are evident through visual inspection, HVAC is considered clean and acceptable.
4. If contaminants are evident through visual inspection, repeat cleaning system areas where contaminants are visible.

    a. Notify Owner and Architect Project Manager to schedule cleanliness re-inspection.

D. Surface Comparison Test for Porous Surfaces Only:

1. If visual inspection is inconclusive or disputed, then perform Surface Comparison Test in accordance with ACR, The NADCA Standard.

    a. Attach vacuum brush to operating contact vacuum.
    b. Employ contact vacuum with HEPA-filtered discharge, capable of achieving minimum 80 inches w.g. static lift and fitted with 2.5-inch diameter round nylon brush attached to 1.5-inch diameter vacuum hose.

c. Pass brush over surface test area four times.
d. Visually compare tested and untested surfaces to determine whether visible surface characteristics are detectable.

2. When surface comparison test is complete, HVAC component surface is considered acceptably clean if there is no visually detectable difference between tested and untested surface characteristics.

E. NADCA Vacuum Test for Non-Porous Surfaces Only:

1. When required, perform Vacuum Test in presence of Engineer and in accordance with ACR, The NADCA Standard.
2. Apply NADCA Vacuum Test template to flowing-air side of component's surface.
3. Attach vacuum cassette with filter media to calibrated air sampling pump and pass open face of filter cassette over two 2 cm x 25 cm openings marked on template.
4. Pass vacuum cassette over system surfaces at 2 inches/second.
5. When sampling is complete, prepare filter cassette and weigh it to determine total amount of debris collected.
6. Surface is considered acceptably clean, when net weight of debris collected on filter cassette is less than 0.75 mg/100 cm2.

3.14 SYSTEM STARTUP

A. Install closures over services access openings before allowing system restart for normal facility operation.

B. When system is placed in operation, remove temporary filter elements after minimum 24 hours operation.

3.15 DISPOSAL OF JOB SITE DUCT CLEANING WASTE

A. Seal HVAC system debris and removed contaminated materials in containers before removal from work area.

B. Handle materials classified as hazardous by governmental agencies in accordance with applicable federal, state, and local, regulations and codes.

C. Dispose of debris removed from HVAC System in accordance with applicable federal, state, and local requirements.

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.
2. Barometric relief dampers.
3. Manual volume dampers – Handle Actuated
4. Manual volume dampers – Remote Actuated
5. Control dampers.
6. Fire dampers.
7. Flange connectors.
8. Turning vanes.
9. Duct-mounted access doors.
10. Flexible connectors.
11. Duct accessory hardware.

1.3 SUBMITTALS

A. 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.
b. Manual volume damper installations. Handle, Cable, and Shaft actuated.
c. Control damper installations.
d. Fire-damper, combination fire- and smoke-damper, including sleeves; and duct-mounted access doors and remote damper operators.
e. Wiring Diagrams: For power, signal, and control wiring.

B. 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.

C. Source quality-control reports.

D. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with 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.

1. Galvanized Coating Designation: G90 (Z275).
2. Exposed-Surface Finish: Mill phosphatized.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. NCA Manufacturing, Inc.
4. Pottorff; a division of PCI Industries, Inc.

5. Ruskin Company.

B. Description: Gravity balanced

C. Maximum Air Velocity: 2000 fpm (10 m/s)

D. Maximum System Pressure: 5-inch wg (0.25 kPa)

E. Frame: 0.063-inch- (1.6-mm-) thick extruded aluminum.

F. Blades: Multiple single-piece blades, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Neoprene, mechanically locked.

I. Blade Axles:

1. Material: Galvanized steel.
2. Diameter: 0.20 inch (5 mm)

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.
4. Chain pulls.
5. Front of rear screens.
6. 90-degree stops.

N. Sleeve: Minimum 20-gage (1.0-mm) thickness.

2.3 BAROMETRIC RELIEF DAMPERS

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

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. NCA Manufacturing, Inc.
4. Pottorff; a division of PCI Industries, Inc.
5. Ruskin Company.

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: 2000 fpm (10 m/s).

D. Maximum System Pressure: 5-inch wg (0.5 kPa).

E. Frame: 0.064-inch- (1.6-mm-) thick, galvanized sheet steel, with welded corners and mounting flange.

F. Blades:

1. Multiple, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum.
2. Maximum Width: 6 inches (150 mm).
3. Action: Parallel.
4. Balance: Gravity.
5. Eccentrically pivoted.

G. Blade Seals: Neoprene.

H. Blade Axles: Galvanized steel.

I. Tie Bars and Brackets:

1. Material: Galvanized steel.
2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: Stainless steel.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.4 MANUAL VOLUME DAMPERS (HANDLE ACTUATED)

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. METALAIRE, Inc.
   c. Nailor Industries Inc.
   d. Pottorff; a division of PCI Industries, Inc.
   e. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.

4. Frames:

   a. Hat-shaped, galvanized-steel channels, 0.064-inch (1.62-mm) 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 (1.62 mm) thick.

6. Blade Axles: Galvanized steel.

7. Bearings:

   a. Stainless-steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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:

1. Size: 1-inch (25-mm) diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.5 MANUAL VOLUME DAMPERS (REMOTE ACTUATED)

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. METALAIRE, Inc.
   c. Nailor Industries Inc.
   d. Pottorff; a division of PCI Industries, Inc.

e. Ruskin Company.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:

   a. Hat-shaped, galvanized-steel channels, 0.064-inch (1.62-mm) minimum thickness.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

   a. Radial-Twist

6. Blade Axles: Galvanized steel.
7. Tie Bars and Brackets: Galvanized steel.

B. Damper Hardware

1. Provide 60” cable, field cut to terminate at face of service diffuser.
2. Cable actuated with hexagonal nut driver.

2.6 CONTROL DAMPERS

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

1. Duro Dyne Inc.
2. Flexmaster U.S.A., Inc.
3. Greenheck Fan Corporation.
4. METALAIRE, Inc.
5. Nailor Industries Inc.
6. NCA Manufacturing, Inc.
7. Ruskin Company.

B. Low-leakage rating, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. Angle shaped.
2. Galvanized-steel channels, 0.064 inch (1.62 mm) thick.
3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 8 inches (200 mm).
2. Opposed-blade design.
3. Galvanized Stainless steel.

4. 0.064 inch (1.62 mm) thick.
5. Blade Edging: Closed-cell neoprene edging.

E. Blade Axles: 1/2-inch- (13-mm-) diameter; galvanized 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 (minus 40 to plus 93 deg C).

F. Bearings:

1. Oil-impregnated bronze.
2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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.

2.7 FIRE DAMPERS

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

1. Greenheck Fan Corporation.
2. METALAIRE, Inc.
3. Nailor Industries Inc.
4. NCA Manufacturing, Inc.
5. Pottorff; a division of PCI Industries, Inc.
6. Prefco; Perfect Air Control, Inc.
7. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 5-inch wg static pressure class and minimum 4000-fpm (20-m/s) velocity.

D. Fire Rating:1-1/2] hours.

E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) 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 (1.3 or 3.5 mm) 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- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

2.8 FLANGE CONNECTORS

A. Description: Roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.9 TURNING VANES

A. 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.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Single wall.

E. Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

2.10 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."

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 (25-by-25-mm) 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 (300 mm) Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches.
d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2.11 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

2.12 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 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.
2. Install aluminum volume dampers in aluminum 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 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 (15-m) spacing.
5. Upstream of turning vanes.
6. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

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 (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Install duct test holes where required for testing and balancing purposes.

O. 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 (6-mm) 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, 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.

END OF SECTION 233300

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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. 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.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators.

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.

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: Two set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL FANS

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

1. Twin City
2. Greenheck.
3. Loren Cook Company.

B. Description: In-line, direct-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. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. 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.

F. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

G. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

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 units using elastomeric mounts having a static deflection of 1 inch (25 mm)

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.

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 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. Section Includes:

1. Rectangular and square ceiling diffusers.
2. Louver face diffusers.
3. Linear bar diffusers.
4. Linear slot diffusers.
5. Adjustable bar registers and grilles.
6. Fixed face registers and grilles..
7. Linear bar grilles.

1.3 SUBMITTALS

A. Product Data: For each type of 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. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. See units specified on drawings

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

a. Anemostat Products; a Mestek company.
b. Carnes.
c. Hart & Cooley Inc.
d. METALAIRE, Inc.

e. Nailor Industries Inc.
f. Price Industries.
g. Titus.

