SECTION 230100 – TABLE OF CONTENTS

DIVISION 01 - GENERAL

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

END OF TABLE OF CONTENTS

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1: GENERAL

1.1 RELATED PROVISIONS

a. The requirements of the general conditions and of Division 01 apply to that portion of the work specified in this section.

b. These specifications and the accompanying drawings shall include the furnishing of all labor, tools, materials, fixtures, transportation, appurtenances and service necessary and incidental to the installation of a complete and operative system as indicated and intended on the Drawings and as herein specified.

c. Contractor shall coordinate the work and equipment of this division with the work and equipment specified elsewhere in order to assure a complete and satisfactory installation. Work such as excavation, backfill, concrete, flashing, etc., which is required by the work of this Division of the Specifications, shall be provided by this Division unless otherwise indicated.

d. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.

1.2 DESCRIPTION OF THE WORK:

a. Work included under this Division includes installation of a new cooling and heating system and associated electrical system and controls system. The systems shall be installed complete, with boilers, piping, chiller, pumps and auxiliaries as hereinafter called for. Miscellaneous items including conduits, concrete slab, etc., are to be provided as indicated.

b. It shall be the responsibility of the Contractor to provide a complete and operating system according to the true intent and meaning of the plans and specifications and all pipe, controls and equipment, etc.

1.3 DEFINITION

a. The word "Contractor" as used in this Section of the Specifications refers to the HVAC Contractor unless specifically noted otherwise. The word "provide" means furnish, fabricate, complete, install, erect, including labor and incidental materials, necessary to complete in place and ready for operation or use the items referred to or described herein, and/or as shown or referred to on the Contract Drawings.

1.4 HVAC CONTRACTOR'S QUALIFICATIONS

a. It is assumed that the contractor has had sufficient general knowledge and experience to anticipate the needs for a construction of this nature. The contractor shall furnish all items required to complete the construction in accordance with reasonable interpretation of the intent of the Drawings and Specifications. Any minor items required by Code, law or regulations shall be provided whether or not specified or specifically shown.

b. All work must be done by first class and experienced mechanics properly supervised, and it is understood that the Engineer has the right to stop any work that is not being properly done

and has the right to demand that any incompetent workman be removed from the job and a competent workman be substituted therefor.

c. All work must be done in strict accordance with standards of AME, ASHRAE and the building laws of all character in force in the locality where the apparatus is being installed. All work must also be in accordance with rules and regulations of the National Board of Fire Underwriters.

1.5 DUTIES OF CONTRACTOR

a. Contractor is responsible for familiarizing himself with the details of the construction of the building. Work under these specifications installed improperly or which requires changing due to improper reading or interpretation of building plans shall be corrected and changed as directed by Engineer without additional cost to the Owner.

b. Contractor shall leave the premises in a clean and orderly manner upon completion of work, and shall remove from premises all debris that has accumulated during the progress of the work. The HVAC Contractor shall have the permanent HVAC systems in sufficient readiness for furnishing temporary climatic control at the time the building is enclosed. The HVAC systems control shall maintain climatic control throughout the enclosed portion of the building sufficient to allow completion of the interior finishers of the building. A building shall be considered enclosed when it has windows installed and when doorways and other openings have protection which will provide reasonable climatic control. The appropriate climatic condition shall be jointly determined by the Contractor and the Architect. Use of the equipment in this manner shall in no way affect the warranty requirements of the Contractor.

1.6 CODES, RULES, PERMITS AND FEES

a. The contractor shall give all necessary notices, obtain all permits and pay all government sales taxes, fees and other costs including utility connections or extension, in connection with his work; file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments having jurisdiction; obtain all required certificates for inspection for his work and deliver same to the Architect before request for acceptance and final payment for the work.

b. The contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus, ordinances, rules and regulations as required to complete the project in accordance with the intent of the drawings.

c. All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of all governmental departments having jurisdiction.

1.7 SURVEYS AND MEASUREMENTS

a. The contractor shall base all measurements, both horizontal and vertical, from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check correctness of same as related to the work.

b. Should the contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the drawings and Specifications, he shall notify the Architect and shall not proceed with his work until he has received instructions from the Architect.

1.8 PLANS

a. Except where dimensions are shown, mechanical plans are diagrammatic; see Architectural drawings for building dimensions and locations of windows, doors, ceiling diffusers, lights, etc. The plans are not intended to show each and every fitting, valve, pipe or pipe hanger, or a complete detail of all the work to be done, but are for the purpose of illustrating the type of system, pipe and duct sizes, etc. and special conditions considered necessary for the experienced mechanic to take off his material and lay out his work. Contractor shall be responsible for taking such measurements as may be necessary at the job, and adapting his work to the local conditions.

1.9 DRAWINGS AND SPECIFICATIONS

a. Plans are diagrammatic, and it sometimes occurs that conditions exist in buildings which require certain changes in drawings and specifications. In event that such changes are necessary, the same are to be made by Contractor without expense to the Owner, provided however, that such changes, do not require furnishing more material or performing more labor than the true intent of the drawings and specifications demand.

b. It is understood that while the drawings are to be followed as closely as circumstances will permit, the Contractor is held responsible for the installation of the system according to the true intent and meaning of the drawings. Anything not entirely clear on the drawings or in the specifications will be fully explained if application is made to the Engineer. Should however, conditions arise where in the judgment of the Contractor certain changes would be advisable. Contractor will communicate with Engineer and secure approval of the changes before going ahead with the work.

c. The electrical and mechanical systems for this job have been designed on the basis of the mechanical equipment listed or data given herein or on the drawings. It shall be the responsibility of the Contractor to determine that the electrical service outlets, wiring, conduit and all overcurrent protective and safety devices furnished are adequate to meet Code Requirements for the equipment which he proposes to use. Changes required in the electrical system to accommodate the proposed mechanical equipment shall be worked out and the details submitted for approval. The cost of making the necessary changes to the electrical system shall be the responsibility of the Contractor.

1.10 SHOP DRAWINGS

a. Refer to Division 01.

b. All items submitted to Architect for review shall bear stamp or notation indicating contractor's prior review and approval.

c. Any Electrical or other changes required by substituted equipment to be made at no change in contract price.

d. Submit manufacturer's certified performance data for all equipment.

e. Coordinate installation drawings with other parts of the work, whether specified in this Division or other Divisions.

f. Approval of shop drawings by the Engineer shall not relieve the Contractor from his obligation to provide equipment, control, and operation to the true intent of plans and specifications.

g. The Contractor shall submit to the Engineer, within ten (10) days after approval of bids by the owner, a list indicating the manufacturer of all equipment and materials which he proposes to use. After that date, no substitution will be approved and all items shall be as specified.

1.11 SCAFFOLDING, RIGGING, HOISTING:

a. This contractor shall furnish all scaffolding rigging, hoisting, and services necessary to erection and delivery into the premises of any equipment and apparatus furnished. Remove same from premises when no longer required.

1.12 FOUNDATIONS, SUPPORTS, PIERS, ATTACHMENTS:

a. Contractor shall furnish and install all necessary foundations, supports, pads, bases and piers required for all air conditioning equipment, piping, pumps, tanks, compressors, and for all other equipment furnished under this contract.

1.13 SLEEVES AND OPENINGS:

a. Contractor must have an experienced mechanic on the job before concrete slab floors or concrete masonry walls are poured or built into place, whose duty it shall be to locate exact positions of any and all holes necessary for future installation of his pipe work, ducts or equipment. Where pipes pass through concrete or masonry walls or floors, steel pipe sleeves shall be furnished. These shall be the same length as wall thickness and shall extend 1/2" above finished floors. Pipe sleeves in equipment room floors shall extend 3" above refinished floor. Pipe sleeves in equipment room floors shall extend 3" above finished floor. Sleeves shall be placed in position by this Contractor.

b. This Contractor shall arrange for proper openings in the building to admit his equipment. If it becomes necessary to cut any portion of building to admit his equipment, portions cut must be restored to their former condition by this Contractor.

c. This Contractor will provide duct openings or chases in masonry or concrete; however, it is this Contractor's responsibility to advise exact dimensions, shape and locations of openings required in sufficient time for the Contractor to make necessary provisions. This Contractor shall be responsible for correct size and location of each opening for his equipment through these openings.

d. Wall openings that require a fire or smoke damper shall be made as nearly possible to the damper or duct size so that an angle frame can close the opening entirely.

e. Where pipes or ducts penetrate floors or partitions which are fire or smoke barriers, the integrity of the barrier shall not be compromised by such penetration.

1.14 CUTTING AND PATCHING:

a. The Contractor shall do all cutting, fitting and patching as required to install piping and equipment except openings through the roof shall be provided by the General Contractor. Patching shall be done by mechanics skilled in the various trades and work shall match the existing work.

b. All exposed openings in walls and floors for piping shall be core drilled. Cutting of holes by hand will not be allowed.

c. Provide all required protection including but not limited to, welding blankets, dust covers, shoring bracing and supports to maintaining structural integrity, safety and cleanliness of the work.

1.15 EXCAVATION AND BACKFILLING:

a. All excavation and backfilling, pudding and tamping required to properly install work under this contract shall be done by this Contractor.

b. Backfill shall be clear of rocks and trash. Backfilling shall be water tamped so as to provide firm footing for finish work, and shall be maintained at proper level for duration of the Contract. No backfilling shall be done until work to be covered has been inspected. Excessive excavation material shall be deposited on site and leveled as directed by the engineer.

1.16 POURED IN PLACE CONCRETE WORK:

a. Furnish and install all concrete work required for the construction of anchors, guide bases and elsewhere as indicated on the Drawings. Refer to appropriate Section in Division 3 for specification requirements.

PART 2: PRODUCTS

2.1 MATERIALS

a. Provide equipment complete with all components and accessories necessary to its satisfactory operation.

b. Listing of a manufacturer's name in this Division does not infer conformity to all requirements of the Contract Documents, nor waive requirements thereof.

PART 3: EXECUTION

3.1 BELT DRIVES

a. V-belt drives shall be rated at not less than 200% of nominal motor horsepower.

b. Motor sheaves shall be adjustable type.

c. Scheduled fan static pressures are estimated. Provide one extra drive per device as required to allow adjustment to deliver scheduled air quantities against actual system resistance.

d. Provide guards for all belt drives not enclosed within equipment housings. Provide openings in guard at driving and driven sheaves for use of revolution counter.

3.2 MAINTENANCE AND OPERATING INSTRUCTIONS

a. Upon completion of all work, the Contractor shall furnish a complete set of operating instructions for all equipment. Such instructions shall be diagrammatic in form on heavy white paper, suitably framed, protected with glass and hung where directed by the owner. A preliminary draft of the instruction sheets shall be submitted to the engineer for approval before making same.

b. Manufacturer's instruction books, card, etc., (to each individual piece of equipment furnished under this contract) shall be furnished to the owner. These shall contain instructions for the operation and maintenance of all equipment. Where such is not furnished by the manufacturer, the contractor shall give written instructions to the owner for the maintenance of the equipment involved.

c. All above ceiling equipment shall be accessible using a standard step ladder. No special scaffolding or other means of accessibility will be acceptable.

3.3 DUCTS, PLENUM, ETC.

a. As indicated on drawings, provide a system of ducts for supplying returning and exhausting air from various spaces. All details of the ductwork are not indicated and the necessary bends, offsets and transformations must be furnished whether shown or not.

b. All sheet metal ducts, casing, plenums, etc., of sizes indicated, shall be constructed from prime galvanized sheet steel, and shall be in accordance with or equal to standards set forth in latest issue of SMACNA low velocity duct manual for gauges of materials, (2" pressure), workmanship, method of fabrication and erection.

c. All uninsulated panels of ducts over twelve inches (12") wide shall be cross-broken, except on plenums, which shall be braced with angle iron as required to prevent breathing.

d. All ductwork must present a smooth interior and joints must be airtight. Where there is evidence of undue leakage at the joints in low pressure ducts, they shall be sealed with cement similar to Foster 30-02.

e. Depending upon space requirements, round or square elbows may be used as required or at the Contractors option in low velocity ducts. All elbows shall be constructed for minimum pressure drop. All elbows with an inside radius less than 3/4 the width of the duct must be fitted with multiple double thickness turning vanes.

f. No transformations or offsets shall be made with a slope greater than (7 to 1), space conditions permitting.

g. Where indicated on drawings, ductwork is to be lined with flexible fiberglass acoustics material weighing not less than 1 1/2 lb. per cubic foot and having a flame spread classification of not more than twenty-five (25) as listed under Underwriters Laboratories. Liner shall be applied according to SMACNA duct liner standard. Thickness shall be as indicated on the drawings. Duct sizes on plan are inside clear sizes, increase the actual sheet metal size accordingly in sizing the duct.

h. The lining shall be secured to the ductwork with a suitable adhesive and with mechanical fasteners center. Liner shall be cut such that adjacent sections of insulation butt together and are sealed with Foster 30-02 joints.

i. All duct connections to and from all centrifugal fans or cabinets containing fans, shall be made with fabric equal to "Ventfab" as made by Ventfabrics, Inc., not less than four inches (4") long secured by peripheral iron straps holding fabric in galvanized iron, except as otherwise noted.

j. Vertical ducts shall be supported by means of an angle iron frame riveted to the ductwork on at least two (2) sides. Horizontal runs of ductwork shall be supported on not more than 8'-0" centers as required.

k. Manual volume and splitter dampers shall be furnished and installed where shown and where necessary for proper regulation of the air distribution. A quadrant and set screw equal to "Ventlock" #641 shall be installed for all dampers which are concealed above plaster or gypsum board ceilings, or behind the masonry construction, furnish and install concealed regulators ("Ventlock" #666) with chrome cover plate.

l. All ductwork shall operate without chatter and vibration, and shall be free from pulsations.

3.4 ACCESS DOORS OR PANELS

a. Provide duct access doors of approved construction at any apparatus requiring service and inspection. Doors shall suit finish in which installed.

b. Access doors in rated walls or assemblies shall be rated as required to maintain rating of assembly. Rated access doors shall bear U.L. Label.

3.4 ITEMS OF ELECTRICAL EQUIPMENT

a. All electrical work shall be done by properly licensed electrical mechanics in accordance with Division 26 of the specifications under supervision of a licensed Electrical Contractor as approved by the Architect.

b. The Electrical Contractor shall provide all power wiring to motor starter and/or disconnect switch and from starter/disconnect switch to motor. The Mechanical Contractor shall provide all control wiring, low voltage or line voltage, as required for the operation of all mechanical equipment. All control devices such as motor starters, thermostats, switches, etc. shall be provided by the Mechanical Contractor.

c. All motor starters shall be provided with a “hand-off-auto” switch on the starter cover.

d. All items of mechanical equipment electrically operated shall be in complete accordance with electrical division of the specifications. Mechanical equipment, other than individually mounted motors, shall be factory prewired so that it will only be necessary to bring connections to a single set of terminals.

e. Mechanical equipment electrical components shall all be bonded together and connected to electrical system ground.

f. All mechanical equipment electrical components shall be U.L. listed and labeled.

g. No joints allowed in piping that crosses cable trays. Cable tray installation shall be coordinated with all other trades prior to installation. Where water piping must cross a cable tray, a drip pan will be required to be provided.

3.5 WARRANTY AND SERVICE

a. Upon completion of all work, the contractor shall check the system out so that all motor bearings are greased as required and have all systems balanced. He shall be responsible for original service, of starting the system up, and providing one set of replacement filters after final acceptance.

b. All equipment shall carry a full one - year warranty with a five - year warranty on the cooling cycle on all packaged type equipment in accordance with Division 01 of the specifications.

3.6 INSPECTION AND ACCEPTANCE TEST

a. The project will be checked periodically as construction progresses. The contractor shall be responsible for notifying the Engineer at least 48 hours in advance when any work to be covered up is ready for inspection. No work will be covered up until approved by the Engineer.

b. Upon completion of erection of all equipment and work specified herein and shown approved shop drawings, and at the time designated by the engineer, the contractor shall start all apparatus, making necessary tests as directed and as specified herein, and make adjustments of all parts of all equipment before acceptance of equipment by the owner. The contractor must demonstrate to the owner, by performance, that all equipment operates as specified and meets the guarantee called for.

c. Tests shall include satisfactory evidence that all systems operate as called for on the drawings, and that all pieces of equipment operate at specified ratings under specified operating conditions.

d. The contractor shall furnish all fuel and power required for these purposes, and provide the proper and necessary help required to operate the system while tests are being made.

e. All drainage piping shall be tested by filling with water to a point 10' above the underground drains or to point of discharge to grade and let stand thus filled for 3 hours.

f. Tests on all pipe work shall be subject to the inspection of the Engineer. He shall be given 24-hours notice when a section pipe is to be tested and the test shall not be removed until permission is given by the Engineer.

3.7 AS BUILT DRAWINGS

a. This contractor shall keep on the job at all times, a clean set of contract drawings in blueprint form. As the job progresses, any and all deviations from the arrangements, piping runs, equipment locations, etc., shown on the bid prints shall be marked on this set with red ink. These prints shall not be used for any other purpose than to be marked up as "As-Built" Drawings.

3.8 OWNER TRAINING

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain the equipment listed below:
   1. DDC Control Systems
   2. Air Handlers

B. Extent of Training:

   1. Base extent of training on scope and complexity of equipment installed and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
   2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
   3. Minimum Training Requirements:

      a. Provide not less than the number days of training indicated below.

1) DDC Control Systems - 2 days (16 hours)

b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.

C. Training Schedule:

1. Schedule training with Owner **20** business days before expected Substantial Completion.
2. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions.
3. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
4. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

E. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

F. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:

a. Daily operators.
b. Advanced operators.
c. System managers and administrators.

G. Training Outline:

1. Submit training outline for Owner review at least **10** business day before scheduling training.
2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

H. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.

2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

I. Training Content:

1. Basic operation of each system.
2. Understanding each unique product type installed including performance and service requirements for each.
3. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.

END OF SECTION 230500

SECTION 23 05 19 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Liquid-in-glass thermometers.
2. Thermowells.
3. Dial-type pressure gages.
4. Gage attachments.
5. Test plugs.
6. Test-plug kits.

1.3 SUBMITTALS

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

B. Wiring Diagrams: For power, signal, and control wiring.

C. Product Certificates: For each type of meter and gage, from manufacturer.

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

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flo Fab Inc.
b. Tel-Tru Manufacturing Company.
c. Trerice, H. O. Co.
d. Weiss Instruments, Inc.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.
a. Design for Air-Duct Installation: With ventilated shroud.
b. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

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

2.3 THERMOWELLS

A. Thermowells:
1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR.
4. Material for Use with Steel Piping: CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.4 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flo Fab Inc.
   b. Tel-Tru Manufacturing Company.
   c. Trerice, H. O. Co.
   d. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   e. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: Liquid-filled or sealed type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Metal.
11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flow Design, Inc.
   2. Trerice, H. O. Co.
   3. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   4. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

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

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

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

G. Install valve and snubber in piping for each pressure gage for fluids (except steam).

H. Install test plugs in piping tees.

I. Install permanent indicators on walls or brackets in accessible and readable positions.

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

K. Install thermometers in the following locations:
   1. Inlet and outlet of each chiller.
   2. Inlet and outlet of each hydronic boiler.
   3. Inlet and outlet of each hydronic coil in air-handling units.

L. All thermometers shall be legible from ground level.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines and equipment.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

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

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each chiller shall be the following:
1. Industrial-style, liquid-in-glass type.
2. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:
1. Industrial-style, liquid-in-glass type.
2. Test plug with EPDM self-sealing rubber inserts.

C. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be the following:
1. Industrial-style, liquid-in-glass type.
2. Test plug with EPDM self-sealing rubber inserts.

D. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

B. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be the following:
1. Liquid-filled or sealed, direct-mounted, metal case.
2. Test plug with EPDM self-sealing rubber inserts.

B. Pressure gages at suction and discharge of each pump shall be the following:
1. Liquid-filled or sealed, direct-mounted, metal case.
2. Test plug with EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 200 psi.

B. Scale Range for Heating, Hot-Water Piping: 0 to 200 psi.

END OF SECTION 23 05 19

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 Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following general-duty valves:
1. Copper-alloy ball valves.
2. Ferrous-alloy ball valves.
3. Ferrous-alloy butterfly valves.
4. Bronze globe valves.
5. Cast-iron globe valves.

B. Related Sections include the following:
1. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and charts.
2. Division 23 Section "Instrumentation and Control for HVAC" for control valves and actuators.

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:
1. CWP: Cold working pressure.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. PTFE: Polytetrafluoroethylene plastic.
4. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.9 for building services piping valves.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

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

1.6 DELIVERY, STORAGE AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle and globe valves closed to prevent rattling.
4. Set ball valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 VALVES - GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.

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

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:
1. Gear Drive: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

G. Extended Valve Stems: On insulated valves.

H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

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

2.3 COPPER-ALLOY BALL VALVES

A. Available Manufacturers:

B. Manufacturers:
1. Copper-Alloy Ball Valves:
a. Conbraco Industries, Inc.; Apollo Div.

b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Div.
d. Grinnell Corporation.
e. Jamesbury, Inc.
f. Kitz Corporation of America.
g. Legend Valve & Fitting, Inc.
h. NIBCO INC.
i. Watts Industries, Inc.; Water Products Div.

C. Copper-Alloy Ball Valves, General: MSS SP-110.

D. Two-Piece, Copper-Alloy Ball Valves: Bronze body with regular-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

2.4 FERROUS-ALLOY BALL VALVES

A. Available Manufacturers:

B. Manufacturers:
1. Conbraco Industries, Inc.; Apollo Div.
2. Crane Co.; Crane Valve Group; Stockham Div.
3. Hammond Valve.
4. Jamesbury, Inc.
5. Kitz Corporation of America.
6. Milwaukee Valve Company.
7. NIBCO INC.
8. Worcester Controls.

C. Ferrous-Alloy Ball Valves, General: MSS SP-72, with flanged ends.

D. Ferrous-Alloy Ball Valves: Class 150, full port.

E. Ferrous-Alloy Ball Valves: Class 300, full port.

2.5 FERROUS-ALLOY BUTTERFLY VALVES

A. Available Manufacturers:

B. Manufacturers:
1. Ferrous-Alloy Butterfly Valves:
a. Crane Co.; Crane Valve Group; Stockham Div.
b. Grinnell Corporation.
c. Hammond Valve.
d. Kitz Corporation of America.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Red-White Valve Corp.
h. Tyco International, Ltd.; Tyco Valves & Controls.
i. Watts Industries, Inc.; Water Products Div.

C. Ferrous-Alloy Butterfly Valves, General: MSS SP-67, Type I, for tight shutoff, with disc and lining suitable for potable water, unless otherwise indicated.

D. Single-Flange, 150-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Wafer-lug type with one or two-piece stem.

E. Flanged, 150-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Flanged-end type with one or two-piece stem.

2.6 BRONZE GLOBE VALVES

A. Available Manufacturers:

B. Manufacturers:
1. Type 2, Bronze Globe Valves with Nonmetallic Disc:
   a. Cincinnati Valve Co.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Div.
   e. Grinnell Corporation.
   f. Hammond Valve.
   g. Kitz Corporation of America.
   h. Milwaukee Valve Company.
   i. NIBCO INC.
   j. Powell, Wm. Co.
   k. Red-White Valve Corp.
   l. Walworth Co.

C. Bronze Globe Valves, General: MSS SP-80, with ferrous-alloy handwheel.

D. Type 2, Class 150, Bronze Globe Valves: Bronze body with PTFE or TFE disc and union-ring bonnet.

2.7 CAST-IRON GLOBE VALVES

A. Available Manufacturers:

B. Manufacturers:
1. Type I, Cast-Iron Globe Valves with Metal Seats:
   a. Cincinnati Valve Co.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Div.
   e. Grinnell Corporation.
   f. Hammond Valve.
   g. Kitz Corporation of America.
   h. Milwaukee Valve Company.
   i. NIBCO INC.
   j. Powell, Wm. Co.
   k. Red-White Valve Corp.
   l. Walworth Co.

C. Cast-Iron Globe Valves, General: MSS SP-85.

D. Type I, Class 125, Cast-Iron Globe Valves: Gray-iron body with bronze seats.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

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

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

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

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

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

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball or butterfly valves.
   2. Throttling Service: Ball, butterfly, or globe valves.

B. When 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. Hot Water, and Chilled Water Piping: Use the following types of valves:
   1. Ball Valves, NPS 2 and Smaller: One-piece, 400-psig CWP rating, copper alloy.
   2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
   3. Butterfly Valves, NPS 2-1/2 and Larger: Flangeless, single-flange or flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.
   4. Globe Valves, NPS 2 and Smaller: Type 2, Class 150, bronze.
   5. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.

D. Select valves, except wafer and flangeless types, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for condenser water services.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged or threaded ends.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged or threaded ends.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.
   7. For Grooved-End, Copper Tubing and Steel Piping: Valve ends may be grooved. Do not use for steam or steam condensate piping.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

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

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

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

F. Install check valves for proper direction of flow.

3.4 JOINT CONSTRUCTION

A. Refer to Division 23 Section "Common Work Results for HVAC" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

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

3.5 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.

END OF SECTION 23 05 23

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 Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

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

C. Valve numbering scheme.

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

1.4 COORDINATION

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

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

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

PART 2 - PRODUCTS

2.1 LETTERING AND GRAPHICS

A. Coordinate names, abbreviations and other designations used in mechanical identification work with corresponding designations shown pre-existing, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.

B. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (for example: Boiler No. 1; AHU-1; etc.).

2.2 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch or 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: Yellow.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 5 inches x 4 inches.
6. Minimum Letter Size: 1/4 inch for principal lettering; include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's unique equipment number, areas served (use actual room numbers used at the facility – not architectural room numbers, substantial completion date (S.C.D.), extended warranty period, number and size of filters and capacity. The following are examples of labeling to be used:
1. Air Handling Units:

AHU-1 (Classrooms #212, 213, 214 & 215)
S.C.D.: 06/01/2011
Filters: 4(24x24x2 inch)
2(24x12x2 inch)
Capacity: 4000 CFM @ 1.0 inch ESP

2. Condensing Units:

CU-1 (Office #202 & 203)
S.C.D.: S.C.D.: 06/01/20011 (5 years Comp. Warranty)
Capacity: 3 Tons

3. Fan Coil Units:

FCU-2 (Office #122 & Storage #122A)
S.C.D.: S.C.D.: 06/01/2011
Filters: 1(60x10x1 inch)
Capacity: 1200 CFM

4. Use similar protocol for Chillers, Boilers, Pumps, Fans, and VFD’s.

C. A phenol tag (3” x 2”) shall visually identify all VAV boxes with the box number engraved on it, permanently attached by screws to the ceiling grid directly under the VAV box.

D. A phenol tag (3” x 2”) shall visually identify all HVAC hydronic system isolating valves, permanently attached by screws to the ceiling grid directly under the valves.

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

2.3 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch > thick, and having predrilled holes for attachment hardware.

B. Letter Color: Comply with ANSI A13.1, except where another color selection is indicated.

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

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Fasteners: Stainless-steel self-tapping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Label Content: Include caution and warning information, plus emergency notification instructions.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, polished finish, minimum 19-gauge, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Solid brass chain (wire link or beaded type); size as required for attaching tags.
   3. Tag Size: 1-1/2-inch diameter, except as otherwise indicated.

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

2.5 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.
   1. Major mechanical equipment shall include:
      a. Pumps

B. Locate equipment labels where accessible and visible.

3.3 VALVE-TAG INSTALLATION

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

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
      a. Chilled Water: 1-1/2 inches round
      b. Hot Water: 1-1/2 inches round
      c. Gas: 1-1/2 inches round
   2. Valve-Tag Color:
      a. Chilled Water: Blue
      b. Hot Water: Red
      c. Gas: Yellow
   3. Letter Color:
      a. Chilled Water: White
      b. Hot Water: White
      c. Gas: White

3.4 WARNING-TAG INSTALLATION

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

END OF SECTION 230553

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Chilled water piping insulation.
   2. Hot water piping insulation.

1.3 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aeroflex
   2. Armacell
   3. Certain Teed Corp.
   4. Johns Manville
   5. Knauf Insulation
   6. Owens Corning
   7. Pittsburg Corning Corp.
   8. Dyplast Products

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

1.6 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.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Coordinate installation and testing of heat tracing.

1.8 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 "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

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

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

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

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Block Insulation: ASTM C 552, Type I.
2. Special-Shaped Insulation: ASTM C 552, Type III.
3. Board Insulation: ASTM C 552, Type IV.
4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
5. Preformed Pipe Insulation with Factory-Applied [ASJ] [ASJ-SSL]: Comply with ASTM C 552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell materials. Comply with ASTM C 534, Type I for tubular materials.

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

I. 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.

J. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

K. Phenolic:

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. See Division 01 Section "Product Requirements."

1. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
2. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
3. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
   a. Preformed Pipe Insulation: ASJ.
   b. Board for Duct and Plenum Applications: ASJ.
   c. Board for Equipment Applications: ASJ.

2.2 INSULATING CEMENTS

A. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. PVC Jacket Adhesive: Compatible with PVC jacket.
1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

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

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220 deg F.

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

2.5 LAGGING ADHESIVES
1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.6 SEALANTS

A. Joint Sealants:
1. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
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.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
6. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

2.10 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. 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. Adhesive: As recommended by jacket material manufacturer.
2. Color: Color-code jackets based on system. Color as selected by Architect.

3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.11 TAPES

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

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 6.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches.
   2. Thickness: 3.7 mils.
   3. Adhesion: 100 ounces force/inch in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   1. Width: 3 inches.
   2. Film Thickness: 4 mils.
   3. Adhesive Thickness: 1.5 mils.
   4. Elongation at Break: 145 percent.
   5. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   1. Width: 3 inches.
   2. Film Thickness: 6 mils.
   3. Adhesive Thickness: 1.5 mils.
   4. Elongation at Break: 145 percent.
   5. Tensile Strength: 55 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:
1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

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

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

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

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

L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [2 inches] [4 inches] o.c.
    a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

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

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

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

P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

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

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

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

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

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

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
      a. Install preformed removable insulation over all control valve bodies with water resistant, attached reusable fasteners. Insulation assembly and fasteners shall be suitable for the environment and will not impede the operation of the valve or block visual sight of the actuator indicator.
   2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
   5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

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

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

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

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

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

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

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

3.8 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

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

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

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

3.9 PHENOLIC INSULATION INSTALLATION

A. General Installation Requirements:
1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

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

C. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
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.

3.10 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 overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

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

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

E. Where PVDC jackets are indicated, install as follows:
1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.11 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

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

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

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

3.12 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to [3] three locations of straight pipe, [3] three locations of threaded fittings, [3] three locations of welded fittings, [3] three locations of threaded valves, and [3] three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

3.13 PIPING INSULATION SCHEDULE, GENERAL

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

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:
1. All Pipe Sizes: Insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Polyolefin: 1 inch Chilled Water:
2. Chilled Water Supply & Return NPS 14 and Smaller: Insulation shall be one of the following:
   a. Cellular Glass: 2 inches
   b. Flexible Elastomeric: 2 inch thick.
   c. Polyolefin: 1-1/2 inch thick.
   d. Phenolic: 1-1/2 inches thick.

B. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. NPS 1-1/2” and Smaller: Insulation shall be one of the following:
   a. Flexible Elastomeric: 2 inch thick.
   b. Polyolefin: 1-1/2 inch thick.
   c. Cellular Glass: 2 inches thick
   d. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick
2. NPS 2” and Larger: Insulation shall be one of the following:
   a. Flexible Elastomeric: 2 inch thick.
   b. Polyolefin: 2 inch thick.
   c. Cellular Glass: 2 inches thick
   d. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick

C. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch thick.

3.15 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water:
1. All Pipe Sizes: Insulation shall be one of the following:
   a. Cellular Glass: 3 inches thick.
   b. Flexible Elastomeric: 3 inches thick.
   c. Polyolefin: 3 inches thick.
   d. Phenolic: 1-1/2 inches thick.

B. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation shall be one of the following:
   a. Flexible Elastomeric: 2 inches thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation shall be one of the following:
   a. Flexible Elastomeric: 2 inches thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Exposed:
1. Aluminum, Smooth0.024 inch thick.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Exposed:
1. Aluminum, Smooth 0.024 inch thick.

3.18 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

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END OF SECTION 230719

SECTION 23 08 00 - MECHANICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. ASHRAE Standard 90.1-2010

C. ASHRAE Guideline 0 - 2013 – The Commissioning Process

D. ASHRAE Guideline 1.1-2007 - HVAC&R Technical Requirements for The Commissioning Process

E. E. ASHRAE Standard 202-2013 – Commissioning Process for Buildings and Systems

F. The project's Commissioning Plan (Cx Plan) (Construction Phase) will be developed and issued at the start of construction. The Cx Plan is a live document that is maintained by the Cx Authority; updated periodically during the course of the project, as required.