B. All diffusers, registers and grilles shall be of aluminum construction.

2.2 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 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 practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 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 236423 – AIR COOLED 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. Section Includes:

1. Packaged, air-cooled, electric-motor-driven, scroll water chillers.

1.3 DEFINITIONS

A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

B. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

C. IPLV: Integrated part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.

D. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

E. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

1.4 PERFORMANCE REQUIREMENTS

1.5 SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Performance at ARI standard conditions and at conditions indicated.
2. Performance at ARI standard unloading conditions.
3. Minimum evaporator flow rate.
4. Refrigerant capacity of water chiller.

5. Oil capacity of water chiller.
6. Fluid capacity of evaporator.
7. Fluid capacity of condenser.
8. Characteristics of safety relief valves.
9. Minimum entering condenser-water temperature.
10. Performance at varying capacity with constant design condenser-water temperature. Repeat performance at varying capacity for different condenser-water temperatures from design to minimum in 5 deg F (3 deg C) increments.
11. Minimum entering condenser-air temperature
12. Performance at varying capacity with constant design entering condenser-air temperature. Repeat performance at varying capacity for different entering condenser-air temperatures from design to minimum in 10 deg F (6 deg C) increments.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

D. Startup service reports.

E. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

F. Warranty: Sample of special warranty.

1.6 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 590 certification program.

B. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.

2. ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.
3. ASHRAE/IESNA 90.1 for energy efficiency.

D. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

E. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

B. Package water chiller for export shipping.

1.8 COORDINATION

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

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified period.

1. Compressor Warranty Period: Five years from date of Final Acceptance.

PART 2 - PRODUCTS

2.1 PACKAGED AIR-COOLED WATER CHILLERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Carrier Corporation; a United Technologies company.
2. Trane.
3. York International Corporation.

B. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.

C. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.

D. Cabinet:

1. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.

2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.

3. Casing: Galvanized steel.

4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.

5. Sound-reduction package consisting of the following:

   a. Acoustic enclosure around compressors.
   b. Reduced-speed fans with acoustic treatment.
   c. Designed to reduce sound level without affecting performance.

6. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

E. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.

2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.

3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.

4. Capacity Control: On-off compressor cycling.

5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.

6. Vibration Isolation: Mount individual compressors on vibration isolators.

F. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.

2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

G. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

H. Refrigeration:

1. Refrigerant: R-410a. Classified as Safety Group A1 according to ASHRAE 34.

2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

3. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

I. Evaporator:

1. Brazed-plate or shell-and-tube design, as indicated.

2. Shell and Tube:

   a. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
   b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
   c. Shell Material: Carbon steel.
   d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
   e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with flanged end connections for connection to field piping.
   f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

3. Brazed Plate:

   a. Direct-expansion, single-pass, brazed-plate design.
   b. Type 316 stainless-steel construction.
   c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
   d. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

4. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).

5. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.

J. Air-Cooled Condenser:

1. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).

   a. Construct coils of copper tubes mechanically bonded to aluminum fins.
   b. Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
   c. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.

3. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

4. Fan Guards: Steel safety guards with corrosion-resistant coating.

5. Hail guards on all condenser coils.

K. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

2. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.

3. Wiring shall be numbered and color-coded to match wiring diagram.

4. Install factory wiring outside of an enclosure in a raceway.

5. Field power interface shall be to EMA KS 1, heavy-duty, nonfused disconnect switch.

6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

   a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
   b. NEMA KS 1, heavy-duty, nonfusible switch.
   c. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

7. Provide each motor with overcurrent protection.

8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

9. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

10. External phase protection is also required in addition to factory safety. External phase protection shall activate chiller safety circuitry and generate alarm in the controls system,.

11. Provide power factor correction capacitors to correct power factor to 0.90 at full load.

12. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

    a. Power unit-mounted controls where indicated.
    b. Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.

13. Control Relays: Auxiliary and adjustable time-delay relays.

14. All circuitry shall be rated for minimum 65K AIC

15. Indicate the following for water chiller electrical power supply:

    a. Current, phase to phase, for all three phases.
    b. Voltage, phase to phase and phase to neutral for all three phases.
    c. Three-phase real power (kilowatts).
    d. Three-phase reactive power (kilovolt amperes reactive).
    e. Power factor.
    f. Running log of total power versus time (kilowatt hours).
    g. Fault log, with time and date of each.

L. Controls:

1. Stand-alone, microprocessor based.

2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

3. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

    a. Date and time.
    b. Operating or alarm status.
    c. Operating hours.
    d. Outside-air temperature if required for chilled-water reset.
    e. Temperature and pressure of operating set points.
    f. Entering and leaving temperatures of chilled water.
    g. Refrigerant pressures in evaporator and condenser.
    h. Saturation temperature in evaporator and condenser.
    i. No cooling load condition.
    j. Elapsed time meter (compressor run status).
    k. Pump status.
    l. Antirecycling timer status.
    m. Percent of maximum motor amperage.
    n. Current-limit set point.

o. Number of compressor starts.

4. Control Functions:

a. Manual or automatic startup and shutdown time schedule.
b. Entering and leaving chilled-water temperatures, control set points, and motor load limit.
c. Chilled-water leaving temperature shall be reset based on BAS input.
d. Current limit and demand limit.
e. External water chiller emergency stop.
f. Antirecycling timer.

5. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset: Any alarm requiring manual reset shall notify the BAS.

a. Low evaporator pressure or high condenser pressure.
b. Low chilled-water temperature.
c. Refrigerant high pressure.
d. High or low oil pressure.
e. High oil temperature.
f. Loss of chilled-water flow.

6. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor, control, and display water chiller status and alarms.

a. Hardwired Points:

1) Monitoring: On/off status, common trouble alarm, electrical power demand (kilowatts), electrical power consumption (kilowatt hours).
2) Control: On/off operation, chilled-water discharge temperature set-point adjustment.

b. ASHRAE 135 BACnet communication interface with building management system shall enable building management system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building management system.

M. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.

2. Thickness: 1-1/2 inches (38 mm)

3. Factory-applied insulation over cold surfaces of water chiller components.

a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.

4. Apply protective coating to exposed surfaces of insulation.

N. Accessories:

1. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.

2. Provide with low ambient operating controls

3. Provide with Sound Attenuation package if projected sound ratings exceed 80dBA @ 50ft.

2.2 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

C. Factory test and inspect evaporator according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

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

3.2 WATER CHILLER INSTALLATION

A. Install water chillers on support structure indicated.

B. Equipment Mounting: Install water chiller on concrete bases with elastomeric mounts.

1. Minimum Deflection: 1/4 inch (6 mm).

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Maintain manufacturer's recommended clearances for service and maintenance.

D. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

E. Install separate devices furnished by manufacturer and not factory installed.

3.3 CONNECTIONS

A. Comply with requirements in Division 23 Section "Hydronic Piping" Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Division 23 Section "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to chiller to allow service and maintenance.

D. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, and drain connection with valve. Make connections to water chiller with a flange.

E. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15.

F. Connect each drain connection with a union and drain pipe and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.

3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Prepare a written startup report that records results of tests and inspections.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain water chillers.

END OF SECTION 236423

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SECTION 237313 - MODULAR 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.
2. Variable-air-volume, multizone air-handling units.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/100> 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. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.

2. Support location, type, and weight.
3. Field measurements.

C. Source quality-control reports.

D. Field quality-control reports.

E. 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: Two set(s) for each air-handling unit.
2. Gaskets: One set(s) for each access door.
3. Fan Belts: Two set(s) for each air-handling unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Carrier Corporation; a member of the United Technologies Corporation Family.

2. Trane; American Standard Inc.
3. YORK International Corporation.

2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant.
4. Factory Finish for Steel and Galvanized-Steel Casing.
5. Casing Coating: Powder-baked enamel.
6. Double wall construction.

B. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, Type I.
2. Location and Application: Encased between outside and inside casing.

C. 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: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:

   a. Hinges: A minimum of two ball-bearing hinges and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Neoprene, 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 24 by 60 inches (600 by 1500 mm).

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.

D. 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, and a minimum of 6 inches (150 mm) downstream from cooling-coil face).
2. Stainless steel construction, with insulated backing.
3. A minimum of 2 inches (50 mm) deep, and complying with requirements in ASHRAE 62.1.
4. Drain Connections: Both ends of pan with NPS 1 (DN 25) threaded nipple.

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 (89 mm) wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized-steel sheet or 0.032-inch- (0.8-mm-) thick aluminum sheets; select metal compatible with casing.

C. 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.

D. Fan Shaft Bearings:

1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of 250,000 hours according to ABMA 9.
2. Provide automatic oilers if manufacture recommends lubrication more often than every 2000 hrs.