1.2 SUMMARY

A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:
1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

A. Refer to Division 01 Section 019113 "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

A. Refer to Division 01 Section 019113 "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

A. Refer to Division 01 019113 Section "General Commissioning Requirements" for CxA's role.

B. Refer to Division 01 Section "Submittals" for specific requirements.

C. In addition, provide the following:
1. Certificates of readiness
2. Certificates of completion of installation, prestart, and startup activities.

3. O&M manuals
4. Test reports

D. Control Drawings Submittal
1. The control drawings shall have a key to all abbreviations.
2. The control drawings shall contain graphic schematic depictions of the systems and each component.
3. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. Provide a full points list with at least the following included for each point:
   a. Controlled system
   b. Point abbreviation
   c. Point description
   d. Display unit
   e. Control point or set point (Yes / No)
   f. Monitoring point (Yes / No)
   g. Intermediate point (Yes / No)
   h. Calculated point (Yes / No)

1.6 QUALITY ASSURANCE

A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system in Division 23. A sufficient quantity of two-way radios shall be provided by each subcontractor.

B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.

C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.

D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.

E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems

B. Red-lined Drawings:
1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

C. Operation and Maintenance Data:
1. Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems.
2. The CxA will review the O&M literature once for conformance to project requirements.
3. The CxA will receive a copy of the final approved O&M literature once corrections have been mad by the Contractor.

D. Demonstration and Training:
1. Contractor will provide demonstration and training as required by the specifications.
2. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training.
3. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session.
4. The CxA shall be notified at least 72 hours in advance of scheduled tests so that testing may be observed by the CxA and Owner's representative. A copy of the test record shall be provided to the CxA, Owner, and Architect.
5. Engage a Factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specific equipment.
6. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, trouble shooting, servicing, and maintaining equipment.
7. Review data in O&M Manuals.

E. Systems manual requirements:
1. The Systems Manual is intended to be a usable information resource containing all of the information related to the systems, assemblies, and Commissioning Process in one place with indexes and cross references.

2. The GC shall include final approved versions of the following information for the Systems Manual:
   a. As-Built System Schematics
   b. Verified Record Drawings
   c. Test Results (not otherwise included in Cx Record)
   d. Periodic Maintenance Information for computer maintenance management system
   e. Recommendations for recalibration frequency of sensors and actuators
   f. A list of contractors, subcontractors, suppliers, architects, and engineers involved in the project along with their contact information
   g. Training Records, Information on training provided, attendees list, and any on-going training
3. This information shall be organized and arranged by building system, such as fire alarm, chilled water, heating hot water, etc.
4. Information should be provided in an electronic version to the extent possible. Legible, scanned images are acceptable for non-electronic documentation to facilitate this deliverable.

3.2 CONTRACTOR'S RESPONSIBILITIES

A. Mechanical and Controls Contractors. The commissioning responsibilities applicable to each of the contractors of Division 23 are as follows (all references apply to commissioned equipment only):

B. Perform commissioning tests at the direction of the CxA.

C. Attend construction phase controls coordination meetings.

D. Attend testing, adjusting, and balancing review and coordination meetings.

E. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

F. Provide information requested by the CxA for final commissioning documentation.

G. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.

H. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

I. Update schedule as required throughout the construction period.

J. During the startup and initial checkout process, execute the related portions of the prefunctional checklists for all commissioned equipment.

K. Assist the CxA in all verification and functional performance tests.

L. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

M. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA (45) days after submittal acceptance.

N. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

O. Notify the CxA a minimum of (2) weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.

P. Participate in, and schedule vendors and contractors to participate in the training sessions.

Q. Provide written notification to the CM/GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
1. HVAC&R equipment including all fans, air handling units, ductwork, dampers, terminals, and all other equipment furnished under this Division.
2. Fire stopping in the fire rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.
3. Fire detection and smoke detection devices furnished under other divisions of the specification.
4.

R. The equipment supplier shall document the performance of his equipment.

S. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

T. Provide training of the Owner's operating staff using expert qualified personnel, as specified.

U. Equipment Suppliers
1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

V. Refer to Division 01 Section "General Commissioning Requirements" for additional contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

A. Certify in writing to the CxA that *HVAC&R systems, subsystems, and equipment* have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that HVAC&R *instrumentation and control systems* have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC&R contractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 23 sections. Provide submittals, test data, inspector record, and certifications to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Assist the CxA with preparation of testing plans. Provide technicians, instrumentation, tools, and equipment to test performance of sensors, actuators and other system components.

C. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Chilled Water Plant
2. Hot Water Plant
3. Air Handling Units
4. Fan Coil Units
5. Unit Ventilators
6. Exhaust Fans

3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.10 APPROVAL

A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.11 DEFERRED TESTING

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.12 OPERATION AND MAINTENANCE MANUALS

A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

C. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

3.13 TRAINING OF OWNER PERSONNEL

A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

B. Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:
   1. Provide the CxA with a training plan two weeks before the planned training.
   2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, all HVAC equipment (ex. pumps, heat exchangers, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.)
   3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
   4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
   5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
   6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
   7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
   8. Training shall include:
      a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
      b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
      c. Discussion of relevant health and safety issues and concerns.
      d. Discussion of warranties and guarantees.
      e. Common troubleshooting problems and solutions.
      f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
      g. Discussion of any peculiarities of equipment installation or operation.
      h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-2007, is recommended.
   9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
   10. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
   11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

C. Controls Contractor. The controls contractor shall have the following training responsibilities:
   1. Provide the CxA and AE with a training plan four weeks before the planned training.
   2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.
   3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the CxA and AE. Copies of audiovisuals shall be delivered to the Owner.
   4. The trainings will be tailored to the needs and skill-level of the trainees.

5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.
6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
7. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
8. There shall be three (3) training sessions:
    a. Training I. Control System. The first training shall consist of 8 hours of actual training. This training may be held on-site or in the supplier's facility. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
    b. Training II. Building Systems. The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:
        1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.
        2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing set points and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
        3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
        4) Every screen shall be completely discussed, allowing time for questions.
        5) Use of keypad or plug-in laptop computer at the zone level.
        6) Use of remote access to the system via phone lines or networks.
        7) Setting up and changing an air terminal unit controller.
        8) Graphics generation
        9) Point database entry and modifications
        10) Understanding DDC field panel operating programming (when applicable)
    c. Training III. The third training will be conducted on-site six months after occupancy and consist of 8 hours of training. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

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END OF SECTION 23 08 00

SECTION 23 09 00 – ENERGY MANAGEMENT SYSTEM AND BUILDING AUTOMATION SYSTEM CONTROL FOR HVAC AND LIGHTING

PART 1 - GENERAL

1.1 INSTRUCTIONS TO VENDORS

A. Vendor is cautioned that the Owner reserves the right to reject any Vendor, which in the Owner's sole judgment, takes meaningful deviation or exception to Division 23 Direct Digital Control (DDC) Standards. The Charlotte-Mecklenburg Schools' (CMS) Energy Manager and/or designated representative of the Energy Management Department (EMD) shall review all vendor substitution submittals. Vendor substitution approval/disapproval shall be returned via the project architect in writing from Charlotte-Mecklenburg Schools' Energy Manager and designated EMD Project Manager.

B. The overriding requirement is the use of the DDC Control System to maintain design occupant comfort with optimal minimized energy consumption while maximizing equipment, component, and system design function integrity and life.

1.2 RELATED DOCUMENTS

A. Drawings (both mechanical and electrical project manual drawings) and general provisions (within Divisions 23) of the Contract, including General Conditions apply to this Section.

B. The provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as through bound herein.

C. Sections within Division 23 Mechanical apply, including though not limited to

D. 23 09 01 – BAS Graphical User Interface Guidelines

E. 23 09 02 – BAS Point Naming and Tagging Guideline

F. 23 08 00 – Commissioning of HVAC and BAS

1.3 SUMMARY

A. This Section includes Energy Management and Remote Automated Computer Control Systems for HVAC and Lighting systems and components, including control components for terminal heating and cooling units including approved integration with factory-wired controls. The work of this section 23 09 00 shall be provided by the Building Automation Systems controls contractor.

B. The Building Automation System (BAS) Controls shall be comprised of a Direct Digital Control (DDC) network of interoperable, stand-alone digital controllers communicating on a BACnet communication network over IP across the CMS network to CMS owned virtual server hosting the Web Supervisor(s).

C. The system 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.

1.4 ABBREVIATIONS AND ACRONYMS

A. AHU: Air Handling Unit

B. AI: Analog Input

C. ANSI: American National Standards Institute

D. AO: Analog Output

E. ASC: Application Specific Controller

F. ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers

G. ASPE: American Society of Plumbing Engineers

H. ASME: American Society of Mechanical Engineers

I. ASTM: American Society for Testing and Materials

J. ATC: Automatic Temperature Control System

K. AWG: American Wire Gauge (Standard)

L. BACnet/IP, BACnet/MSTP: Acceptable Communication Protocols across the EMS/BAS Controls Network.

M. BAS: Building Automation System

N. BI: Binary Input

O. BMS: Building Management System

P. BO: Binary Output

Q. CAD: Computer Aided Design

R. CCC: Central Communications Controller

S. CCU: Central Control Unit

T. CPU: Central Processing Unit

U. CRT: Cathode Ray Tube

V. DALI: Digital Addressable Lighting Interface

W. DCP: Digital Control Panel

X. DDC: Direct Digital Controls

Y. DI: Discrete Input

Z. DMA: Direct Memory Access

AA. DMZ: Demilitarized Zone Network

BB. DO: Discrete Output

CC. EMS/BAS: Energy Management System / Building Automation System

DD. FAC LAN: Facility Local Area Network

EE. FACP: Fire Alarm Control Panel

FF. FCC: Fire Command Center

GG. FCIP: Fire Fighters' Control and Indicating Panel

HH. FMS: Facility Management System

II. GUI: Graphical User Interface

JJ. HTML5: Hyper Text Markup Language 5

KK. HVAC: Heating Ventilating and Air Conditioning

LL. I/O: Input/output.

MM. IP: Internet Protocol

NN. ISA: Intelligent Sensor or Actuator

OO. MS/TP: Master Slave/Token Passing

PP. MSCP: Mass Storage Control Protocol

QQ. MSI: Master System Integrator

RR. NC: Network Controller

SS. NCP: Network Control Panel

TT. NEC: National Electric Code

UU. NI: Network Integrator

VV. NIC: Not in Contract

WW. NPBI; Needle Point Bipolar Ionization

XX. NFPA: National Fire Protection Association

YY. NSS: Network Services Server

ZZ. NSI: Network Services Interface

AAA. OS: Operating System

BBB. PCU: Programmable Control Unit

CCC. PID: Proportional Integral Derivative

DDD. PRV: Pressure Reducing Valve

EEE. RAM: Random Access Memory

FFF. ROM: Read Only Memory

GGG. RTD: Resistance temperature detector

HHH. SCADA: Supervisory Control and Data Acquisition System

III. SI: Systems Integrator

JJJ. SNVT: Standard Network Variable Type

KKK. SPACE; A complete ventilation path as defined by ASHARE

LLL. TCP/IP: Transmission Control Protocol / Internet Protocol

MMM. THHN: Thermoplastic High Heat Resistant Nylon Coated-Cable Coating

NNN. TP: Twisted Pair

OOO. UL: Underwriters Laboratory

PPP. UML: Unified modeling Language

QQQ. UPS: Uninterruptible Power Supply

RRR. VAV: Variable Air Volume

SSS. VCS: Voice Communication System

TTT. VFD: Variable Frequency Drive

UUU. XML: Extensible Markup Language

1.5 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Graphic Display: Display graphical information at the present day fastest refresh interval capable by the most current updated graphical software revisions within the confines of the firmware of the connected equipment.
   2. Graphic Refresh: Display information at the fastest refresh interval of the most recent graphical software revision within parameters of the workstation.
   3. Object Command: Reaction time shall be at the fastest refresh interval with the most current up-to-date graphical software version within the firmware capabilities of the connected equipment. In no case shall that be more than two seconds between operator command of a binary object and device reaction.
   4. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
   5. Reporting Accuracy and Stability of Control: Report values and maintain measured variables to within industry standards and tolerances no greater than those as follows:
      a. Space Temperature: Plus or minus 1 deg F.

b. Ducted Air Temperature: Plus or minus 1 deg F.
c. Outside Air Temperature: Plus or minus 2 deg F.
d. Dew Point Temperature: Plus or minus 3 deg F.
e. Temperature Differential: Plus or minus 0.25 deg F.
f. Relative Humidity: Plus or minus 5 percent.
g. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
h. Airflow (Terminal): Plus or minus 10 percent of full scale.
i. Air Pressure (Space): Plus or minus 0.01-inch wg.
j. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
k. Carbon Monoxide: Plus or minus 5 percent of reading.
l. Carbon Dioxide: Plus or minus 50 ppm.
m. Electrical: Plus or minus 5 percent of reading.

1.6 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, options provided, finishes for materials, and installation and startup instructions for each type of product indicated.
1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, programming, sequence of operations, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and specific location and size of each assembly and field connection.
1. See paragraph 2.3.A.2 for digital storage of controls shop drawings as-builts and product data sheets.
2. Bill of materials of equipment indicating quantity, manufacturer, and model number.
3. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
4. Wiring Diagrams: Power, signal, and point to point control wiring.
5. Details of control panel faces, including controls, instruments, and labeling.
6. Written description of sequence of operation for each system and component.
7. Schedule of dampers including size, leakage, and flow characteristics.
8. Schedule of valves including flow characteristics.
9. DDC System Hardware:
a. Wiring diagrams for control units with enumerated termination numbers.
b. Schematic diagrams and floor plans for field sensors and control hardware.
c. Schematic diagrams for point-to-point control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
10. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, pdf links, and operator notations.
11. Controlled Systems:
a. Schematic diagrams of each controlled system with control points labeled and control elements graphically and geographically shown, with wiring.
b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
c. Written description of sequence of operation including schematic diagrams in pdf to be embedded on graphical screens.
d. Points list with corresponding controller ID’s.

12. Submittal of graphical interface and graphical representations of each component.

C. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Maintenance instructions and lists of spare parts for each type of control device.
   2. Interconnection wiring diagrams with identified and numbered system components and devices.
   3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
   4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   5. Calibration records and list of set points.
   6. Normal, range and failsafe position for each device.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative, who is trained and approved for installation of system components required for this Project, and who employs only factory trained personnel, with minimum experience as follows:
   1. Firm: Ten years.
   2. Project Manager: Five years.
   3. Project Engineer, Application Engineering Staff: Three years.
   4. Electronic Technicians: Two years.

B. Approved manufacturers shall have minimum three full-time factory trained and certified service personnel located within twenty-five miles travel distance of CMS Building Services.

C. Comply with ANSI/ASHRAE Standard 135-1995 for DDC system components for BACnet MSTP at the unit controller level.

D. Controls equipment and components shall meet or exceed the following standards: UL-916; Energy Management Systems (EMS).

E. Preinstallation Conference: Including Architect, Owner's representative, and affected Installers, to review approved submittals and installation strategies.

1.8 QUALIFICATION REQUIREMENTS

A. The EMS/BAS controls contractor must have a minimum of 10 years of experience manufacturing and installing the controls system similar in performance to that specified herein and shall be prepared to evidence this history as condition of acceptance and approval prior to bidding.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Delivery of material shall not be considered complete until installed. Components shall be protected from detrimental environmental conditions until mounted at the component’s final location.

B. Storage shall be at the contractor’s risk and responsibility in collaboration with the Owner.

C. All material handling shall remain the contracts responsibility.

D. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

1.10 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with owner, plans and room details before installation. All field installed components shall remain accessible for maintenance and repair.

B. Coordinate equipment with Division 26 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system. Provide LED RIB Relays or approved devices for demarcation between 3rd party systems. Label all devices with function.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Electrical requirements Section "Panelboards" to achieve compatibility with starter coils and annunciation devices, VFD's, Lighting Controls and annunciation devices. Provide LED RIB Relays or approved devices for demarcation between 3rd party systems. Label all devices with function.

E. Global site controllers shall have dedicated power circuits, with UPS and Emergency Generator backup.

F. All work with trades for 3rd party devices and equipment that are to be supplied and or interfaced "by others.".

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers approved as listed below:
1. Automated Logic's (ALC) WebCTRL as provided by Automated Logic – North Carolina, Charlotte, NC.
2. Trane Tracer Ensemble as provided by Carolina Trane in Charlotte, NC.
3. Johnson Controls Metasys as provided by Johnson Controls (JCI) in Charlotte, NC
4. Niagara N4 with Schneider Electric IA as provided by Schneider Electric, Charlotte, NC
5. Niagara N4 with (TBD) as provided by Platinum Building Automation
6. Niagara N4 with Honeywell as provided by United Automation Controls, Charlotte, NC

B. Comply with qualification requirement in above sections 1.7 and 1.8.

C. Control system shall have critically defined data made available and integrated via BACnet/IP to a JACE with capabilities to hyperlink and navigate to/from the BAS.

D. Pre-approval does not relieve the manufacturer from compliance of 23 09 00.

2.2 CONTROL SYSTEM

A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems. System must be hardwired controllers, and field devices, wireless, or IP addressable when approved.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on BACnet network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 GENERAL

A. The Building Automation System (BAS) shall include but not be limited to the following components.
   1. The BAS Operator Interface shall be accessible from any internet browser using HTML5 current technology via Windows 10 or greater OS from Microsoft Edge, Google Chrome, and/or Mozilla Firefox, and/or a mobile app. The Global Operator Interface is a graphical display providing efficient and effective navigation across multiple platforms initially thru a higher-level CMS designated single web supervisor frontend with navigation capabilities to and thru any one of the CMS five vendor specific secondary level frontends. The BAS Operator Interface consists of hardware and software that allows full user monitoring, adjustment of system parameters, fault detection and diagnostic capabilities. The systems shall support an unlimited number of passwords protected concurrent users, if view only, and shall be individually identifiable if provided with command and control.
   2. Digital storage of as-built control drawings and product data sheets including sequences of operation, and relevant project manual as-built drawings/information shall be in pdf format; stored on the virtual server; and made accessible from the site front page via a navigation link. BAS Drawings and product data sheets pdf are to be stored in the BAS by the building automation controls contractor. Drawings and other project information electronic pdf are to be provided by others and stored and made accessible in the BAS by the Controls Contractor.
   3. System Level Controllers shall manage the Energy and Building Management capabilities of the automation system as well as facilitate remote communications and central monitoring.
   4. Application Specific Controllers shall provide distributed, pre-engineered control, specific to the mechanical equipment specified.
   5. Custom Application Controllers with distributed custom programming capability shall provide control for nonstandard control sequences.
   6. The Data Communications capability shall allow data to be shared between the various controllers in the architecture.
   7. The system software shall include system software for global application functions, application software for distributed controllers, and operator interface software.
   8. End devices such as sensors, actuators, dampers, valves, and relays. AI/AO DI/DO's must be compatible and afforded isolation/protection from 3rd party devices.
   9. All 3rd party controllers read, write, AV/BV values shall be BACnet compatible. All non-vendor specific controllers shall be preapproved by CMS.

B. The failure of any single component shall not interrupt the control strategies of other operational devices. System expansion shall be through the addition of end devices, controllers, and other devices described in this specification.

C. Hard wired Safety circuit end of line devices shall reside in the same controller as the equipment being protected.

D. All Controllers shall automatically reboot and retain system properties programming and settings in the event of a power failure.

2.4 DDC EQUIPMENT

A. Only CMS authorized and configured computers by Building Services Support Services Technology Group are permitted. All required software for the BAS Controls and DDC system diagnostics shall be loaded onto multiple CMS computers, compatible with current CMS technology. All necessary operational and utility software to operate, configure, maintain, program, trend, perform diagnostics, override control points, and edit graphics shall be provided and reside on the server. No annual renewal fees shall be required on software.

B. Building Controls Contractor shall coordinate with Owner's IT department to interface with the local demilitarized zone (DMZ) network. The DMZ subnetwork is logistically located between the public

internet and private networks. The contractor shall be responsible to coordinate the security of the Building Automation System's network.

2.5 BUILDING AUTOMATION FUNCTIONS

A. System Graphics. The BAS panel shall serve up HTML5 type data and standard equipment graphics pages arranged alphabetically by school/facility. No special software on any remote computer shall be required to view/edit the graphics. IT connectivity shall be provided by Owner. The BAS GUI shall also have navigation tree. Provide a standardized and consistent method in conjunction with existing navigation for the operator to easily move between graphic displays. See section 230901 for information on Graphical User Interface and Tree and Branch Layouts.

B. Data on web pages must be returned and updated on a given web page at the maximum interval the control processor can deliver but no less than 5 seconds.

C. System Applications. Provide the following applications:
1. Area Control: Area application coordinates HVAC equipment for a specific area of the building. The application shall assign unit controllers, binary outputs, and binary values to be members of a common area to efficiently perform a single operation (such as changing a setpoint, creating a schedule, performing an override) and apply it to all members of the area. In addition, the area application shall use algorithms, along with area temperatures and humidity inputs, to make an economizing decision. The application shall also include optimal start/stop, humidity pulldown, night purge, unoccupied heating/cooling, unoccupied humidify, unoccupied dehumidify, and timed override functions.
2. The Variable Air Systems: (VAS) application coordinates air-handling units, variable-air-volume (VAV) boxes, and ventilation within a building. VAV units are assigned to the air-handling unit that supplies air to them. The VAS application coordinates the start-up and shut-down of the system to ensure proper static pressure control.
3. Integration: Energy-saving applications, including static pressure optimization and ventilation optimization, are required features. Control sequences of dedicated primary pumps shall be provided by the dedicated primary system served, (e.g. Boilers, Chillers, etc.) BAS DDC functionality can be supplemented with BACnet connections for feedback provided stand alone and local capabilities, and Safety sequences are not compromised. Safety circuits should not be wired through the BAS.
4. Reports features: The operator interface shall provide a reporting package that allows the operator to select reports. Standard reports for equipment shall be made available from the BAS. These reports provide a valuable source of data that can be used for record-keeping and troubleshooting.
5. Report types shall include: Site reports, VAS commissioning reports, All Points in Alarm Report: Provide an on demand report showing all current alarms, All Points in Override Report: Provide an on demand report showing all overrides in effect, Points report: Provide a report that lists the current value of all points, the operator interface shall provide a reporting package that allows the operator to select reports, the operator interface shall provide the ability to schedule reports to run at specified intervals of time. The operator interface shall allow a user to export reports and logs from the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing.
6. System Diagnostics: The BAS shall automatically monitor and report the operation and condition of all network connections, building management panels, and controllers. High level notification of critical alarms will be reported and displayed at the GUI listed in alphabetical order and have the following summarized notification of 3 critical alarms:
    a) Network Comm/Site's BAS Controller Down,
    b) Site Mechanical Plant Chiller, Boiler, Ancillary Equipment Down,
    c) NPBI Module Non-Functional
7. Override Point Control: Provide a tracked method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs. A summary log of all Overrides, the point(s)

overridden, by whom, when, for how long shall be on the BAS front end, and all override shall have a default "TEMPORARY-TIMED-OPTION" with an automatic return to the designed setting parameter. Permanent operator overrides shall only be assigned with high level password access.

8. Override Owners: The system shall convey to the user the owner of each override for all priorities that an override exists. Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
9. Datalogs; Provide Data logs for each major piece of equipment (chillers, boilers, air handling units, rooftop units, and pumps) by School. Temperature sensors in IDF/MDF rooms shall also be trended. Logs shall be capable of being viewed in real-time, or at a later time (historical data) in graphical and tabular format. They shall also be capable of being printed and saved. With the proper security access, system users can configure (create, delete, and update) and manage (clear, enable, and disable) data logs in the system. Each point in the data log should clearly be delineated by color and key in a multiple simultaneous per data log capability. The operator interface shall allow a user to export trend log data in CSV or PDF format for use by word processing and spreadsheet packages such as Microsoft Office Word and Excel. Data logs shall be able to be stored for up to three years.
10. Scheduling: Schedules by ventilation space (e.g. AHU, RTU, DX) and/or groups of zones (e.g. Multiple Buildings, Schools, Event sites, etc.) shall be programmed into the system at owner turnover, confirmed during owner training. A user shall be able to perform the following tasks utilizing the operator interface: Edit an existing schedule; Create a new schedule; Defining the default values, events and membership; Create exceptions to a schedule for any given day, and/or hours within a day; Apply an exception that spans a single day or multiple days, independent or consecutive; View a schedule by day, week and month with exceptions, schedules, and holidays characterized and shown clearly a calendar format. Modify the schedule events, members and exceptions. Scheduling should be able to be deployed and integrated to by facility-type (ES, MS, HS, Admin, et al), basis from the BAS. Overlapping schedules shall be clearly indicated and displayed.
11. Alarm/Event Notification: An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon. A display of the last Alarm and counter of the same previous alarms in history is preferred.
12. Alarm/Event Log: The operator shall be able to view all logged system alarms/events from any operator interface. The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity. Alarm/event messages shall use full language, easily recognized and consistent descriptors. An operator with the proper security level may acknowledge and clear alarms/events. All alarms/events that have not been cleared by the operator shall be stored by the building controller. The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
13. Alarm Processing: Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system. If an alarm exists, an alarm shall be uniquely visible in the GUI and Global navigation bars (N4 & Vendor Platforms). The data displayed in the log includes when and where the event occurred and whether the operator is required to acknowledge it. An operator shall also have the capability to use the log to add comments about events. Column headings can be used to sort and filter events. They shall also be available to be removed or exported from the log.
14. Alarms and Events: log shall contain multiple categories that can be used to sort and filter them. Sorting shall be based, for example, on severity level. Filtering shall be used to view only the alarms from a specific piece of equipment, or space, or those received at a specific time or from a specific alarm category.
15. Security: Each operator shall be required to login to the system with a unique username and password to view, edit, add, or delete data. Multiple User Profiles shall be provided to restrict the user to only the objects, applications, and system functions as assigned by the system administrator. User logon/logoff attempts shall be recorded. The system shall protect itself from

unauthorized use by automatically logging off after a predetermined adjustable time following the last keystroke. The delay time shall be administrator definable by log in.

16. Pre-defined Profiles: The system shall include pre-defined profiles that allow a system administrator to quickly assign levels of permissions to a user or group of users.
17. Help; Provide a context sensitive, online help system to assist the operator in navigation and configuration of the system. On-line help step by step shall be available for all system functions and shall provide the relevant data for each particular screen.
18. Network Monitoring: The system shall automatically monitor the operation of all network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operators and geographically depict the fault location.
19. The building automation system (BAS) shall provide the ability to initiate the auto-commissioning/auto-calibration command directly from the user interface. Special service tools shall not be required. The terminal boxes shall allow the operator to perform on an individual or group basis auto-commissioning report for the VAV box which contains the results of the auto-commissioning/auto-calibration tests which is printable and remain in memory until the next auto-commissioning test is initiated. This report shall contain, at a minimum, the following information for each VAV box in the system. Name of terminal box. Date and time the terminal box was tested. Presence of any alarms. Space temperature and set-point. Active airflow (in CFM). Air valve/damper position when the terminal box reaches 40 percent of the maximum cooling airflow set-point. Air valve / damper position when the terminal box reaches 100 percent of the maximum cooling airflow set-point. Discharge air temperature (if specify on points list) of the terminal box when the terminal local fan is off. Discharge air temperature of the terminal box when the terminal local fan is on. Discharge air temperature of the terminal box when the hot heat is active.
20. Controls contractor shall provide commissioning agent all controls software at no additional cost.

2.6 ARCHITECTURE/COMMUNICATIONS

A. This project shall be comprised of a high-speed Ethernet network utilizing BACnet/IP communications between System Server, Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall utilize BACnet/IP (owner preferred) or wireless communications.

1. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet protocol as prescribed by the BACnet standard. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.

2.7 SYSTEM LEVEL CONTROLLERS

A. System level controller shall reside on the CMS enterprise-Wide Area Network (WAN). The enterprise WAN is provided by the owner and supports the Internet Protocol (IP). Local Area Network connections for the Building Controllers shall be provided by the controls contractor on ISO 8802-3 (Ethernet). Each Building Controller shall also perform routing to a network of Custom Application and Application Specific Controllers. Each Building Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet MSTP. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Testing Lab.

B. System level controller shall support hardwire communications to equipment level direct digital controllers. Multiplexing of receivers and transmitters is not acceptable.

C. Each System Level Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all BACnet/MSTP controllers within the system.

D. The System Level Controller shall have ample memory to support its operating system, database, and programming requirements. All trending history shall be stored at the system level controller for 48 hours and then automatically downloaded to the CMS server.

E. The System Level Controller shall store database and programming files.

F. The operating system of the System Level Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

G. Data shall automatically be shared between System Level Controllers when they are networked together. All System Controllers shall have a real time clock.

H. The database and custom programming routines of remote System Level Controllers shall be editable from a single operator station.

I. The System Level Controllers shall have the capability of being remotely monitored over LAN. Additional capabilities shall include automatically sending out alarms, gathering alarms, reports and logs, programming and downloading databases.

J. The controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:
1. Assume a predetermined fail-safe failure mode.
2. Emit an alarm condition, displaying visually on graphics and/or audibly, and/or via email or SMS.
3. Create a retrievable file of the state of all applicable memory locations at the time of the failure unless latched.
4. Automatically reset the System Controller to return to a normal operating mode.
5. Automatically reboot with all programming and memory function intact upon a voluntary or involuntary power cycle.

K. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure and shall be rated for operation at -40 C to 50 C [-40 F to 122 F].

2.8 EMS/BAS APPLICATION SPECIFIC CONTROLLERS

A. Application Specific Controllers shall be stand-alone, microprocessor based Direct Digital Controllers with sufficient memory to handle its operating system, database, and programming requirements of the BAS. These controllers are assumed to be used for air handling units, chillers, etc.

B. The Application Specific Controller shall be pre-programmed, tested, and factory mounted on the mechanical equipment to ensure reliability. Where factory mounting is not possible, the controllers shall be factory programmed and tested prior to shipment to the jobsite. The controllers shall be clearly labeled as to controller type, where it is to be installed, and software address (if applicable). The controller shall be fully tested upon installation to ensure that it is properly matched to the equipment it is controlling.

C. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components.

D. BACnet Application Specific Controller (ASC) shall provide I/O points based on the points list to fulfill the sequence of operation section of this specification manual. BACnet Unitary application specific controllers shall provide I/O points based on the points list in the sequence of operation section of this

specification manual. The controller shall include, as required by the points list or sequence of operation, two of each additional AI/AO/BI/BO points beyond what is shown on the points list.

E. The hardware shall be suitable for the anticipated ambient conditions.
1. Controllers used outdoors or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at minus 40 to 155 degrees F.
2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32 to 120 degrees F.

F. The ASC unit controller shall be dedicated for each ASC unit, with one single processor to handle all points specified.

2.9 EMS/BAS CUSTOM APPLICATION CONTROLLERS

A. The Custom Application Controllers shall provide stand-alone control and require no additional system components for complete operation. It shall have sufficient memory to support its operating system, database, and programming requirements. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components. All controllers shall be BACnet BTL listed communications MSTP.

B. BACnet Programmable controller shall have built-in I/O points based on the points list in the sequence of operation section of this specification manual. All programming required for operation shall be memory resident and shall be retained in permanent memory.

C. The Custom Application Controller shall be configured such that the Portable Operator Interface can be plugged directly into it or within sight for programming, editing, and other operator functions.

D. Controller hardware shall be suitable for the anticipated ambient conditions.
1. Controllers used outdoors or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at minus 40 to 155 degrees F.
2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32 to 120 degrees F.

2.10 CONTROLLERS SOFTWARE PROGRAMMING, CONFIGURATION, SERVICE TOOL

A. Provide one copy of software programming and service tool that is specifically compatible with the BACnet unit level controllers. This software shall be registered and shall be property of the Owner at project completion. This software tool shall not have installer license restriction that prevents the Owner or his servicing agent from use of the tool. The software tool shall not require annual subscription or renewal fees.

B. The software service tool shall be installed on Owner’s provided computer and transferrable to any other CMS.computer.

C. The software service tool shall have the ability to perform the following tasks:
1. View Controller status.
2. View status of points and alarms.
3. Create, edit and override points.
4. Configure and commission System, Application Specific and Custom Programmable controllers.
5. View data logs.
6. Download configuration files, logic program files, and firmware.
7. Upload programs.
8. Backup and restore firmware, configuration files, and logic program files.
9. Create and edit graphics.
10. Modify existing control program.