E. 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.
2. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives. Belts and drives shall be equipped with cog type drive belts.
4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.

F. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm).

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

G. Variable Frequency Controllers:

1. Specified in other sections.

H. Motor: Grease-lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.4 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. Coils shall not act as structural component of unit.
4. Coil sections shall be no higher than 42”. Split coils are required over 42”

   a. Provide interim drain pans for all split coil sections.

B. Hot Water Heating Coil Construction

1. Minimum of 6 row construction, Maximum of 8 rows.
2. Minimum fouling factor of 0.0005
3. Non-Ferrous headers.
4. Coil casings shall be stainless steel.
5. Coil face area shall be sized for: Maximum 550fpm.

6. Copper tubes:

   a. Minimum thickness 0.035”
   b. Minimum tube velocity shall be 4fps at full load conditions.
   c. Tubing shall be a minimum of 5/8” diameter

7. Aluminum Fins:

   a. Maximum 10 fins per inch
   b. Minimum thickness 0.0075”

C. Chilled Water Heating Coil Construction

1. Minimum of 6 row construction, Maximum of 8 rows.
2. Minimum fouling factor of 0.0005
3. Non-Ferrous headers.
4. Coil casings shall be stainless steel.
5. Coil face area shall be sized for: Maximum 5000fpm.
6. Copper tubes:

   a. Minimum thickness 0.035”
   b. Minimum tube velocity shall be 4fps at full load conditions.
   c. Tubing shall be a minimum of 5/8” diameter

7. Aluminum Fins:

   a. Maximum 10 fins per inch
   b. Minimum thickness 0.0075”

2.5 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

B. Disposable Panel Filters:

1. Factory-fabricated, pleated, throw-away.
2. Thickness: 2 inches (50 mm).
3. Merv (ASHRAE 52.2): 12.
4. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
5. Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

2.6 DAMPERS

A. Damper Operators: Comply with requirements in Division 23 Section "Instrumentation and Control for HVAC."

B. Outdoor- and Return-Air Dampers: Opposed-blade. Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in parallel -blade arrangement with steel operating rods rotating in stainless-steel sleeve bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).

C. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

D. Combination Filter and Mixing Section:

1. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat, permanent or throwaway filters.
2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

2.7 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 (2070 kPa) 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 – Indoor Applications: Install air-handling units on concrete bases. Secure units to anchor bolts installed in concrete bases.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

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. 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.

E. Connect duct to air-handling units with flexible connections.

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 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 proper thermal-overload protection is installed for electric coils.
9. Install new, clean filters.
10. 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.
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.

END OF SECTION 237313

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. The work of this section includes the furnishing and installation of all electrical equipment, materials and devices as shown on the electrical drawings and/or as specified herein, including but not limited to:

1. Conduit and Wire
2. Safety Switches and Fuses
3. Wiring Devices
4. Lighting
5. Fire Alarm Systems

B. The term "provide" shall mean furnish and install.

C. Applicable Publications:

1. Where publications are listed in each Section, they form a part of that Section to the extent referenced.
2. When a standard is specified by reference, comply with the requirements and recommendations stated in that standard, except when its requirements are modified by the Contract Documents or applicable codes establish stricter standards.
3. When a code is not specified by reference in a Section, the work of that Section shall comply with applicable codes listed in the General Conditions.
4. The publication date is the publication in effect as of the bid date, except when a specific publication date is specified.
5. Obtain copies of referenced standards direct from publication source, when needed for proper performance of work, or when required for submittal by Contract Documents.

1.3 QUALITY ASSURANCE

A. Codes and Standards:

1. The installation of all work under this section shall comply with all applicable codes, laws, standards and regulations. Nothing in the specifications shall be construed to permit deviation from these governing items.
2. Electrical material and equipment shall bear the UL label except where UL does not label such types of material and equipment. Materials, equipment and installation shall meet requirements of applicable codes and standards listed below:

National Electric Code	NEC

National Electrical Safety Code	NESC
Electrical Testing Lab	ETL
Underwriters Laboratories, Inc.	UL
Certified Ballast Manufacturing	CBM
National Electrical Manufacturers Association	NEMA
Illuminating Engineering Society	IES
Institute of Electrical and Electronic Engineers	IEEE
American National Standards Institute	ANSI

B. Qualifications of Workmen:

1. Provide sufficient qualified journeyman electricians who are thoroughly experienced with the materials and methods specified and familiar with the design requirement.
2. At least one qualified journeyman shall be present at all times during the execution of the work.
3. In acceptance or rejection in any portion of the electrical work, no allowance will be made for lack of skill on the part of the workmen.

1.4 INTENT OF DRAWINGS AND SPECIFICATIONS

A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable electrical and mechanical systems in every respect.

B. The drawings are diagrammatic only, intending to show general arrangement and location of system components. Due to the small scale of the drawings, and to unforeseen job conditions, all required offsets and fittings may not be shown, but shall be provided at no change in contract price.

C. All work shall be accurately laid out and coordinated with other trades to avoid conflicts and to provide maximum accessibility for operation and maintenance.

1.5 SUBMITTALS

A. Submit shop drawings of the electrical materials to the Designer for review in accordance with the provisions of Division 01 of these specifications.

B. The following is a list of those items required to be submitted:

1. Wiring Devices and Floor Boxes
2. Wire, Conduit, Boxes.
3. Safety Switches and Fuses
4. Lighting and Lighting Control
5. Fire Alarm Systems

C. Contractor shall not begin fabrication or work which requires submittals until return of submittals.

1.6 SUBSTITUTIONS

A. Refer to the appropriate Division 01 Specification for requirements on Substitutions.

1.7 VISIT TO THE SITE

A. All persons proposing to submit quotations for work in accordance with these plans and specifications are expected to visit the site of the work covered by the plans and specifications and are to familiarize themselves with existing conditions as they affect the work of this section of the specifications. Claims resulting from a failure to visit the site or inspect the existing conditions will not be considered.

1.8 OPERATING AND MAINTENANCE DATA

A. Compile product data and related information appropriate for Owner's maintenance and operation of products furnished under Contract.

1. Prepare operating and maintenance data as specified in this section and as referenced in the General Conditions and applicable Section of Division 01 General Requirements.

B. Instruct Owner's personnel in maintenance of products and in operation of equipment and systems.

C. Preparation of data shall be done by personnel:

1. Trained and experienced in maintenance and operation of desired products.
2. Familiar with requirements of this Section.
3. Skilled as technical writer to the extent required to communicate essential data.
4. Skilled as draftsperson competent to prepare required drawings.

D. Prepare data in form of an instructional manual for use by Owner's personnel.

1.9 PAINTING

A. Suitable finish coatings shall be provided under this section of the Specifications on all items of electrical equipment and wiring which are exposed. This shall consist of either an approved factory applied finish or an acceptable finish applied during or after installation. Equipment which is furnished in finishes such as stainless steel or satin aluminum is not to be painted. Exposed equipment and/or wiring in finished areas such as panel covers or surface raceway shall be supplied with factory applied prime coat and shall be professionally painted or enameled as directed to result in a completely coated and attractively finished manner. All such finishing shall be as directed and shall be satisfactory to the Architect/Engineer.

B. All factory finished steel surfaces; boxes, enclosures, etc., shall be cleaned and retouched or repainted as necessary to provide a rust resistant coating. Where painting or galvanizing is not specifically specified, ferrous devices, bolts, nuts, inserts, etc., shall be galvanized.

C. All nameplates shall be left unpainted and in a clean condition.

1.10 WIRING AND ELEMENTARY DIAGRAMS

A. Wiring and elementary diagrams for equipment as shown on the drawings are based on the product of the specified equipment manufacturer and are shown for convenience to aid in estimating the extent of the work involved. The equipment actually installed shall be wired and connected in accordance with the equipment manufacturer's recommendations and shall conform to details in approved wiring diagrams to be furnished by the equipment manufacturer. All equipment so connected shall be made to operate in a safe, proper and efficient manner. Note that control circuitry is not necessarily shown on the drawings but shall be installed in conduit between the points and devices indicated on the diagrams.

1.11 EQUIPMENT TESTS

A. An operating test of the complete electrical system shall be made. System shall test free from grounds, shorts and other faults. Connections shall be for positive mechanical and electrical connection and continuity. Equipment shall be demonstrated to operate in accordance with the requirements of the plans and specifications. Contractor shall furnish all personnel and test instruments required. Performance of tests shall be made in the presence of the Owner's representative, where requested.