11. Add new points and edit database.

2.11 INPUT/OUTPUT INTERFACE

A. Hardwired inputs and outputs may tie into the system through System Application, Custom Application, or Application Specific Controllers. Slave devices are also acceptable. Any critical points requiring immediate reaction shall be tied directly into the controller hosting the control software algorithm for the critical function.

B. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall be compatible with commonly available control devices. All status points shown on the point list shall be positive proof differential pressure or current sensing binary switches.

C. Analog inputs shall allow the monitoring of low voltage, current, or resistance signals and shall have a minimum resolution of 0.1 percent of the sensing range. Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.

D. Binary outputs shall provide a continuous low voltage signal for on/off control of remote devices.

E. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 MA signal as required to provide proper control of the output device.

F. Universal and pulse inputs shall be supported.

G. System architecture shall allow for point expansion in one of the following ways:
1. The addition of input/output cards to an existing System Application Controller.
2. A slave controller may be used to expand point capacity.

2.12 AUXILIARY CONTROL DEVICES

A. Motorized dampers: Ruskin or approved equal, unless otherwise specified elsewhere, shall be as follows.
1. The Building Automation System supplier shall provide all automatic control dampers not specified to be supplied integral to the HVAC equipment.
2. Dampers shall be high velocity low leakage as specified in the sequence of operations. All proportional dampers shall be opposed blade type. Two position dampers may be opposed or parallel blade type.
3. Damper frames and blades shall be galvanized steel and a minimum of 16 gauge. Blade width shall not exceed 8 inches. Dampers and seals shall be suitable for temperature ranges of minus 50 to 250 degrees F.
4. High Velocity Low Leakage Dampers; All dampers shall be low leakage dampers. Field replaceable edge and end seals shall be installed along the top, bottom, and side of the frame and each blade. Seals and bearings shall be suitable for temperature ranges from minus 40 to 200 degrees F. Leakage shall not exceed 6 CFM/SF at 4 inches WC differential. High Velocity Low Leakage dampers shall be Ruskin, Model CD60 or equal.

B. Electric damper actuators: Belimo.
1. Damper actuators shall be electronic, spring return, low voltage (24VAC) and shall be properly sized so as to stroke the damper smoothly and efficiently throughout its range. Actuator response shall be linear in response to sensed load. End of each damper rod shall be permanently-scored so as to indicate physical position of damper blades. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
2. 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. Unless noted in the sequence of operation or utilized for outside air, for VAV box, Unit Ventilators, Fan Coil Units or terminal units, floating actuator fail in place is permitted. VAV boxes may be as provided by controls

MFG if Belimo actuator is integrated into the MFG's controller provided parts are fully interchangeable.

3. Outside air dampers shall fail close. Return air damper shall fail open. Relief damper shall fail close.
4. All Outside Air, Relief Air and Return Air damper actuators associated with units that have static safety pressure switches shall have position proving switches or blade switches.
5. All dampers shall be equipped to allow manual override.

C. Control Valves: Belimo,
1. Control valves shall be two-position isolation or modulating service as scheduled or shown. Valves 1/2" through 2" shall be forged brass body, stainless steel ball and stem, PTFE seat, EPDM packing, equal percentage flow. Valves 2-1/2" and larger shall be cast iron body, bronze seats, stainless steel stem, bronze plug, no lip packing, ANSI class 125, leakage class III, flanged end fitting.
2. Body, trim style and materials shall be per manufacturer's recommendations for design conditions and service shown.
3. Isolation valves shall be line size full port, 2 position control.

D. Chilled water valves shall fail to 50% open except as allowed in paragraph D.6 below. Hot water valve shall fail open except as allowed in paragraph D.6 below. Electric valve actuators: Belimo, fully integrated into actuator.
1. Valve actuators shall be electronic, low voltage (24VAC), and properly selected for the valve body and service. Actuator shall have clutch or gear operator for manual operation.
2. No more than one pipe size body reduction shall be permitted for hydronic coils.
3. 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 with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
4. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
5. Actuators shall be provided with a conduit fitting and a minimum 3 foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
6. Unless noted in the sequence of operation, for VAV box, Unit Ventilators, Fan Coil Units or terminal units, floating actuator fail in place is permitted.

E. Temperature Sensors: Kele, or approved equal
1. Temperature sensors shall be Thermistor type 10kohm as dictated by the requirements of this specification. Thermistors are acceptable for space temperature sensors and other monitoring only points.
2. AHU unit sensors shall be averaging as specified in the sequence of operations. Averaging sensors shall be a minimum of 6 feet in length. For existing application or where installed ductwork exterior to the AHU, duct sensor 12" probe is acceptable.
3. Averaging sensors shall be 3x3 sq-ft per linear foot of sensor.
4. Immersion sensors shall be provided with a separable stainless steel well. Immersion sensor probe length shall be sized to meet pipe diameter requirements. MFG Thermal lubricant shall be provided.
5. Space sensors shall be flat-plate type sensors. Accuracies shall be plus or minus 1 degree F.

F. Flow and Status Switches: Kele, JCI, Trane, Veris
1. Current sensing relays may be used for flow sensing or terminal devices, as shown. Current-operated switches shall be self-powered, solid state with adjustable trip current. The current switches shall be selected to match the current and electrical characteristics of the equipment being monitored and ~~of~~ the application and output requirements of the DDC system.

2. Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum). Adjustable sensitivity with NEMA 1 Type enclosure unless otherwise specified.
3. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 Type enclosure, with scale range and differential suitable for intended application, or as specified. Water Differential Pressure Switches and shall be installed with full port isolation valves and gauge test ports and made fully accessible or piped to an area where access is afforded without the use of scaffolding or a lift.

G. High Limit Thermostats: Kele, or approved equal High limit thermostats shall be manual reset type set at 120 degrees F.

H. Low Limit Thermostats and Line Voltage Thermostat: Kele, or approved equal.
1. Safety low limit thermostats shall be vapor pressure type with 1 sq-ft coil area per foot of capillary. Element shall respond to the lowest temperature sensed by any one foot section.
2. Low limit shall be DPDT manual reset only rated for the application
3. Where required multiple low limit thermostats shall be installed.
4. Low-Voltage Space Thermostats shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented cover.
5. Line-Voltage Space Thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented cover.

I. Carbon Dioxide (CO2) Sensors: E+E Elektronik, or approved equal
1. Carbon Dioxide sensors shall measure CO2 in PPM in a range of 0-2000 ppm. Accuracy shall be +/- 3% of reading with stability within 5% over 3 years. Sensors shall be outside, duct or space mounted as indicated in the sequence of operation.

J. Interface High Voltage/Current Control Relays: RIB or approved equal
1. Control relays shall be UL listed. Contact rating, configuration, and coil voltage suitable for application.
2. Control relays shall be provided with LEDs to indicate status of the coil.
3. Current sensing relays shall be split core.
4. Time delay relays shall be UL listed dry contact input. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 Type enclosure when not installed in local control panel.

K. Static/Differential Pressure Sensors: Kele, Veris or approved equal
1. Sensor shall have linear output signal. Zero and span shall be field-adjustable.
2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.
3. Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 mA output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.
4. Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 mA output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.
5. Air static or differential pressure sensor shall have range appropriate for their application.
6. Wet Differential Pressure Sensors and transducers shall be installed with full port isolation valves and gauge test ports and made fully accessible either in a mechanical room or within 24” of an accessible ceiling.

L. Humidity Sensors: Kele, or approved equal
1. Duct and room sensors shall have a sensing range of 20% to 80% with accuracy of ±3% R.H. Outdoor air humidity sensors shall have a sensing range of 20% to 95% R.H. It shall be suitable for ambient conditions of -40° C to 75° C [-40° F to 170° F].
2. Duct sensors shall be dedicated duct-mounted probe type.
3. Humidity sensor's drift shall not exceed 1% of full scale per year.

M. Water Flow Metering - Onicon or approved equal
1. Magnetic Water flow measuring sensor shall be Onicon F-3500 series dual turbine.

N. Air Flow Station for Fan Inlet Air Flow Measuring Stations - Ebtron or approved equal
1. Airflow Station: plus/minus 5% accuracy down to 15% nominal flow. Air flow station to be provided by building automation supplier. Provide air flow station only if shown on controls flow diagram or if required by sequence of operation.
2. At the inlet of each fan and near the exit of the inlet sound trap, airflow traverse probes shall be provided that shall continuously monitor the fan air volumes and system velocity pressure.
3. Each traverse probe shall be of a dual manifolded, cylindrical, type 3003 extruded aluminum configuration, having an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching airflow. The manifold should not have forward projecting sensors into the air stream. The static pressure manifold shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as + 20° in the approaching air stream.
4. The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Each airflow-measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.
5. Remote indication is not required if CFM can be displayed on the building automation system.

O. Air Flow Station for Single Probe Air Flow Measuring Sensor – Ebtron Gold Series or approved equal
1. Airflow Station: plus/minus 5% accuracy down to 15% nominal flow. Air flow station to be provided by building automation supplier. Provide air flow station only if shown on controls flow diagram or if required by sequence of operation.
2. The single probe airflow-measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a hot wire anemometer and utilize two temperature sensors and a heater element temperature. The other sensor shall measure the downstream air temperature. The temperature differential shall be directly related to airflow velocity.
3. Remote indication is not required if CFM can be displayed on the building automation system.

P. Air Flow Station for Duct Air Flow Measuring Stations - – Ebtron Gold Series or approved equal
1. Airflow Station: plus/minus 5% accuracy down to 15% nominal flow. Air flow station to be provided by building automation supplier. Provide air flow station only if shown on controls flow diagram or if required by sequence of operation.
2. Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.
3. Airflow measuring stations shall be fabricated of 14-gauge galvanized steel welded casing with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4” maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 6000 feet per minute. This air directionalizer

and parallel cell honeycomb suppressor shall provide 98% free area, equalize the velocity profile, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.

4. Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.
5. Remote indication is not required if CFM can be displayed on the building automation system.

Q. Transformers and Power Supplies.

1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with resettable over-current protection in both primary and secondary circuits for Class 2 service.
2. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection. Unit shall be UL recognized.
3. Controller Power supplies shall be conditioned and not loaded more than 75% of rated capacity.

R. Integrated Boiler Controls.

1. Shall be BACnet compatible and interfaced to the BAS with sufficient capabilities to satisfy the control sequences of the equipment served.
2. Binary Values (BV) shall be provided for monitoring system status and fault indication.
3. Integration of systems to BAS for Class II circuits over 50 volts shall be provided by LED RIB Relays.
4. Each Rib Relay shall be clearly identified.
5. All integral internal and external safety circuits for Boiler protection shall be internal to Boiler controls. All safety circuit wiring shall be direct from safety devices to equipment controller.

S. Integrated Chiller Controls.

1. Shall be BACnet compatible and interfaced to the BAS with sufficient capabilities to satisfy the control sequences of the equipment served.
2. Binary Values (BV) shall be provided for monitoring system status and fault indication.
3. Integration of systems to BAS for Class II circuits over 50 volts shall be provided by LED RIB Relays.
4. Each Rib Relay shall be clearly identified.
5. All integral internal and external safety circuits for Chiller protection shall be internal to Chiller controls. All safety circuit wiring shall be direct from safety devices to equipment controller.

2.13 ENERGY MANAGEMENT SYSTEMS (EMS) SOFTWARE

A. The following Energy Management capabilities shall be furnished standard as part of the Building Automation System Panel.

B. Trend Log Application.

1. Trend log data shall be sampled and stored on the System Controller panel and shall capable of being archived to a BACnet Workstation for longer term storage.
2. Trend logs shall include interval, start-time, and stop-time.
3. Trend log intervals shall be configurable as frequently as 1 minute and as infrequently as 1 year.
4. The system controller shall automatically create trend logs for defined key measurements for each controlled HVAC device and HVAC application.
5. The automatic trend logs shall monitor these parameters for a minimum of 7 days at 15 minute intervals. The automatic trend logs shall be user adjustable.

C. Trend log shall be maintained for three years.

D. Optimum Start/Stop
1. An optimum start/stop program shall determine the required equipment start/stop timing by applying inside/outside temperature information to the user's time of day schedule.
2. The optimum start/stop program shall run independently for each controlled load or zone.
3. The program shall automatically make adjustments to itself based on historical data, limited to 4 hours.

E. Alarm/Event Log.
1. Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state.
2. Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system.
3. An alarm/event shall be capable of triggering any of the following actions: Route the alarm/event to one or more alarm log, route an e-mail message to an operator(s), Log a data point(s) for a period of time, Run a custom control program.

F. Chilled Water System. An operator shall be able to view and control (where applicable) the following parameters via the operator interface:
1. System mode of the chiller plant.
2. Chiller enable/disable status.
3. System supply water setpoint.
4. System supply and return water temperature for each chiller and circuit.
5. System Chilled water pump status for each chiller and circuit.
6. Operator description as to when an additional chiller will be added or removed from operational sequence.
7. Chiller or support system failure information.
8. Chiller pump, tower, rotation information.
9. Override capabilities to force an added chiller, subtract a chiller, or change of sequence.
10. Control to remove a chiller from a sequence temporarily for service purposes.
11. In addition to system flow graphics, provide a system operator information screen.

G. Variable Volume Air System. An operator shall be able to view and control (where applicable) the following parameters via the operator interface:
1. System Mode.
2. System Occupancy.
3. Space Temperature.
4. RTU/Air Handler Static pressure setpoint.
5. RTU/Air Handler Static pressure status.
6. RTU/Air Handler occupancy status.
7. RTU/Air Handler Supply air cooling and heating set points.
8. RTU/Air Handler minimum, maximum and nominal static pressure setpoints.
9. VAV box minimum and maximum flow.
10. VAV box occupancy status.
11. VAV box Airflow to space.
12. VAV box supply temperature (with coils)
13. Average space temperature.
14. Minimum space temperature.
15. Maximum space temperature.
16. Discharge air temperature.
17. Damper positions.
18. Unit mode.
19. Fan start/stop and status.
20. OA flow.
21. RA temp.

H. Air handling unit freeze stat(s) shall be identified, and factory mounted in a location readily accessible by the technician for operation and repair, with manual reset option only.

I. Duct Static Pressure Optimization must be application complying with ASHRAE 90.1-2010 energy saving requirements at a minimum, the screen shall display airflow graphics and duct pressure readings.

J. Demand Control Ventilation must be application complying with ASHRAE 62.1-2004 ventilation requirements. At a minimum, the screen shall display airflow graphics, CO2 readings, and OSA damper position.

K. Totalizing.
1. A totalizing program shall be provided to enable the building operator to monitor and totalize any user-defined flow such as water flow, electricity, and natural gas.
2. A minimum of 64 totalizing equations shall be provided.

L. Expanded Messages.
1. The user shall be able to define a minimum of ten 40 character messages for automatic printing in the event of system alarm and/or run time and maintenance events.
2. A minimum of 64 totalizing equations shall be provided.

M. Diagnostics.
1. The building operator shall be provided with a report containing common symptom and diagnostic trouble shooting guides for HVAC system equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that duct and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Each equipment shall have a dedicated new DDC controller and must be mounted at respective equipment or in unit mechanical room for ease of maintenance.

B. Interlock wiring cable shall be white color or as coordinated with other trade not to conflict.

C. Smoke detector interlock shutdown wiring cable and RIB Relay shall be red color or as coordinated with other trade not to conflict.

D. All DDC cabling shall be purple color with yellow stripe.

E. Interlock shutdown wiring shall be wired directly fail safe from the signaling device to the actuated equipment Integrated Controls and be supported at regular interval. The interlock shutdown signaling device shall also be wired fail safe to the BAS DDC controls.

F. All electrical work performed in the installation of the BAS/ATC system as described in this specification shall be per the National Electrical Code (NEC) and per applicable state and local codes. All wiring shall be installed in electric metallic tubing conduit except as allowed below. Where exposed, conduit shall be run parallel to building lines properly supported and sized at a maximum of 40 percent fill. In no cases

shall field installed conduit smaller than ½ inch trade size be allowed. All electrical work shall comply with Electrical requirements of these specifications.

G. If not indicated on the electrical drawings to be provided by the Electrical Contractor, the Automatic Temperature Controls contractor shall be responsible for dedicated ATCS power to closest electrical panel that can support a 120 volt 20 ampere breaker.

H. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except where UL Listed for the purpose of interfacing the two (e.g. relays and transformers.)

I. All wire-to-device connections shall be made at a terminal blocks or terminal strip and clearly identified. All wire-to wire connections shall be at a terminal block. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

J. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device with each conductor clearly identified.

K. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation, CMS color code and NEC.

L. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures unless UL Listed for the purpose.

M. Adhere to Electrical requirements for installation of raceway.

N. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3 feet in length and shall be supported at each end. Flexible metal conduit less than ½ inch electrical trade size shall not be used.

O. Mount laminated controls drawings and operational sequences next to the main controller.

P. Mount the panel specific labelled wiring diagrams inside the main controller. Provide specific termination labeled wiring diagram for each controller. Laminate and adhere to the inside of each individual panel door.

Q. All field devices and controllers shall be provided clear access for service and labeled. All devices concealed above ceilings shall have the access point identified with a laminated engraved tag firmly affixed to the ceiling grid.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Electrical requirements.

B. Install building wire and cable according to Electrical requirements Section "Low-Voltage Electrical Power Conductors and Cables."

C. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

D. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

E. Provide laminated engraved tags for every box and cabinet containing devices, controllers, transformers, or equipment.

F. Identify raceway junction box covers containing Network Cables with the color purple.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test each point through its full operating range to verify that safety and operating control set points are as required.
4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
5. Test each system for compliance with sequence of operation.
6. Test software and hardware interlocks.
7. Provide seasonal testing while building is occupied in August/September for cooling mode, and December/January for heating mode.
8. Inspect all field equipment for proper DDC tagging wire identification and labeling.

C. DDC Verification:
1. Verify that instruments are installed before calibration and testing.
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 temperature instruments and material and length of sensing elements.
5. 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 sequence of operation functional performance.
6. Verify that the systems control, and sequence of operations can be accessed from the graphical interface via the embedded pdf. File per specification section 230901.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:
1. After completion of the installation, perform final checkout and adjustments of the equipment provided under this contract and supply services incidental to the proper performance of the ATC and BAS system under warranty below.
2. Adjust initial temperature and other set points.
3. See sequence of operation for initial temperature/pressure setpoint values.

B. Provide final time schedule programming during Owner’s training.

3.6 INTEGRATION OF NON-HVAC BUILDING SYSTEMS

A. See Sequence of Operation section 23 09 93 for miscellaneous integration or monitoring requirements to be connected to BAS.

B. HVAC equipment, generators, and electrical smart meters shall be provided with protocol capability as stated in Sequence of Operation section 23 09 93. The work to provide, install, and valid functions of these system shall be provided by the Division 26 Electrical Contractor. The Division 26 Electrical Contractor shall provide the objects points list to the BAS contractor so integration to BAS.

C. The work to provide, install, and validate functions of the lighting system shall be provided by the Division 26 Electrical Contractor.

D. All the classrooms, offices, storage rooms, and similar spaces will have vacancy sensors which will turn the lights off automatically. All other spaces (hallways, corridors, gym, locker rooms, cafeteria, multipurpose room, electrical & mechanical rooms, and similar spaces) having manual switches will not have occupancy sensors and will be scheduled and controlled by the Building Automation System (BAS). The BAS lighting control shall be on a separate schedule from the HVAC.

E. Lights will be zoned into logical areas, each controlled by a zone contactor. An output from the BAS drives each zone contactor and is wired in a fail-safe manner that causes the lighting contactors to close (normal state) if any part of the BAS fails.

F. Provide output signal to each electrical room with a lighting panel for lighting control through the BAS. There will be an override bypass switch/timer for each lighting zone (electrical room). To accommodate school activities that may occur outside these hours, a bypass timer will be provided by the Electrical Contractor for each lighting zone. These timers will provide an input to the BAS while they are timing and have a maximum setting of 4 hours. They will be grouped at the front office. If a timer is activated, it will bypass the normal time schedule for the set hours and close the lighting contactor. When the timer times out, it will cause the contactor state to revert to whatever is specified in the time base. Five minutes before the timer is to time out, it will cause the contactor to drop out for an instant as a warning that if additional time is desired, the timer needs to be reset. Controls Contractor to provide and install low voltage wiring from timers to BAS.

G. There shall be a burglar alarm override of the BAS lighting control.

H. Provide input to the BAS indicating when the security system is armed. If the input is ON, the building is assumed to be unoccupied and the contactors are opened immediately regardless of the state of the normal time base or the bypass timers. If the security system is unarmed, the contactors revert to whatever state is called for by the time base or bypass timers. Controls Contractor to provide and install wiring from the security panel to the BAS.

I. The Controls Contractor shall provide zone contactors. The Electrical Contractor will provide the lighting contactors. See Electrical Drawing Details for Interior Lighting Control Wiring Diagram.

J. An ON-OFF-AUTO switch will be provided by the Electrical Contractor. The Controls Contractor shall wire the switch to interface to the BAS to function as follows:
   1. AUTO: BAS control of lights. Enabled with burglar alarm and bypass switch/timer overrides enabled.
   2. ON: BAS control of lights enabled with burglar alarm and bypass switch/timer overrides disabled.
   3. OFF: BAS control of lights disabled with burglar alarm and bypass switch/timer overrides disabled. Lights under local switch control only.

K. The Controls Contractor shall demonstrate an operational lighting control system to the owner upon completion of the project. Demonstration shall include the following:

1. BAS time based control of ON/OFF
2. Security override of time based control. Check armed and unarmed state.
3. Bypass switch/timer functionality.
4. ON-OFF-AUTO switch/timer function.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's Energy Management Staff (PM's and EMS Control Specialists) in two phases. to adjust, operate, and maintain HVAC instrumentation and controls. Provide a site walk-thru to view the layout and placement of the EMS/BAS System controllers, equipment controlled, integration to equipment, and sensor locations as marked. Provide 24 hours of technical classroom training of the BAS Vendor's system "live," on site or another suitable location to be determined by CMS over a multi-day/week time period. The agenda will be defined to include remote access to the completed project's GUI, exercises using diagnostics utilizing all the software and hardware capabilities of the BAS, programming, graphical editing, editing/addition of tags, labels and hyperlinking of points and pdf's.

3.8 SPARE PARTS LIST

A. Controls contractor shall provide spreadsheet bill of materials for each specific component used on the project. Spreadsheet shall be provided as a hyperlink on the BAS front end.

3.9 WARRANTY REQUIREMENTS

A. TWO YEAR WARRANTY: Provide all labor, material, and equipment necessary to maintain beneficial performance of the entire control system for a period of two (2) years after DELIVERY OF THE COMPLETED FLAWLESS GRAPHICAL USER INTERFACE as accepted by no less than two EM/EMS staff members. The controls subcontractor at no charge to the Owner shall promptly correct any defects in workmanship or material during the warranty period. All work shall be accomplished during normal working hours M-F if possible. Precaution shall be taken to minimize disruption of facility operations.
   1. Provide an alternate price to extend this warranty to five (5) years.

END OF 23 09 00

SECTION 23 09 01 – BUILDING AUTOMATION SYSTEM GRAPHICAL USER INTERFACE

PART 1 - GENERAL

1.1 INSTRUCTIONS TO VENDORS

A. Vendor is cautioned that the Owner reserves the right to reject any Vendor, which in the Owner's sole judgment, takes meaningful deviation or exception to Division 23 Direct Digital Control (DDC) Standards. The Charlotte-Mecklenburg Schools' (CMS) Energy Manager and/or designated representative of the Energy Management Department (EMD) shall review all vendor substitution submittals. Vendor substitution approval/disapproval shall be returned via the project architect in writing from Charlotte-Mecklenburg Schools' Energy Manager and designated EMD Project Manager.

1.2 RELATED DOCUMENTS

A. Drawings (both mechanical and electrical project manual drawings) and general provisions (within Divisions 23, 26, 27) of the Contract, including General Conditions apply to this Section.

B. The provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as through bound herein.

C. Sections within Division 23 – Mechanical and Division 26 – Electrical apply, including though not limited to
   1. 23 09 00 – Energy Management System (EMS) and Building Automation System (BAS) Control for HVAC and Lighting
   2. 23 09 02 – BAS Point Naming and Tagging Guideline

1.3 SUMMARY

A. This Section includes the proposed structure of the Charlotte Mecklenburg Schools Building Automation System Graphical User Interface.

1.4 ABBREVIATIONS AND ACRONYMS

A. AHU: Air Handling Unit

B. GUI: Graphical User Interface

C. IP: Internet Protocol

D. PC: Personal Computer

1.5 SYSTEM PERFORMANCE

A. The GUI shall be accessible by entering individual unique user ID's and passwords with varying levels of administrator functionality from any IP connected user device without the need for special software or a dedicated PC.

B. Navigation shall be via point and click mouse selection and keyboard entry by personnel requiring little or no formal training.

C. A navigation tree shall be provided for selection of Graphics being pulled up by School name, listed in descending Alphabetical Order with an initial Summery Graphic at the top of the Tree Listing all Schools by Grade. Subgroups by grade and/or building function shall also be provided.

D. Selecting subsequent branches for each school shall depict the individual Schools GUI Summery Page showing the Site Plan for the School's entire Campus Buildings in a dynamic key plan to allow the user to drill down to further levels of zoom and sub-branches from the tree.

E. Zoom of plan GUI screens shall be either mouse wheel or subsequent point-n-click levels of plan drawings to provide the sufficient level of details. The layout and structure for all equipment and subsequent devices should be consistent for both enumeration and format regardless of vendor.

F. All GUI plan drawings shall be oriented so that the front of the school's main entrance is at the bottom of the page. All subsequent levels of zoom for floor plans shall retain the same orientation.

G. All GUI screens shall be titled on every page in sequence by the School Courier Code; Formal assigned Name; and further branches down the tree by Type of major piece of equipment; Individual Device; separated by hash marks. Each Schools initial Summery page shall also provide the US Postal Address of the building in its entirety and an orientation indicator to due North

H. School summary page should also show Primary Central Plant equipment status and primary AHU's general status with site wide combined selected high-level alarms status. Hyperlinks shall be provided to allow for global parameters to be set, monitored, and modified.

I. Subsequent branches down from the school summary page shall depict the Building(s,) then Floor Plans from lowest elevation to the highest elevation, including lofts and Mezzanines. The geographic location of every major monitored, and controlled piece of equipment placed in its physically installed position shall be shown on overlays of the site/floorplan and/or riser/line diagrams by School. The building overall floor plans shall also show each individual controlled spaces temperature with relevant thermographic color infills depicting controlled spaces actual temperature in relation to setpoints. Green within range, Blue cooler than rage, Red warmer than range. Colors out of range shall show in 2-degree gradients. Deeper colors of Red and Blue shall show the greatest range deviations from setpoints.

J. All building floor plans used for GUI base drawings must show all fixed structural elements, doors, room designations, stairs, and shaft ways. Mechanical background drawings showing equipment locations such as AHU, VAV, and associated ductwork are preferred.

K. Subsequent branches drilling down into major pieces of equipment shall depict sub-component and end of line devices in their geographic position within a room and/or in proper alignment on equipment pictographs as installed over layered on one line flow diagrams, mechanical floorplan details, or the detailed equipment graphics.

L. Tree Layout. The navigation tree consists of tabs that contain nodes, legible display text, graphical links, and icons. It shall be assembled and built by choosing display text for nodes, arranging the nodes, and assigning associated graphics to them.

M. Branch Layout. Shall be arranged first by School Site, then by Building, then by Floor and further, if necessary, by Room. Branches shall also be provided for diagnostic and programming tables for individual equipment for use by technicians.

N. All branches shall be constructed in a consistent logical, flow and format as follows:

O. a) First Branch; The CMS name and courier address of the campus grouped by grade in descending alphabetical order; (Linked to sites Summery Page /Campus Overview)

P. b) Second Branches; ALL Sub-buildings number/letter within a Campus (where applicable); (Linked to Ground Level Elevation of the selected building.)

Q. c) Third Branches; ALL Individual elevations of the building including Roof Elevations, (Links to specific elevation.)

R. d) Fourth Branch; Spaces (by Room number based on the designation from the architectural plans.)

S. e) Subsequent Branches; Sub-branches of Central Plants, grouped equipment and components with navigation links to upstream/downstream system components; Relevant links to troubleshooting aids, setpoints and pdf's. (Linked to individual specific components and/or Central Plants)

T. BAS Global Navigation Task Bar. Provide task bar for Global Set Points, Alarm, User, Admin and Help Functions queries. Global Navigation shall be at the top of the tree and transfer data to and from all subsequent branches of the tree.

U. System Navigation Links: Provide links to point's status, graphics, data logs, alarms and events, equipment, spaces, systems, points, schedules, reports, tools
1.

V. All equipment ID's shall be enumerated based on a sequence starting from left to right with the major equipment type abbreviation, floor elevation, then the specific units building zone and/or room number. Dedicated pumps and fans shall be enumerated with the same numerical designation as the major equipment upstream the pump or fan serves. If more than one of the same types of pumps or device exists in parallel an alpha character shall also be sub-assigned to differentiate each device. Where multiple rooms are served by a single piece of equipment, the area containing the controlling device shall dictate primary upstream equipment's unique enumeration.

W. All equipment down to the end line devices shall be clearly identified with sufficient branches, zoom and scale to make it clear to the operator specifically where in a building or room the equipment is physically located relevant to the building drawings.

X. All relevant documentation derived from installation, including operational design parameters, sequences, point to point wiring diagrams, device catalogue cuts, plan mechanical drawings, riser drawings, device details, maintenance manuals and repair procedures shall be segregated then embedded with a point-n-click navigation from the Site Summery Page and/or the lowest zoom level where the device depicted resides.

Y. For each piece of equipment, a GUI screen hyperlink shall be provided to display a drill down screen showing the technical parameters of the device for troubleshooting and diagnostics.

Z. The layout for every GUI screen shall be consistent for each like piece of equipment regarding positioning of relevant information. The One Line diagram and flow of Central plant piping shall be as close as possible to a direct representation of actual field conditions.

AA. The grouping of GUI parameters for each screen shall be consistent throughout all similar screens for ALL schools.

1.6 SUBMITTALS

A. Product Data: Include manufacturer's examples of graphics for each type of system indicated.
   1. Control System Software: Include technical data for operating system software, operator interface, color graphics, programming, sequence of operations, and other third-party applications.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 WARRANTY REQUIREMENTS

A. TWO YEAR WARRANTY: Provide all labor, material, and equipment necessary to maintain beneficial performance of the entire control system for a period of two (2) years after DELIVERY OF THE COMPLETED FLAWLESS GRAPHICAL USER INTERFACE as accepted by no less than two EM/EMS staff members. The controls subcontractor at no charge to the Owner shall promptly correct any defects in workmanship or material during the warranty period. All work shall be accomplished during normal working hours M-F if possible. Precaution shall be taken to minimize disruption of facility operations.
   1. Provide an alternate price to extend this warranty to five (5) years.

END OF 23 09 01

SECTION 23 09 02 – BAS POINT NAMING AND TAGGING GUIDELINE

PART 1 - GENERAL

1.1 INSTRUCTIONS TO VENDORS

A. Vendor is cautioned that the Owner reserves the right to reject any Vendor, which in the Owner's sole judgment, takes meaningful deviation or exception to Division 23 Direct Digital Control (DDC) Standards. The Charlotte-Mecklenburg Schools' (CMS) Energy Manager and/or designated representative of the Energy Management Department (EMD) shall review all vendor substitution submittals. Vendor substitution approval/disapproval shall be returned via the project architect in writing from Charlotte-Mecklenburg Schools' Energy Manager and designated EMD Project Manager.

B. The overriding requirement is the use of the DDC Control System to maintain design occupant comfort with optimal minimized energy consumption while maximizing equipment, component, and system design function integrity and life.

1.2 RELATED DOCUMENTS

A. Drawings (both mechanical and electrical project manual drawings) and general provisions (within Divisions 23, 26, 27) of the Contract, including General Conditions apply to this Section.

B. The provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as through bound herein.

C. ASHRAE Standard 135 (latest version)

D. Sections within Division 23 – Mechanical and Division 26 – Electrical apply, including though not limited to:

1. 23 09 00 - Instrumentation and Control for HVAC
2. 23 09 01 – BAS Graphical User Interface Guidelines
3. 23 08 00 – BAS & HVAC Commissioning
4. 26 08 00 - Electrical Commissioning

1.3 SUMMARY

A. An individual piece of equipment should have the same name convention regardless of where in the system the points may be defined. There should be one and only one standard point name for each distinct point and type. Abbreviations of complete point names will be permitted for GUI displays when the points geographic location is obvious on the graphic depicted.

B. An equipment point name combination should uniquely identify the piece of equipment and its geographic location in a building with the complete and unambiguous context of the point.