B. The following tests shall be performed as a minimum:

1. Control and Distribution Equipment:

a. Check the wire terminals, clean connections.
b. Check all control switches, alarm devices, indicating instruments for proper operation under normal and simulated abnormal conditions.

2. Phase rotation: The connections of all equipment shall be checked for correct phase rotation.
3. Circuit Breakers: The following tests shall be performed:

a. Inspect each circuit breaker.
b. Check for loose connections.
c. Operate each circuit breaker manually.
d. Set the adjustable trips to the values specified.

C. Spot-checks and/or back-checks to verify the testing accuracy shall be made for the Engineer or his agent during job-site visits.

D. Validity of the ground path shall be assured by constant and careful attention to the thorough tightening of all couplings, connectors, locknuts, screws, bolts, etc. and by frequent checking of the path resistance with a quality low-range ohmmeter. Resistance of the path should not exceed one ohm between any two points. If a reading in excess of this is observed, it shall be discussed with the Engineer for an appraisal of the condition.

E. After all fixtures, devices and equipment are installed and all connections completed to each panel – disconnect neutral feeder conductor from neutral bar and take a megger reading between neutral bar and grounded can. If this reading is less than 250,000 ohms, disconnect branch circuit (or sub-feeder) neutral wires from this neutral bar. Test each one separately to the panel can until low reading ones are found. Correct troubles reconnect and retest until at least 250,000 ohms from neutral bar to grounded panel can is achieved with only neutral feeder disconnected. In addition all wiring shall be tested. All phase and neutral conductors shall be tested with a 500 volt megger. Minimum acceptable readings shall be 1,000,000 ohms for conductors #6 awg and smaller; 250,000 ohms for conductors #4 awg and larger. All measurements shall be between the conductor and the grounding conductor.

F. Upon completion of work, but before final inspection, the Contractor shall send a letter to the engineer and the Owner certifying that these tests have been accomplished and tabulating the megger readings for each panel. During field visits, contractor shall demonstrate installation and make such tests as may be required to satisfy the Designer and Owner that work is installed in accordance with drawings, specifications and instructions.

1.12 WARRANTIES

A. All equipment installed under this Division of the work shall be warranted for a minimum of one year after project acceptance.

B. During this warranty period, replace any and all defective equipment and parts at no cost to the Owner.

1.13 BRANCH CIRCUITS

A. The number of conductors in each run of conduit is indicated on the drawings and where there is a conflict between the number of wires indicated and the actual number required as determined by the functional design requirements, the number of wires determined by the functional design requirements shall govern.

B. In general, there is a number associated with each branch circuit outlet which identifies the particular branch circuit to which the device served by the outlet is to be connected. The circuit number indicated has been assigned only for reference and guidance, and is not intended to limit panelboard circuitry. All branch circuits shall be connected to breakers in accordance with circuit requirements and good industry practice. The balancing of all loads shall be included in the work of this DIVISION.

C. Home runs shall not be combined where such would require derating of conductor ampacity. Separate neutrals shall be provided for all branch circuits.

1.14 MOTOR, APPLIANCE AND EQUIPMENT CONNECTIONS

A. Unless otherwise shown on the drawings or specified herein, it is the intent of this DIVISION to provide all electrical equipment and connections required to protect, properly operate, and control all motors, appliances, electrical devices, and equipment furnished and installed under this and other DIVISIONS of the specifications or shown on the drawings.

1.15 SETTING OF EQUIPMENT

A. The setting of equipment shall be carefully coordinated with the work and requirements of the other trades involved to ensure compatibility and to avoid conflicts.

B. Equipment, base mounted on concrete or masonry slabs, pads and piers, or mounted on stands, gratings, platforms, or other, shall not be set in any manner, except on the finished and permanent support.

C. Support of equipment on studs or by other means, and the placing or building of the supporting slab, pad, pier, stand, grading, or other, "to the equipment", is prohibited.

1.16 ACCESS DOORS

A. Where inaccessible ceilings or wall spaces are encountered by the Contractor and there is a need for access to junction boxes or other equipment as required by the NEC, the contractor shall provide any and all access doors at no additional cost. Doors shall be sized to meet the requirements of the work to be installed. Provide doors per Section 08 Access Doors and Frames.

1.17 RECORD DRAWINGS/MANUALS

A. Upon completion of the installation, Contractor shall submit to the Designer marked prints of drawings showing any changes made in circuits, location of equipment, panelboards or any other revision in the Contract Drawings, for the Owner's use in maintenance work and for future additions and expansions. Marked changes shall also include changes due to change orders unless already recorded by revised drawing or bulletin drawing. ***Underground conduit installations shall be dimensioned from a fixed point(s) on the drawings in all three (3) dimensions***.

B. These records shall be submitted in one of two formats: either a clean, legible, marked set of prints with all markings in distinguishable colored pencil such as red; or a set of reverse-run reproducible sepia prints marked in soft pencil so that blue-line prints can be reproduced as required. The format to be used shall be as defined in the General Requirements section of the contract documents. If no format is defined, the marked blue-line prints shall be submitted.

C. Operation and Maintenance manuals shall be submitted to the Designer at 80% completion. Information included shall be a copy of all submittal data, shop drawings and necessary operating and maintenance instructions and wiring diagrams on all major items of equipment and all special systems (fire alarm, intercom, etc.). Submit these manuals in the quantities and format described in the General Requirements section.

END OF SECTION 260500

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Field quality-control test reports.

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.
B. Conductor Insulation: Comply with NEMA WC 70 for Types THW, and THHN-THWN.

2.2 CONNECTORS AND SPLICES

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

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Coordinate sleeve selection and application with selection and application of firestopping specified in Specification Section "Firestopping."

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid or stranded for No. 10 AWG and smaller **except stranded wire shall be provided where wiring is connected to vibrating equipment**; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN-THWN, single conductors in raceway.

D. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN-THWN, single conductors in raceway.

G. Class 1 Control Circuits: Type THHN-THWN, in raceway.

H. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

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 splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

I. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Specification Section "Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

D. Cut sleeves to length for mounting flush with both wall surfaces.

E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Specification Section "Joint Sealants."

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Specification Section "Penetration Firestopping."

J. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

K. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

L. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.6 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Specification Section "Firestopping."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements of other sections.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

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

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Field quality-control test reports.

1.3 QUALITY ASSURANCE

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Receptacle circuits.
3. Single-phase motor and appliance branch circuits.
4. Three-phase motor and appliance branch circuits.
5. Flexible raceway runs.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

END OF SECTION 260526

SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.2 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

1.3 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.
B. EMT: ANSI C80.3.
C. FMC: Zinc-coated steel.
D. LFMC: Flexible steel conduit with PVC jacket.
E. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Fittings for EMT: Steel, compression insulated throat type.

2.2 BOXES, ENCLOSURES, AND CABINETS

A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
C. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
D. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

E. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit.
2. Concealed Conduit, Aboveground: Rigid steel conduit.
3. Underground Conduit: Rigid Steel conduit, unless otherwise noted on the Drawings.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: Type NEMA 4X Stainless Steel.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:

   a. Mechanical rooms below 8’-0” AFF.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.

C. Minimum Raceway Size 3/4-inch (21-mm) trade size, interior applications, and 1-inch for underground applications and interior telecommunications applications.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. EMT: Use steel compression fittings; connectors shall have insulated throats.
3. EMT: Where conduits do not terminate in a box or other enclosure, provide with insulated throat connector at termination point.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

I. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

J. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.

K. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70, including service entrance points (NEC230-8).

L. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

M. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

N. Where concentric, eccentric or over-sized knockouts are encountered, a grounding-type insulated bushing shall be provided.

O. GRC shall be terminated with either double lock nuts/bushings or in a threaded hub.

P. The use of LBs shall be limited as much as possible. Where used for raceway larger than 2” in size, “mogul” type bodies shall be provided.

Q. Set metal floor boxes level and flush with finished floor surface.

R. No flexible conduits or condulets shall be used for Telecommunications cabling installation. In addition, pull boxes must be installed on all Telecommunications raceway where the number of bends exceeds 180 degrees between boxes.

S. Boxes and Conduit shall be painted as identified in other sections of the specifications or as detailed on the Drawings. Circuit information on above ceiling boxes shall be clearly indicated with indelible marker on all lighting and power circuits.

3.3 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Specification Section "Firestopping."

END OF SECTION 260533

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Identification for conductors and communication and control cable.
2. Warning labels and signs.
3. Equipment identification labels.

1.2 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

1.4 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

PART 2 - PRODUCTS

2.1 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Marker Tape: Vinyl or vinyl -cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.2 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Fasteners for Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

F. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 mm)."
3. Arc Flash Hazard Warning: “DANGER-ARC FLASH AND SHOCK HAZARD-APPROPRIATE PPE REQUIRED”

a. Label shall include a location for the following information to be written in by the Contractor; Flash Hazard Category, Min. Arc Rating, Flash Hazard Boundary.
b. Contractor shall refer to the riser diagram for this information and confer with the Designer at the end of the Project to confirm that the values are still valid. Contractor shall finalize labeling after receiving approval of the Designer.

2.3 EQUIPMENT IDENTIFICATION LABELS

A. Engraved phenolic labels, lettering no less than 3/8” high.

PART 3 - EXECUTION

3.1 APPLICATION

A. Auxiliary Electrical Systems Conductor and Cable Identification: Use marker tape to identify field-installed alarm, control, signal, sound, intercommunications, voice, and data wiring connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and cable pull points. Identify by system and circuit designation.
2. Use system of designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

B. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

   a. Blue surface with white core for 208Y/120 volt equipment.
   b. Black surface with white core for 480Y/120 volt equipment
   c. Red surface with white core for life safety equipment

2. Equipment to Be Labeled:

   a. Panelboards, electrical cabinets, and enclosures.
   b. Enclosed circuit breakers and disconnect switches.
   c. Motor starters and VFDs. Division 26 shall provide all labels.
   d. Fire alarm panel.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. Paint conduit and boxes per Wake County Standards. Refer to the Drawings for additional information.

G. Color-Coding for Phase Identification, 600 V and Less: Use the colors listed below for ungrounded conductors UNLESS EXISTING COLOR CODING DIFFERS:

1. Color shall be factory applied.
2. Colors for 208Y/120-V Circuits:

   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.

d. Neutral: White
e. Ground: Green

3. Colors for 480Y/277-V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.
d. Neutral: Gray
e. Ground: Green

END OF SECTION 260553

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following lighting control devices:

1. Indoor occupancy sensors.
2. Lighting contactors.

B. See Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Field quality-control test reports.
C. Operation and maintenance data.

1.3 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 INDOOR OCCUPANCY SENSORS

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

1. Hubbell Lighting.
2. Leviton Mfg. Company Inc.
3. Sensor Switch, Inc.
4. Watt Stopper (The).

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.

3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.

C. Dual-Technology Type: **Wall/Ceiling** mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of **1000 square feet (110 square meters)** when mounted48 inches (1200 mm) above finished floor.

2.2 LIGHTING CONTACTORS

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

1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. GE Industrial Systems; Total Lighting Control.
3. Hubbell Lighting.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Square D; Schneider Electric.
6. TORK.

B. Description: Electrically operated and **electrically** held, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.

2.3 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to **two** visits to Project during other than normal occupancy hours for this purpose.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch (13 mm).

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

END OF SECTION 260923

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, **20** A.
2. GFCI receptacles, 125 V, 20 A.
3. Occupancy sensors.
4. Digital timer light switches.
5. Wall plates.

1.3 DEFINITIONS

A. AFCI: Arc-fault circuit interrupter.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with requirements in this Section.

F. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

G. Device Color:

1. Wiring Devices Connected to Normal Power System: **Gray** unless otherwise indicated or required by NFPA 70 or device listing.

H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A :
1. Description: Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.

3. Standards: Comply with UL 498 and FS W-C-596.

B. Weather-Resistant Duplex Receptacle, 125 V, 20 A :
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

2.3 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A :
1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.4 OCCUPANCY SENSORS

A. Wall Switch Sensor Light Switch, Dual Technology :
1. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) technology.
2. Standards: Comply with UL 20.
3. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
4. Adjustable time delay of **20** minutes.
5. Connections: Provisions for connection to BAS.
6. Connections: RJ-45 communications outlet.
7. Connections: Integral wireless networking.

2.5 TIMER LIGHT SWITCH

A. Digital Timer Light Switch
1. Description: Switchbox-mounted, combination digital timer and conventional switch lighting-control unit, with backlit digital display, with selectable time interval in **20**-minute increments.
2. Standards: Comply with UL 20.
3. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
4. Integral relay for connection to BAS.

2.6 DIMMERS

A. Wall-Box Dimmers:

1. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
2. Control: Continuously adjustable **slider**; with single-pole or three-way switching.
3. Standards: Comply with UL 1472.
4. LED Lamp Dimmer Switches: Modular; compatible with LED lamps.

2.7 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: **0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel**.
3. Material for Unfinished Spaces: **Galvanized steel**.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant**, die-cast aluminum** with lockable cover.

D. Antimicrobial Cover Plates:

1. Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
2. Tarnish resistant.

2.8 FLOOR SERVICE FITTINGS (TYPE FB-1 BOX)

A. Flush-Type Floor Service Fittings:
1. Description: Type: Modular, flush-type, dual-service units suitable for wiring method used, with cover flush with finished floor.
2. Compartments: Barrier separates power from voice and data communication cabling.
3. Service Plate and Cover: Rectangular, die-cast aluminum with finish by Architect.
4. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
5. Data Communication Outlet: N/A

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles **up**, and on horizontally mounted receptacles to the **right**.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

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

D. Prepare test and inspection reports.

END OF SECTION 262726

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SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.

1.2 DEFINITIONS

A. NC: Normally closed.
B. NO: Normally open.
C. SPDT: Single pole, double throw.

1.3 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

C. Field quality-control reports.

D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified third party testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses, lockable handle with capability to accept three padlocks, and provided with a defeatable interlock with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Suitable for number, size, and conductor material.
5. Auxiliary Form C contact that changes state based on position of handle.

2.2 NONFUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and provided with a defeatable interlock with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Suitable for number, size, and conductor material.
4. Auxiliary Form C contact that changes state based on position of handle.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.

2. **Outdoor Locations: NEMA Type 4X, Stainless Steel.**

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.2 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection report, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

END OF SECTION 262816

SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

1.3 DEFINITIONS

A. BF: Ballast factor.
B. CRI: Color-rendering index.
C. CU: Coefficient of utilization.
D. HID: High-intensity discharge.
E. LER: Luminaire efficacy rating.
F. Luminaire: Complete lighting fixture, including ballast housing if provided.
G. RCR: Room cavity ratio.

1.4 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Ballast.
4. Energy-efficiency data.
5. Life, output, and energy-efficiency data for lamps.
6. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.

   a. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.

1. Wiring Diagrams: Power wiring.

C. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture Schedule. Each sample shall include the following:

1. Lamps: Specified units installed.
2. Accessories: Cords and plugs.

D. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.

E. Qualification Data: For agencies providing photometric data for lighting fixtures.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

H. Warranties: Special warranties specified in this Section.

I. SPECIAL SHOP DRAWING SUBMITTAL

1. The contractor shall provide a full photometric point-by-point analysis of the First and Second Floors (excludes the Ground Floor) utilizing the submitted lighting fixtures for this project. Analysis shall be on a 5’-0” “grid”.
2. Shop drawings shall show two scenarios-a) full illumination of the levels under normal conditions and b) illumination of the levels under emergency lighting conditions.
3. The Designer will provide CADD drawings files and other pertinent data for use by the Contractor and the vendor in producing these documents.
4. The Designer may request up to three (3) iterations of this submittal.
5. This submittal SHALL be provided with the Product Data package. One will not be reviewed without the other.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

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

C. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
4. LED Luminaire Warranty:
   a. Provide a comprehensive written 5-year warranty for including luminaire finish, on-site replacement of material, and workmanship. On-site replacement includes transportation, removal, and installation of new products. Finish warranty shall include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
   b. Provide a written 5-year replacement material warranty for defective or non-starting LED source assemblies.
   c. Provide a written 5-year replacement material warranty on all PSUs.
   d. Provide a written 5-year replacement warranty for non-maintained illuminance levels on all light sources (LED package, LED array, or LED module) including, but not limited to the LED die, encapsulate, and phosphor. If the expected useful life of the luminaire system as defined in this specification is not maintained, then the manufacturer shall replace the light source(s) or luminaire as needed.
   e. Provide a written 5-year warranty that LED color shift from initial shall color be less than 0.007 on the CIE 1976 (u’,v’) diagram

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. LED Modules: 5 for every 100 of each type and rating installed. Furnish at least five (5) of each type.
2. Drivers: 5 for every 100 of each type and rating installed. Furnish at least five (5) of each type.
3. Fixture Types: one (1) of each type except Type PA2.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

F. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metallized Film: 90 percent.