1.4 EQUIPMENT

A. Equipment names should be unique-and sequenced to follow a consistent logical flow and order based on its geographic location within a School; The order of the equipment name shall be; Three digit School courier number – Building/Elevation-Room number - Equipment Type - Specific Connected Device Identification

1) Example; (XXX-A1-CR123-AHU-01-SF) XXX=School Courier Code, A1=Building "A" First Floor, CR123 = ClassRoom123, AHU-01=Air Handler Unit #1, SF= Supply Fan

2) Example; (XXX-M2-CR208-FC-01) XXX=School Courier Code, M2=Building "M" Second Floor, CR208=Classroom 208, FC-01=Fan Coil Unit #1

3) Example; (XXX-MSB-BR20-BL-01-PriPmp-01) XXX=School Courier Code, MSB=Building "M" Sub-Basement, BR20=Boiler Room 20, PriPmp01=Primary Pump #1.

B. Equipment represented by a device on a bus should have a unique folder name in the BMS path. The School Courier Code and full name shall be used if possible.

D. Equipment sequence numbers should always be at the end of the equipment name with no additional underscore. Dedicated pumps for upstream Equipment such as Boilers and Chillers shall maintain the same designation as the Boiler or Chiller served. Dedicated Equipment VAVs connected to AHU's shall be enumerated with the same designation as the upstream equipment hyphenated by the room served designation.

1) Example; (XXX-MSB-BR20-BL-01-PriPmp-01) XXX=School Courier Code, MSB="M" building Sub-Basement, BR20=Boiler Room#20, Boiler "#1" shall have the Primary Pump designated PriPup "#1."

2) Example; (XXX-A1-CR123-VAV-01-123A) XXX=School Courier Code, A1="A" Building 1st Floor, Classroom 123, VAV in Room 123 is fr**o**m AHU-01.

E. Trailing Sequential Alphabetic characters should be placed at the end of the sequence number for uniquely identifying multiple parallel equipment that services the same VAV or piece of equipment.

1) Example, (XXX-MSB-BR20-BL-01-PriPmp-01A) and (XXX-MSB-BR20-BL-01-PriPmp-01B) represent two pumps in parallel servicing the Primary Loop for Boiler #1.

2) Example, (XXX-A1-CR123-VAV-01-123A) and (XXX-A1-CR123-VAV-01-123B) represent two VAV's in Room 123 supplied from AHU 01

F. Equipment software points defined in separate control routines should use the same unique name at the beginning of the point name followed by an underscore.

G. Equipment names should follow the standard abbreviations with hyphen between unique sequential characters (See STANDARD ABBREVIATIONS Tables). If more than ten units of the same equipment ID number are utilized a preceding zero shall be used;

1. Example: AHU-01, AHU-10.

2. Example: Blr-01, Chlr-02

3. Example: CHP-1A, HWP-1A, BCHP-1A, BHWP-1A

4. Example: VAV-(AHU#)-(Room number served by the VAV)

a. If multiple rooms are served by the VAV, use the room number in which the thermostat is located.

b. If multiple VAV's serve the same room, add an alpha character to designate (VAV-8-215A/B).

5. Example: FCU-(Room number served by the FCU).

a. If multiple rooms are served by the FCU, use the room number in which the thermostat is located.

b. If multiple FCU's serve the same room, add an alpha character to designate (FCU-215A/B).

1.5 POINTS:

A. Point names should follow the standard abbreviations.

B. Point name compounds should progress from left to right, most general to the left and most specific to the right.

1. Example: SaTemp, SaTempSp, SaPress, SaPressSp, RaHum, RaDeHumidifySp, RaHumidifySp

1.6 HISTORIES:

A. History names should be generated using the Niagara Bformat strings %parent.name% whenever possible.

B. History names should progress from left to right, most general to the left and most specific to the right.

C. The general format is: 3 digit Courier ID XXX, EquipName_SubEquipName_PointNamePointAttribute

1. Example: XXX_AHU01_SaFanCmd, AHU01_SaFanSpd, AHU01_SaFanSts

2. Example: XXX_AHU02_ChWVlvPos,

3. Example: XXX_Blr01_BlrEnab, XXX_Blr01_BlrIsoVlvCmd, XXX_Blr01_BlrCPCmd, XXX_Blr01_BlrETemp, XXX_Blr01_BlrLTemp

4. Example: XXX_Chlr01_ChlrEnab, XXX_Chlr01_ChlrIsoVlvCmd, XXX_Chlr01_ChlrCPCmd, XXX_Chlr01_ChlrETemp, XXX_Chlr01_ChlrLTemp

5. Example: XXX_CHWS_SupTemp, XXX_CHWS_RetTemp, XXX_CHWS_ChWP01_ChWPCmd, XXX_CHWS_ChWP01_ChWPVFDSpd, XXX_CHWS_ChWP02_ChWPSts

6. Example: XXX_MZ01_Zn03_SpcTemp, XXX_MZ01_Zn03_SpcTempEffSp

7. Example: XXX_HWS_SupTemp, XXX_WS_SupTempSp, XXX_HWS_HWRetTemp, XXX_HWS_HWP01_HWPCmd, XXX_HWS_HWP01_HWPSpd

1.6 STANDARD TERMS

A. Circulation (Pump): A pump typically within the plant that circulates a fluid through an individual piece of equipment such as a chiller, boiler, domestic water heater, cooling tower or heat exchanger. Associated with primary, secondary or recirculation hydronic loops.

B. Chilled Water System: A hydronic cold water loop with various BAS controls to provide constant or variable temperatures where global points related to the overall chilled water plant are defined. Points would include; loop entering/leaving temperatures, setpoints, loop pumps, valves, differential pressures and other global points not necessarily located within the Central Plant. This should match Hot Water System

C. Command: Indicates a piece of equipment, valve, damper, or fan has been command to a Boolean value of on/off or open/close. (See Enabled, Status and Position for related points)

D. Effective: Indicates the current temperature or pressure setpoint target given the current mode of operation. For a temperature or flow set point this value would change as a piece of equipment moves between occupied and unoccupied and heating and cooling modes.

E. Enabled/Disabled: A Boolean software point indicating an equipment's local/embedded controller is being enabled and should provide a physical output change in state to start/stop local control. It does not indicate a piece of equipment is running or not running. Points within the local controller must be monitored to indicate the actual running state. Enabled/Disabled should never be used to indicate the commanding of a point or piece of equipment on or off. (See Command and Status for related points)

F. Energy: Tracks the consumption of a unit of energy (kWh, btu, etc.). Always an accumulated value with a totalized tag.

G. Exhaust: Indicates undesired air leaving the building due to contaminants or other undesirable components like excess heat or humidity. Common areas would include bathrooms, mechanical areas, dryers, pools and laboratories.

H. History Intervals: Numeric history intervals for new projects with newer controllers and adequate memory should be 10 minutes or Change Of Value. Retrofit work should correspond with the existing intervals. In all cases the history interval should be the same for all points on a piece of equipment so that histories align on the same time boundaries.

I. Frequency: Frequency is a range of numeric values either commanding or sensing a VFD running at a specific Hz during a slice in time. See Speed for VFD percent control.

J. Hot Water System: A hydronic hot water loop with various BAS controls to provide constant or variable temperatures. Points would include: loop entering/leaving temperatures, setpoints, loop pumps, valves, differential pressure sensors, enabling values and other global points. not necessarily located within the Central Plant.

K. Pumps should be designated as either Primary, Secondary, or Recirculation. “Loop” designation should not be used as it is uncommon and non-specific.

L. Makeup Air Unit: An air handler that takes in outside air and heats, cools, humidifies, or dehumidifies for deliver to the building with no recirculation. May be a preheat unit to an AHU or general discharge into the building.

M. Mixed Air Damper: Mixed air damper should only be used when there is a specific third damper controlling mixed air separate from the outside air damper and the return air damper. An electronically linked two damper configuration of outside and return air dampers should never name the two dampers as a mixed air damper.

N. Mode: A software point indicating the current operating intent of a piece of equipment. Used to understand the current system mode (i.e. Occupancy, Humidify, Dehumidify, Economizing, IAQ, Heating, Cooling, etc.) when analyzing related points.

O. Occupancy: A state of physical presence within a building space that is detected by a device or produced by a Boolean point indicating a unit is in occupied or unoccupied mode.

P. Phase: Indicates electrical attributes (amps, volts, power or energy) as measured across an individual phase. A string value containing A, B, C, AB, BC, AC, AN, BN, CN.

Q. Power: Tracks the instantaneous value of power (kW, btu/h, etc.).

R. Position: A numeric value indicating a valve or damper open position between 0% (Closed) and 100% (Open)

S. Preheat: Preheat indicates heating coils and valves intended to heat outside air to prevent the freezing of cooling coils. Often seen in cold climates with minimum outside air damper positions or large outside air requirements.

T. Primary: The primary tag is always used in the context of the site. Primary refers to piping, valves, pumps and sensors within the heating/cooling plant that moves water between a specific piece of equipment in the central plant. Common primary equipment includes individual chillers, boilers, heat exchangers, isolation valves, pumps and sensors.

U. Radiant: Indicates hot or cold water radiant heating or cooling systems

V. Relief: Indicates a point at which excess air is leaving the building to maintain overall building static pressure and/or indoor air quality. Most commonly associated with the air handling units.

W. Room: A specific area referenced based on architectural floor plans. This term should not be used. Use "Space" instead to represent any specific area ventilated by mechanical equipment derived from the architectural floor plans.

X. Secondary: The secondary tag is always used in the context of the site. Secondary refers to equipment or points moving air or fluids away from ~~a~~ one or more individual primary source(s) to another area for use. Common sources may include chilled water or hot water plants within a building or a central or district plant on a campus. Common uses may include campus distribution of chilled water, hot water, or steam; or chilled, hot, domestic water loops which are not passing directly through primary equipment within a building. (e.g. Secondary Dual Temperature Pumps)

Y. Space: Space is the general term used to define an airtight compartmentalized indoor area ventilated by mechanical equipment such as AHU’s, VAV’s, UV’s, FC’s including ancillary Supply and Exhaust Fans and influencing ventilated equipment such as Boilers drawing air from a space. The term “Room” or "Zone" should not be used.

Z. Speed: A numeric value commanding a fan or pump to run at a percentage of capacity from 0% (Stopped) to 100% (Full speed.)

AA. Status: A Boolean point indicating proof a commanded action happened. Typically based on an input measure of flow (air, water, current) resulting from the change in state of a field devices physical reaction. Boolean Status should never be used to indicate the commanding of a point on or off. (See Command and Enabled for related points)

BB. Zone: While "zone" is the haystack tag for a space or room, point naming should use the term "space". See Space.

CC. Total Indicates the total power or energy across all phases of electricity.

1.7 SUBMITTALS

A. Provide summary list of BAS Controls Points following the requirements of this specification.

1. Summary list shall follow format noted in Part 2 of this specification.

PART 2 - PRODUCTS

1.

2.1 STANDARD ABBREVIATIONS

Term	Abbreviation
Air	Air/a
Air HandlerUnit (equip)	AHU
Alarm	Alrm
Average	Avg
Current (Amps)	Amp
Backdraft Damper	BDD
Boiler (equip)	Blr
BTU	BTU
Building	Bldg
Bypass	Byp
Cabinet Unit Heater	CUH
Central Exhaust Fan (equip)	CEF
Carbon Dioxide	CO2
Carbon Monoxide	CO
Chilled Water	ChW
Chilled Water System	CHWS
Chiller (equip)	Chlr/Chl/Chr
Circulation Pump (individual equipment)	CP
Cold Deck	CD
Command (Open/Closed/On/Off)	Cmd
Condenser Water	CW
Cooling Coil	CC
Cooling Tower (equip)	CT
Change of Value	COV
Damper	Dmpr
Day	Day
Dedicated Outside Air System	DOAS
DeHumidify (setpoint/enabled/mode)	DeHumidify
Dew Point	DewP
Differential Pressure	DP
Differential Temperature	DT
Discharge Air	Da
Discharge Air Fan	DaFan
Domestic Hot Water System	DHW
Dryer	Dryer
Dryer Exhaust Fan (equip)	DEF
Duct	Duct

Economize (enabled/mode)	Econ
Effective	Eff
Enable	Enab
Entering	Ent
Enthalpy	Enth
Exhaust Fan (equip)	EF
Exhaust Air	Ea
Exhaust Air Fan	EaFan
Evaporative Unit	EVAP
Fan (use pre qualifier: Sa, Ra, Ea)	Fan
Fan Coil Unit (equip)	FCU
Filter	Fltr
Flow	Flow
Freeze	Frz
Frequency	Freq
Fuel Oil	FO
Gallons	Gal
Glycol	Gly
Heat Exchanger (use qualifiers: Stm, ChW)	Hx
Heat Recovery Unit (equip)	HRU
Heating Coil Hydronic	HC
Heating Coil Electric	HCE
High	High/Hi
Hot Deck	HD
Hot Water	HW
Hot Water System	HWS
Hour	Hr
Humidify (setpoint/enabled/mode)	Humidify
Humidity (assumed relative)	Hum
Indoor Air Quality (mode)	IAQ
Interval	INT/int
Isolation	Iso
Kilowatts (power)	kW
Kilowatt Hours (energy)	kWh
Leaving	L/Lv
Level	Lvl
Limit	Lmt
Load	Load
Low	Low/Lo

Makeup Air Unit (equip)	MAU
Maximum	Max
Medium	Med
Millions BTU	MBTU
Minimum	Min
Mixed Air	Ma
Mixing (Valve)	Mix
Mode	Mode
Month	Mo
Multi Zone (equip)	MZ
Occupancy/Occupied	Occ
Outside Air	Oa
Perimeter	Per
Phase	Ph A/B/C
Position (%)	Pos
Power Factor	PF
Preheat (equip)	Preheat
Preheat (points)	PH
Preheat Coil	PHC
Pressure (assumed static)	Press
Primary	Pri
Pump	Pmp
Radiant Heat	Rad
Reheat	Reheat/RH
Relief / Return Relief	Rlf
Return	Ret
Return Air	Ra
Return Air Fan	RaFan
Room	Rm
Rooftop Unit	RTU
Runtime	Run
Secondary	Sec
Setpoint	Sp
Space	Spc
Speed	Spd
Stage(s)	Stg(s)
Standby	Stby
Start/Stop	S/S
Static Pressure	Press

Status	Sts
Steam	Stm
Supply	Sup
Supply Air	Sa
Supply Air Fan	SaFan
Temperature	Temp/T
Tons	Ton
Tons Refrigerant	TonRef
Total	Tot
Unit Heater (equip)	UH
Unit of Measure	UoM
UnOccupied	Unocc
VAV (equip)	VAV
VAV Cooling Only	VAVCO
VAV Heating Only (Dual Duct)	VAVHO
VAV with Reheat	VAVRH
Valve	Vlv/V
Variable Frequency Drive	VFD
Variable Refrigerant Flow/Volume	VRF
Ventilator Fan (equip)	VF
Volts	Volt
Volume	Vol
Water	Wtr/W
Week	Wk
Year	Yr
Zone (multi zone equip)	Zn

Specific Tags can be formulated from using multiple grouped abbreviations from above starting with the equipment type designation then using underscores to drill down to the specific device function (VAV_102_Spc_Temp)

The below charts are examples of compliant configurations for systems. Follow the latest version of ASHRAE Standard 135 for values derived from Data Communication Protocol for Building Automation and Control Networks.