G. Plastic Diffusers, Covers, and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

   a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless different thickness is indicated.
   b. UV stabilized.

2. Glass: Annealed crystal glass, unless otherwise indicated.

2.2 LED LIGHTING

A. General:

1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
3. LED drivers shall include the following features unless otherwise indicated:

   a. Minimum efficiency: 85% at full load.
   b. Minimum Operating Ambient Temperature: -20˚ C. (-4˚ F.)
   c. Input Voltage: 120 - 277V (±10%) at 60 Hz.
   d. Integral short circuit, open circuit, and overload protection.

e. Power Factor: ≥ 0.95.
f. Total Harmonic Distortion: ≤ 20%.
g. Comply with FCC 47 CFR Part 15.

4. LED modules shall include the following features unless otherwise indicated:

a. Comply with IES LM-79 and LM-80 requirements.
b. Minimum CRI 80 and color temperature 3000˚ K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
c. Minimum Rated Life: 50,000 hours per IES L70.
d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Downlights:

1. Housing, LED driver, and LED module shall be products of the same manufacturer.

2.3 EXIT SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

a. Battery: Sealed, maintenance-free, nickel-cadmium type.
b. Charger: Fully automatic, solid-state type with sealed transfer relay.
c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.4 EMERGENCY LIGHTING UNITS

A. Description: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. Operation: Relay automatically turns lamp on when power supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.

2.5 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 16 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

E. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.

3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Adjust aimable lighting fixtures to provide required light intensities.

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

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 265100

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Optical-fiber-cable pathways and fittings.
3. Hooks.
4. Boxes, enclosures, and cabinets.

1.2 ACTION SUBMITTALS

A. Product data for each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale and coordinated with each other, using input from installers of items involved.

B. Qualification Data: For professional engineer.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-D.

C. EMT: Comply with ANSI C80.3 and UL 797.

D. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
2. Fittings for EMT:

a. Material: Steel.
b. Type: Compression.

2.2 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for riser installation unless otherwise indicated.

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

2.3 HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with TIA-569-D.

D. Galvanized steel.

E. J shape.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-D.
2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Metal Floor Boxes:

1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Minimum Pathway Size: 1-inch trade size.

B. Pathway Fittings: Compatible with pathways and suitable for use and location.

C. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

D. Install surface pathways only where indicated on Drawings.

3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

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

D. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

E. Complete pathway installation before starting conductor installation.

F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.

G. Support conduit within 12 inches (300 mm) of enclosures to which attached.

H. Pathways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.
3. Arrange pathways to keep a minimum of 2 inches (50 mm) of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

I. Stub-ups to Above Recessed Ceilings:

1. Use EMT for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

K. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.

L. Cut conduit perpendicular to the length. For conduits of 2-inch (50-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

M. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

N. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.

O. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

P. Hooks:

1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
4. Space hooks no more than 5 feet (1.5 m) o.c.
5. Provide a hook at each change in direction.

Q. Mount boxes at heights indicated on Drawings. Install boxes with height measured to center of box unless otherwise indicated.

R. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

S. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

T. Set metal floor boxes level and flush with finished floor surface.

U. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 270528

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SECTION 283111 L - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Magnetic door holders.
7. Addressable interface device.
8. Digital alarm communicator transmitter.

1.2 SYSTEM DESCRIPTION

A. Noncoded, addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

1.3 SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.
b. NICET-certified fire-alarm technician, Level III minimum.

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

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector

housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.

6. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. Qualification Data: For qualified Installer.

E. Field quality-control reports.

F. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

   a. Frequency of testing of installed components.
   b. Frequency of inspection of installed components.
   c. Requirements and recommendations related to results of maintenance.
   d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

G. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

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.

PART 2 - PRODUCTS

2.1 MANUFACTURER'S/MODELS

A. Manufacturer's/Models: Subject to compliance with requirements in section 1.3.A above, and to meet UL and NFPA requirements related to use of devices with existing systems, the current manufacturer and corresponding panel models that are acceptable to be incorporated into the contract are limited to the following:

1. Edwards System Technology (EST3)
2. Notifier (NSF640 and NSF3030)
3. FCI (S3/E3)

B. All fire alarm panels, components and devices shall be non-proprietary and parts, service, etc shall be available from multiple independent suppliers within 100 miles of the project site."

2.2 FIRE ALARM CONTROL PANEL (FACP)

A. FACP - Minimum Requirements: The CPU shall communicate with and control the following types of equipment used to make up the system: addressable detectors, addressable modules, local and remote operator terminals, printers, annunciators, and other system controlled devices. The main FACP shall perform the following functions:

1. Supervise and monitor all addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
2. Supervise all initiating, signaling, and notification circuits throughout the facility by way of connection to monitor and/or control modules.
3. Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed.
4. Visually and audibly annunciate any trouble, supervisory or alarm condition on operator's terminals, panel display, and annunciators.
5. The FACP shall include a full featured operator interface control and annunciation panel that shall include a backlit, 80 character liquid crystal display, individual, color coded system status LED's, and an alphanumeric keypad for the field programming and control of the fire alarm system.
6. All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel, and shall be password protected with multiple access levels.
7. **System shall be modular in construction. Provide "plug&play" style encapsulated components/units that can be inserted into any relevant slot in the panel.**
8. Shall comply with the UL 9th Edition.

B. System Capacity and General Operation: The system shall have the following capacities and general operation modes:

1. Signal Line Circuits (SLC's): The FACP shall be capable of connecting the number of devices shown in the drawings to SLC's. Alarm, trouble and supervisory signals from all addressable reporting devices shall be encoded onto a Class A Signaling Line Circuit (SLC), (NFPA Style 6), with the capacity for expansion up to at least 198 total addressable devices per SLC and up to at least 636 total points per system. Each SLC shall not carry more than 80% of its rated load capacity on a new system installation. Provide a minimum of one spare SLC card.
2. Initiation Device Circuits: Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D).
3. Notification Appliance Circuits: Notification appliance circuits shall be wired Class B (NFPA Style Y).
4. Digitized Electronic Signals: Shall employ check digits or multiple polling. In general a single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
5. Fire alarm system shall be provided with hot-key overrides for HVAC and AV operation.
6. Loss of Power: Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
7. System Response to an Alarm Condition: When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:

    a. The system alarm LED shall flash.
    b. A local piezo-electric signal in the control panel shall sound.
    c. The 80-character LCD display shall indicate all information associated with the fire alarm condition including: the type of alarm point, the initiating device address and the description of its physical location within the protected premises.
    d. History logging of all information associated with the event, including time and date of occurrence.
    e. Activate all system outputs, including program assigned via control-by-event equations, shall be executed by the particular point in alarm. Exact programming shall be provided by the Contractor to meet the Owners requirements.
    f. Activate all fire alarm Notification Appliances in the building, sounding and flashing in synchronization continuously until manually silenced, or until the initiating device and control unit has been reset to normal condition.
    g. Activate digital alarm communicator.
    h. Deactivate door hold control relay such that all smoke doors are allowed to close.
    i. Deactivate control relays allowing HVAC units to stop.
    j. Activate elevator recall sequence as necessary.
    k. Transmission of all data to any remote annunciation panels.

8. System Response to Trouble and Supervisory Conditions:

    a. The system trouble and/or supervisory LED(s) shall flash.
    b. A local piezo-electric signal in the control panel shall sound.
    c. The 80-character LCD display shall indicate all information associated with the trouble or supervisory condition including: the type of device point, the device address and the description of its physical location within the protected premises.

d. History logging of all information associated with the event, including time and date of occurrence.
e. Activate digital alarm communicator.
f. System AC power trouble signal shall not be sent unless maintained for 8 hours (or more).
g. Provide adjustable time delay for all trouble signals prior to transmission.
h. Transmission of all data to any remote annunciation panels.

C. Remote Transmissions: The FACP shall be interfaced to a separate, Digital Alarm Communications Transmitter (DACT). An integral DACT shall be acceptable on the condition of total compatibility with the owners receiving station equipment. The DACT shall be equipped with backup batteries with an automatic battery charging circuit, capable of performing a self test every 24 hours any failure shall initiate a trouble condition, generating a 24 hour test report to the receiving station equipment, and dual phone line capability. The following signals, in order of precedence shall be reported as applicable:

1. Fire.
2. Trouble.
3. Supervisory.

The unit shall transmit individual addresses and information via contact ID to the Owner's receiving station. Contractor shall coordinate testing with Owner at least two weeks prior to final inspections.

D. Power Supply(ies): The FACP power supply(ies) shall operate on 120 VAC, 60 Hz and shall be adequate to power all equipment and functions in full alarm continuously utilizing only 60% of the rated output. Signal circuits shall each be loaded no more than 60% of their rated capacity. All modules and drivers must be able to withstand prolonged short circuits in the field wiring, either line-to-line or line-to-ground, without damage.

E. Emergency Power Supply: Components include batteries, charger, and automatic transfer circuitry.

1. Batteries: Shall be completely maintenance free, sealed lead calcium construction with fully gelled electrolyte. Battery nominal life expectancy of 15 years, minimum, is required. Battery voltage and capacity shall be determined by the measured load calculations required by the FACP and related connected equipment. Battery shall have sufficient capacity to power the FACP for not less than twenty-four hours standby, plus 5 minutes of full alarm output upon a normal AC power failure.
2. Battery Charger: Solid state, fully automatic, variable-charging-rate type. Provide capacity for 150% of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger charges them completely within four hours. Charger output is supervised as part of system power supply supervision.
3. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

F. Serial Interface Board: The FACP shall contain a serial interface board to provide an EIA 232 interface between the fire alarm control panel and the UL Listed Electronic Data Processing

(EDP) peripherals. The serial interface board shall allow the use of multiple printers, CRT monitors, and other peripherals connected to the EIA 232 ports. In addition, the serial interface board shall provide one EIA-485 port for the serial connection to annunciation and control subsystem components; LED's shall be provided to show operational status. All serial interface input/outputs shall be optically isolated to provide protection from surges and/or earth grounds.

2.3 AUXILIARY POWER SUPPLY PANELS (APS)

A. APS - Minimum Requirements: All APS(s) shall operate on 120 VAC, 60 Hz and shall have a continuous rating adequate to power all equipment and functions in full alarm continuously utilizing no more than 80% of the total rated ampere output capacity. Additionally, no more than 80% per individual output circuit ampere capacity shall be utilized. All modules and drivers must be able to withstand prolonged short circuits in the field wiring, either line-to-line or line-to-ground, without damage. The APS shall provide a battery charger for 24 hours of standby using dual rate-charging techniques for fast battery recharge. The APS shall be capable of providing a minimum of 24 hours of standby power with an additional 5 minutes in full alarm output, for powering all connected devices. All APS's shall be capable of providing the following general requirements, features, and functions when utilized as an integral part of the system:

1. Shall be capable of being externally triggered or initiated by the FACP, via an addressable control module, for all required output activations.
2. Shall provide multiple regulated and conditioned +24VDC output circuits capable of being supervised with on board LED's for fault indication per output circuit.
3. Shall provide at least (1) one +24VDC auxiliary type output.
4. Shall be capable of battery supervision with an onboard LED fault indicator.
5. Shall provide ground fault monitoring circuitry.
6. Shall provide at least (1) Form "C" dry contact or other on board form of dry contact output that will change states during any fault condition detected, for connection to (1) one addressable monitoring device for individual APS, FACP supervision.
7. Output circuits shall have the capability of being selectively disabled, via on board switch configurations, during any AC power failures.

B. Back-up Batteries: Shall be completely maintenance free, sealed lead calcium construction with fully gelled electrolyte. Battery nominal life expectancy of 15 years, minimum, is required. Battery voltage and capacity shall be determined by the measured load calculations required by the APS and related connected equipment. Battery shall have sufficient capacity to power the APS for not less than twenty-four hours standby, plus 5 minutes of full alarm output upon a normal AC power failure.

C. Enclosures: The APS shall be housed in a UL listed cabinet suitable for surface or semi flush mounting. Cabinet and front shall be corrosion protected, given a rust resistant prime coat, and manufacturer's standard finish. The door shall provide a key lock. For convenience, the door may be hinged on either the right or left side (field selectable). Where multiple enclosures are required in the same area, the cabinets shall all be the same size and color. Cabinet doors must be electrically bonded to enclosure it serves.

2.4 ALARM NOTIFICATION APPLIANCES

A. Audible Devices: Shall be located as shown on the Drawings; sounders located outdoors shall be listed for use in wet locations and shall have the following specifications:

1. Voltage: Shall operate on 24 VDC nominal.
2. Programming: Shall be field programmable without the use of special tools, to provide slow whoop, continuous, three pulse temporal or interrupted tones with an output sound level of at least 90 dBA measured at 10 feet from the device.
3. Mounting: Provide surface mounting devices suitable for mounting in a standard device box unless otherwise indicated on the Drawings.

B. Strobe Lights (Strobes): Strobes shall be located as shown on the Drawings. Strobes indicated for use outdoors shall be mounted at the indicated elevation and listed for use in wet locations. Strobe lights shall flash in synchronization and shall have the following specifications:

1. Voltage: Strobe lights shall operate on 24 VDC nominal.
2. Maximum pulse duration: 2/10ths of one second.
3. Mounting: Provide surface mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Unless otherwise indicated on the Drawings, strobe lights shall be mounted at 6'-8" (2.3 M) Above Finished Floor (AFF) or 6" (15.3 Cm) Below Finished Ceiling (BFC), whichever is lower. Ceiling mounted devices are not permitted without specific location approvals by the owner.
4. Strobe intensity and flash rate: Must meet minimum requirements of UL 1971. Provide synchronous strobe lights with specific intensity Candela (Cd) rating of 177 Cd in all locations unless indicated otherwise on the drawings.

C. Audible/Visual Combination Devices: Shall be located as shown on the Drawings and shall comply with all applicable requirements for both Horn and Strobe Lights.

2.5 INITIATING DEVICES

A. Non-Addressable Type Devices – General: Unless otherwise indicated on the Drawings all initiating devices shall be individually addressable. In some cases, the use of non-addressable devices with an addressable monitor type module installed in a conditioned space will be necessary. These areas shall be identified on the Drawing with the acceptable device type for the specific locations.

B. Addressable Type Devices – General: Unless otherwise indicated on the Drawings all initiating devices shall be individually addressable. Addressable devices shall comply with the following general requirements:

1. Address Setting: Addressable devices shall provide an address setting means inherent within the device. Devices, which are addressed by the FACP are also acceptable.

2. Connections: Addressable devices shall be connected to a Signaling Line Circuit (SLC) with (2) two wires. Signaling Line Circuits shall originate at the FACP.
3. Device Identification: Addressable devices shall store an internal specific identifying “type” code that the FACP shall use to identify the type of device.
4. Temperature Ratings: Addressable devices shall not be utilized in unconditioned spaces where temperature and/or humidity ranges can exceed the manufactures recommended ratings of the electronic component circuitry for proper operation.
5. Operational Indications: Addressable devices shall provide powered LED’s. LED’s shall flash under normal conditions, indicating that the device is operational and in regular communication with the FACP. LED’s shall be placed into steady illumination by the FACP to indicate that an alarm or off normal condition has been detected. The flashing mode operation of the detector LED’s shall be optional through the system field program. An output connection shall also be provided in the device base to connect an external/remote LED indication of an alarm or off normal condition in specific required locations.
6. Device Mounting: Unless otherwise specified all devices shall provide the following mounting criteria:

   a. All detectors shall be ceiling-mount type and shall include a separate twist-lock base with a tamper proof feature.
   b. All other addressable devices, remote LED indicators, remote test switches, and isolation modules shall be wall-mount type.

7. Test Means: Detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the FACP. Such a test may be initiated at the detector itself (by activating a magnetic switch), or initiated remotely through means of a test switch (either magnetically or key operated), or on command from the FACP when in the "test" mode of operation.

C. Manual Stations (Pull Stations): Unless otherwise indicated on the Drawings all pull stations shall comply with the following additional requirements:

1. All pull stations shall have a dual-action mechanism requiring two actions to initiate an alarm condition.
2. All pull stations shall provide a clear visual indication when operated, and shall utilize a key type reset for restoral to normal operation. Pull stations that employ a glass break rod are not acceptable.
3. Construction: Pull stations shall be constructed of Lexan or other material suitable to the installation environment with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger. Stations shall be suitable for surface mounting or semi flush mounting as shown on the plans.

D. Smoke Detectors: Unless otherwise indicated on the Drawings all smoke detectors shall comply with the following additional requirements:

1. All smoke/duct detectors shall be "intelligent" in that smoke detector sensitivity shall be set through the FACP and shall be capable of adjustment in the field through the field programming of the system. Sensitivity shall be capable of being automatically adjusted

by the FACP program on a time of day basis. The FACP program must also be capable of automatically compensating for dust accumulation and other slow environmental changes that may affect performance of the smoke and/or duct detectors. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA 72. Devices shall be capable of reporting obscuration levels and maintenance alerts when any smoke/duct detector approaches 80% of its alarm threshold due to gradual contamination.

2. All detectors shall be the plug in type with a separate base to facilitate testing and maintenance.
3. All detector bases shall provide locking tabs for all models located within 12’ of floor and shall provide skirts for the bases to create a finished appearance. Terminals in the fixed base accept the system wiring.
4. Photoelectric Smoke Detectors: Photoelectric smoke detectors shall use the photoelectric (light scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density. Unless otherwise indicated on the Drawings all smoke detectors shall be photoelectric type.
5. Ionization Smoke Detectors: Ionization smoke detectors shall use the dual-chamber ionization principal to measure products of combustion and shall, on command from the control panel, send data to the panel representing the analog level of products of combustion. Ionization type smoke detectors are indicated on the Drawings by the designation ION adjacent to the smoke detector symbol.

E. Non-Addressable Thermal Detectors (Heat): Unless otherwise indicated on the Drawings all heat detectors shall comply with the following additional requirements:

1. Heat Detectors shall be rated at 200°F. (93.3°C.) and unless otherwise indicated on the Drawings shall have a rate-of-rise element rated at 15°F. (-9.4°C.) per minute.
2. Heat detectors located outside conditioned spaces shall be UL listed for Outdoor Use.

2.6 MONITOR AND CONTROL DEVICES

A. Addressable Dry Contact Monitor Modules: Addressable Monitor Modules shall be provided to connect (1) one non-addressable device or to supervise a non-addressable IDC zone (either Style D or Style B) of conventional type alarm initiating devices (any Normally Open [N.O.] dry contact device) to one of the Fire Alarm Control Panel Signaling Line Circuit Loops. Monitor modules shall be installed as required by the system configuration. All required monitor modules may not be shown on the Drawings.

1. Indication of Operation: Unless otherwise indicated on the Drawings an LED shall be provided that shall flash under normal conditions, indicating that the Monitor Module is operational and in regular communication with the FACP.
2. Mounting Requirements: Monitor Modules shall be mounted in a standard 4-inch square, 2-1/8” deep electrical box at the same height requirement as Notification Appliance devices in a clearly visible location.

B. Addressable Control Modules: Addressable Control Modules shall be provided to supervise and control the operation of (1) one conventional Notification Appliance Circuit (NAC) of compatible, 24 VDC powered, polarized Audio/Visual (A/V) Notification Appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay. The control module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. An LED shall be provided that shall flash under normal conditions, indicating that the control module is operational and is in regular communication with the control panel. Control modules shall be rated for the load they control. (Inductive Loads require inductive rated modules.)

1. Mounting Requirements: Control Modules shall mount in a standard 4-inch square, 2-1/8” deep electrical box, and shall only be installed in conditioned spaces.
2. Configuration: The control module NAC circuit may be wired for Style Y Class B with up to 1 Amp of inductive A/V signal, or 2 Amps of resistive A/V signal operation, or as a dry contact (Form C) relay. The control module shall be suitable for pilot duty applications and rated for a minimum of 0.6 amps at 30 VDC. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relay or NAC’s may be energized at the same time on the same pair of wires.
3. Power Source: Audio/visual power shall be provided by a separate supervised power loop from the main fire alarm control panel or from a supervised, UL listed remote power supply. A/V power sources and connections are not shown on the Drawings
4. Test Switch: A magnetic test switch shall be provided to test the module without opening or shorting its NAC wiring.

C. Isolator Modules: Isolator Modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The Isolator Module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop.

1. Operation: Isolator Modules shall operate such that if a wire-to-wire short occurs, the Isolator Module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the Isolator Module shall automatically reconnect the isolated section. The Isolator Module shall not require any address setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an Isolator Module after its normal operation.
2. Locations: Provide (2) Isolator Modules at the FACP for both ends of each SLC loop. Provide a minimum of one (1) Isolator Module in the field at the mid-point of the device loop. Provide additional modules necessary to limit the number of devices between isolators to 24.
3. Mounting: The Isolator Module shall mount in standard 4-inch square, 2-1/8" deep electrical boxes, wall mounted at the same height as A/V devices in a clearly viewable area in corridors. It shall provide a single LED that shall flash to indicate that the Isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

2.7 MISCELLANEOUS SYSTEM ITEMS

A. Remote Display Annunciators: The FACP should be located at the main entrance to the facility in concurrence and request of the Owner and the AHJ. On rare instances when the fire alarm panel cannot be placed at the main entrance, a remote annunciators shall be installed with the following capabilities:

1. Alphanumeric Display Annunciators: Shall be supervised and remotely located as specified on the Drawings.

   a. Unit shall have a back-lit LCD display containing a minimum of (80) eighty characters for alarm annunciation in clear English text.
   b. The LCD annunciator shall display all alarm, trouble, and supervisory conditions in the system and provide duplicate “active” manual switching functions of the FACP, including: Acknowledging, Signal Silencing, System Reset, and Test/Drill.
   c. The annunciator shall be in a lockable cabinet keyed the same as the FACP.
   d. Connections: The annunciator shall connect to a two-wire EIA-485 interface. The two-wire connection shall be capable operation at distances of 6,000 feet. Provide interface to fiber optic cable systems and/or repeater units where such are indicated on the Drawings.
   e. System Capacity: The system shall allow a minimum of four LCD annunciators. In addition to annunciation functions, each LCD annunciator shall be capable of the following software programmed system functions: Acknowledge, Signal Silence and Reset.

2. Serially Connected LED Annunciator: Annunciator shall communicate with the fire alarm control panel via an EIA-485 communications loop (four-wire) and shall individually annunciate all zones in the system. System zones shall be as indicated on the Drawings.

   a. Annunciator Indicators: The annunciator shall provide a red Alarm LED per zone, yellow Trouble LED, and Supervisory Trouble LED per zone. The annunciator shall also have an "ON-LINE" LED, local piezo sounder, local acknowledge/lamp test switch, and custom zone/function identification labels. Annunciator switches may be used for System control such as, Global Acknowledge, Global Signal Silence, and Global System Reset. All annunciator switches and indicators shall be software programmable.
   b. The annunciator shall be in a key lockable cabinet.

3. LED Graphic Display Panel:

   a. Annunciator Indicators: The annunciator shall provide a red Alarm LED per zone, yellow Trouble LED, and Supervisory Trouble LED per zone. The annunciator shall also have an "ON-LINE" LED, local piezo sounder, local acknowledge/lamp test switch, and custom zone/function identification labels. Annunciator switches may be used for System control such as, Global Acknowledge, Global Signal Silence, and Global System Reset. All annunciator switches and indicators shall be software programmable.
   b. Framed under glass graphic shall provide a LED lamp zone matrix/grid displaying each type of initiating device (manual stations, smoke detectors, thermal detectors, elevator lobby detectors, water flow, and supervisory) for each floor contained in the facility. The Owner must approve the specific floor labeling prior to

construction. Floor references may vary per facility (i.e. Ground Floor may be referred to as 1st Floor).

c. The annunciator shall be in a key lockable cabinet.

4. Remote Annunciator Indicator Light (RAIL): Remote annunciator indicator lights shall be provided in locations where indicated on the Drawings. In addition, RAIL's shall have the following features:

a. RAIL's shall be provided with a key type switch for testing of the annunciated device.
b. Voltage: RAIL's shall operate on 24 VDC nominal.
c. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. They shall be mounted in the wall at the same height as A/V devices. Do not mount in ceiling tiles.

B. Wire:

1. Non-Power-Limited Circuits: Copper conductors with 600V rated, THHN/THWN, color coded insulation.

a. Low Voltage Circuits: STRANDED, #18 AWG, minimum.
b. Line Voltage Circuits: SOLID, #12 AWG, minimum.

2. Power Limited Circuits: NFPA70, Types FPL, FPLR, or FPLP, as recommended by the manufacturer. Data Loop wire shall be shielded pair #18 AWG, 30 pf/ft capacitance or less, unless specifically prohibited by the manufacturer and stated on the wiring submittal.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

C. Smoke- or Heat-Detector Spacing:

1. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.
2. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.

D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

E. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

F. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

G. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.

H. Device Location-Indicating Lights: Locate in public space near the device they monitor.

I. Fire-Alarm Control Unit: Surface mounted or semi-recessed as noted, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

3.2 CONNECTIONS

A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Supervisory connections at valve supervisory switches.

B. Identify system components, wiring, cabling, and terminals.

C. Install framed instructions in a location visible from fire-alarm control unit.

3.3 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.4 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction

B. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 283111