2.2 AHU
With Return Air
Equip, hvac, ahu
[rtu],
[elecHeat, hotWaterHeat, steamHeat, gasHeat, noHeat],
[chilledWaterCool, dxCool, noCool],
[directZone, vavZone, chilledBeamZone, multiZone],
[singleDuct, dualDuct, tripleDuct],
[hotDeck, coldDeck, neutralDeck],
[constantVolume, variableVolume]
[humidification, noHumid],
hotWaterPlantRef, chilledWaterPlantRef
Makeup Air
equip, hvac, ahu, mau

Description	Point Name navName	Tags	Point Type	UoM	History
General Points					
AHU Enabled	AHUEnabled	enabled, cmd	Bool	Enabled/Disabled	COV, 30days
Occupied Command	OccCmd	occupied, cmd	Bool	Occupied/UnOccupied	COV, 30days
Occupied Mode	OccMode	occupied, cmd	Enum/Str		COV, 30days
Building Static Pressure	BldgPress	building, air, pressure, sensor	Num, .01	in w.c.	Int, 5 min
Building Static Pressure Setpoint	BldgPressSp	building, air, pressure, sp, hisMode:cov	Num, .01	in w.c.	COV, 30days
Freeze Stat	FrzStat	freeze, air, temp, sensor	Bool	On/Off	COV, 30days
Filters					
Filter Alarm	FilterAlrm	filter, alarm sensor	Bool	On/Off	COV, 30days
Filter Status	FilterSts	filter, run, sensor	Bool	Ok/Dirty	COV, 30days
Filter Pressure Delta	FilterDP	filter, pressure, delta, sensor	Num, .01	in w.c.	Int, 5 min
Single Direct Zone Points					
Space CO2	SpcCO2	zone, co2, sensor	Num, 0	ppm	Int, 5 min
Space CO2 Setpoint	SpcCO2Sp	zone, co2, sp, hisMode:cov	Num, 0	ppm	COV, 30days
Space Humidity	SpcHum	zone air, humidity, sensor	Num, 0	%	Int, 5 min
Space Pressure	SpcPress	zone, air, pressure, sensor	Num, .01	in w.c.	Int, 5 min
Space Pressure Setpoint	SpcPressSp	zone, air, pressure, sp, hisMode:cov	Num, .01	in w.c.	COV, 30days
Space Temperature	SpcTemp	zone, air, temp, sensor	Num, 1	F	Int, 5 min

Space Temperature Average (multiple spaces)	SpcTempAvg	zone, air, temp, avg, sensor	Num, 1	F	Int, 5 min
Space Temperature Setpoint (effective)	SpcTempSp	zone, air, temp, effective, sp, hisMode:cov	Num, 0	F	Int, 5 min
Occupied Cooling Setpoint	OccCoolSp	zone, air, occ, cooling, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Occupied Heating Setpoint	OccHeatSp	zone, air, occ, heating, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Unoccupied Cooling Setpoint	UnoccCoolSp	zone, air, unocc, cooling, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Unoccupied Heating Setpoint	UnoccHeatSp	zone, air, unocc, heating, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Discharge Air Points - VAV Zones					
DA Fan Command (single or common)	DaFanCmd	discharge, air, fan, run, cmd	Bool	On/Off	COV, 30days
DA Fan Status (single or common)	DaFanSts	discharge, air, fan, run, sensor	Bool	On/Off	COV, 30days
DA Fan Speed (single or common)	DaFanSpd	discharge, air, fan, speed, cmd	Num, 0	%	Int, 5 min
DA Fan Frequency (single or common)	DaFanFreq	discharge, air, fan, freq, sensor	Num, 0	Hz	Int, 5 min
DA Humidity	DaHum	discharge, air, humidity, sensor	Num, 0	%	Int, 5 min
DA Humidity High Limit	DaHumHiLmt	discharge, air, humidity, high, sp, hisMode:cov	Num, 0	%	COV, 30days
DA Pressure	DaPress	discharge, air, pressure, sensor	Num, .01	in w.c.	Int, 5 min
DA Pressure Setpoint	DaPressSp	discharge, air, pressure, sp, hisMode: cov	Num, .01	in w.c.	Int, 5 min
DA Pressure High Limit (Alarm)	DaPressHiLmt	discharge, air, temp, high, limit, sp, hisMode:cov	Num, 0	%	COV, 30days
DA Pressure Low Limit (Alarm)	DaPressLowLmt	discharge, air, temp, low, limit, sp, hisMode:cov	Num, 0	%	COV, 30days
DA Temperature	DaTemp	discharge, air, temp, sensor	Num, 1	F	Int, 5 min
DA Temperature Setpoint (effective)	DaTempSp DaTempEffSp	discharge, air, temp, effective, sp, hisMode:cov	Num, 0	F	COV, 30days
DA Temperature High Limit	DaTempHiLmt	discharge, air, temp, high, limit, sp, hisMode:cov	Num, 0	%	COV, 30days
Cold Deck DA Temp	CDDaTemp	discharge, air, temp, sensor, coldDeck	Num, 1	F	Int, 5 min
Cold Deck DA Temp Setpoint	CDDaTempSp	discharge, air, temp, sp, coldDeck, hisMode:cov	Num, 0	F	COV, 30days
Hot Deck DA Temp	HDDaTemp	discharge, air, temp, sensor, hotDeck	Num, 1	F	Int, 5 min
Hot Deck DA Temp Setpoint	HDDaTempSp	discharge, air, temp, sp, hotDeck, hisMode:cov	Num, 0	F	COV, 30days
Systems with Return Air					
RA CO2	RaCO2	return, co2, sensor	Num, 0	ppm	Int, 5 min
RA CO2 Setpoint	RaCO2Sp	return, co2, sp, hisMode:cov	Num, 0	ppm	COV, 30days
RA Damper Position	RaDmprPos	return, air, damper, cmd, outside,	Num, 0	%	Int, 5 min
RA DeHumidify Setpoint	RaDehumidifySp	return, air, humidity, deHumidify, sp, hisMode:cov	Num, 0	%RH	COV, 30days
RA Enthalpy	RaEnthalpy	return, air, enthalpy, sensor	Num, 1	J/g or kJ/kg	Int, 5 min
RA Humidify Setpoint	RaHumidifySp	return, air, humidity, humidify, sp, hisMode:cov	Num, 0	%RH	COV, 30days

RA Humidity	RaHum	return, air, humidity, sensor	Num, 0	%RH	Int, 5 min
RA Fan Command (single or common)	RaFanCmd	return, air, fan, run, cmd	Bool	On/Off	COV, 30days
RA Fan Status (single or common)	RaFanSts	return, air, fan, run, sensor	Bool	On/Off	COV, 30days
RA Fan Speed (single or common)	RaFanSpd	return, air, fan, speed, cmd	Num, 0	%	Int, 5 min
RA Fan Frequency (single or common)	RaFanFreq	return, air, fan, freq, sensor	Num, 0	Hz	Int, 5 min
RA Pressure	RaPress	return, air, pressure, sensor	Num, .01	in w.c.	Int, 5 min
RA Pressure Setpoint	RaPressSp	return, air, pressure, sp, hisMode: cov	Num, .01	in w.c.	COV, 30days
RA Temperature	RaTemp	return, air, temp, sensor	Num, 1	F	Int, 5 min
RA Temperature Setpoint	RaTempSp	return, air, temp, sp, hisMode: cov	Num, 1	F	Int, 5 min
RA Temperature High Limit (Alarm)	RaTempHiLmt	return, air, temp, high, limit, sp	Num, 1	F	COV, 30days
Systems with Relief Air					
Relief Air Damper Position	RlfDmprPos	relief, air, damper, cmd	Num, 0	%	Int, 5 min
Relief Fan Command (single or common)	RlfFanCmd	relief, air, fan, run, cmd	Bool	On/Off	COV, 30days
Systems with Outside Air					
Outside Air Damper Command (open/closed)	OaDmprCmd	outside, air, damper, cmd	Bool	Open/Closed	COV, 30days
Outside Air Damper Position	OaDmprPos	outside, air, damper, cmd	Num, 0	%	Int, 5 min
Outside Air Enthalpy	OaEnthalpy	outside, air, enthalpy, sensor	Num, 1	J/g or kJ/kg	Int, 10min
Outside Air Fan Command (single or common)	OaFanCmd	outside, air, fan, run, cmd	Bool	On/Off	COV, 30days
Outside Air Fan Status (single or common)	OaFanSts	outside, air, fan, run, sensor	Bool	On/Off	COV, 30days
Outside Air Fan Speed (single or common)	OaFanSpd	outside, air, fan, speed, cmd	Num, 0	%	Int, 10 min
Outside Air Flow	OaFlow	outside, air, flow, sensor	Num, 0	cfm	Int, 10 min
Outside Air Humidity	OaHum	outside, air, humidity, sensor	Num, 0	%RH	Int, 10 min
Outside Air Temperature	OaTemp	outside, air, temp, sensor	Num, 1	F	Int, 10 min
Mixed Air Points					
Mixed Air Temp	MaTemp	mixed, air, temp, sensor	Num, 1	F	Int, 10min
Mixed Air Temp Setpoint	MaTempSp	mixed, air, temp, sp	Num, 1	F	COV, 30days
Mixed Air Damper Position	MaDmprPos	mixed, air, damper, cmd	Num, 0	%	Int, 10min
Mixed Air Damper High Position	MaDmprHiPos	mixed, air, damper, high, sp	Num, 0	%	COV, 30days
Systems with Heating					
Hot Water Coil Circulation Pump Command	HWCPCmd	hot, water circ, pump, run, cmd	Bool	On/Off	COV, 30days
Hot Water Coil Circulation Pump Status	HWCPSts	hot, water circ, pump, run, sensor	Bool	On/Off	COV, 30days
Hot Water Coil Isolation Valve Command	HWCPIsoCmd	hot, water Isolation, valve, cmd	Bool	On/Off	COV, 30days
Hot Water Valve Position	HWVlvPos	hot, water, valve, cmd	Num, 0	%	Int, 5min

Heating Coil Air Leaving Temp	HCAirLTemp	heat, air, temp, leaving, sensor	Num, 1	F	Int, 5min
Heating Coil Air Leaving Temp Setpoint	HCAirLTempSp	heat, air, temp, leaving, sp	Num, 1	F	COV, 30days
Preheat Valve Position	PHVlvPos	preheat, water, valve, cmd	Num, 0	%	Int, 10min
PreHeat Coil Air Leaving Temp	PHCAirLTemp	preheat, air, temp, leaving, sensor	Num, 1	F	Int, 10min
PreHeat Coil Air Leaving Temp Setpoint	PHCAirLTempSp	preheat, air, temp, leaving, sp	Num, 1	F	COV, 30days
Heating Stages	HtgStage1-n	heating, stage, cmd	Bool	On/Off	COV, 30days
Systems with Cooling					
Chilled Water Coil Circ Pump Command	ChWCPCmd	chilled, water, pump, run, cmd	Bool	On/Off	COV, 30days
Chilled Water Coil Circ Pump Status	ChWCPSts	chilled, water, pump, run, sensor	Bool	On/Off	COV, 30days
Chilled Water Coil Isolation Valve Command	ChWCPIsoCmd	chilled water Isolation, valve, cmd	Bool	On/Off	COV, 30days
Chilled Water Valve Position	ChWVlvPos	chilled, water, valve, cmd	Num, 0	%	Int, 5 min
Chilled Water Valve Status	ChWVlvSts	chilled, water, valve, sensor	Num, 0	%	Int, 5 min
Chilled Water Temp Leaving	ChWLTemp	chilled, water, temp, leaving, sensor	Num, 1	F	Int, 5 min
Chilled Water Flow	ChWFlow	chilled, water, flow, sensor	Num, 0	gpm	Int, 5 min
Cooling Coil Air Leaving Humidity	CCAirLHum	cool, air, humidity, leaving, sensor	Num, 1	F	Int, 5 min
Cooling Coil Air Leaving Temp	CCAirLTemp	cool, air, temp, leaving, sensor	Num, 1	F	Int, 5 min
Cooling Coil Air Leaving Temp Setpoint	CCAirLTempSp	cool, air, temp, leaving, sp	Num, 1	F	COV, 30days
Cooling Stage Status	ClgStage(1-n)Sts	cooling, stage, sensor	Bool	On/Off	COV, 30days
Cooling Stages Status	ClgStg	cooling, stage, sensor	Num, 0	None	Int, 5 min
Systems that Economize					
Economize Mode	EconMode	economize, run, cmd	Bool	On/Off	COV, 30days
Minumum Outside Air Setpoint	EconOaMinSp	economize, outside, air, min, sp, hisMode:cov	Num, 0	F	COV, 30days
Systems with Direct Evaporative Cooling					
Direct EVAP Drain Command	DirEvapDrainCmd	directEvap, drain, run, cmd	Bool	On/Off	COV, 30days
Direct EVAP Fill Command	DirEvapFillCmd	directEvap, fill, run, cmd	Bool	On/Off	COV, 30days
Direct EVAP Flush Command	DirEvapFlushCmd	directEvap, flush, run, cmd	Bool	On/Off	COV, 30days
Direct EVAP Pump Command	DirEvapPumpCmd	directEvap, pump, run, cmd	Bool	On/Off	COV, 30days
Systems that Humidify					
Humidify Mode	HumidifyMode	humidify, run, cmd	Bool	On/Off	COV, 30days
Humidifier Enable	HumidifierEnab	humidifier, enable, cmd	Bool	Enabled/Disabled	COV, 30days
Humidifier Command	HumidifierCmd	humidifier, run, cmd	Bool	On/Off	COV, 30days

Humidifier Status	HumidifierSts	humidifier, run, sensor	Bool	On/Off	COV, 30days
Humidifier Valve/Output/Level	HumidifierVlv	humidifier, valve, cmd	Num, 0	%	Int, 5 min
See Return Air Humidity & Humidify Setpoint					
Systems that Dehumidify					
DeHumidify Mode	DehumidifyMode	dehumidify, run, cmd	Bool	Active/Inactive	COV, 30days
See Return Air Humidity & Dehumidify Setpoint					
Systems Managing Indoor Air Quality					
Indoor Air Quality Mode	IAQMode	iaq, run, cmd	Bool	Active/Inactive	COV, 30days
VAV Load and Demand Points					
VAV Damper Position Maximum	VAVDmprPosMax	vav, damper, max, sensor	Num, 0	%	Int, 5 min
VAV Damper Position Minimum	VAVDmprPosMin	vav, damper, min, sensor	Num, 0	%	Int, 5 min
VAV Damper Position Average	VAVDmprAvg	vav, damper, avg, sensor	Num, 0	%	Int, 5 min
VAV Cooling Terminal Load Maximum	VAVCoolTermLoadMax	vav, cooling, terminalLoad, max, sensor	Num, 0	%	Int, 5 min
VAV Cooling Terminal Load Minimum	VAVCoolTermLoadMin	vav, cooling, terminalLoad, min, sensor	Num, 0	%	Int, 5 min
VAV Cooling Terminal Load Average	VAVCoolTermLoadAvg	vav, cooling, terminalLoad, avg, sensor	Num, 0	%	Int, 5 min
VAV Heating Terminal Load Maximum	VAVHeatTermLoadMax	vav, heating, terminalLoad, max, sensor	Num, 0	%	Int, 5 min
VAV Heating Terminal Load Minimum	VAVHeatTermLoadMin	vav, heating, terminalLoad, min, sensor	Num, 0	%	Int, 5 min
VAV Heating Terminal Load Average	VAVHeatTermLoadAvg	vav, heating, terminalLoad, avg, sensor	Num, 0	%	Int, 5 min
Energy Points - Heat Recovery Water		equip, water, meter, hru			
Heat Recovery Water Temp Entering	HRUWEtemp	water, temp, entering, sensor	Num, 1	F	Int, 5 min
Heat Recovery Water Temp Leaving	HRUWLTemp	water, temp, leaving, sensor	Num, 1	F	Int, 5 min
Heat Recovery Water Volumertic Flow	HRUWFlow	water, flow, sensor	Num, 1	gal/min	Int, 5 min
Heat Recovery Water Energy (accumulated)	HRUWEnergy	water, energy, hisTotalized, sensor	Num, 0	MMbtu	Int, 5 min
Heat Recovery Water Power	HRUWPower	water, power, sensor	Num, 0	MMbtu/h	Int, 5 min
Heat Recovery Pump Command	HRUCPCmd	hru, circ, pump, run, cmd	Bool	On/Off	COV, 30days
Heat Recovery Air Leaving Temp	HRUALTemp	hru, air, temp, leaving, sensor	Num, 1	F	Int, 5 min

2.3 VAV
equip, vav, ahuRef,
[fanPowered, series, parallel],
[singleDuct, dualDuct],
[hotWaterReheat, elecReheat, coolOnly]

Description	Point Name navName	Tags	Point Type	UoM	History
Bypass Time	BypTime	bypass, time, sensor	Num, 0	h	Int, 10min
Occupied Mode	Occ	occupied, cmd	Bool	Occ/UnOcc	COV, 30days
HVAC Mode	HVACMode	hvac, sensor	Str	Heating/Cooling/Bypass	COV, 30days
Discharge Air Flow	DaFlow	discharge, air, flow, sensor	Num, 0	cfm	Int, 10min
Discharge Air Flow Setpoint	DaFlowEffSp	discharge, air, flow, effective, sp	Num, 0	cfm	Int, 10min
Damper Position	DmprPos	air, damper, cmd	Num, 0	%	Int, 10min
Reheat Valve	RHVlvlPos	reheat, water, valve, cmd	Num, 0	%	Int, 10min
Discharge Air Temperature	DaTemp	discharge, air, temp, sensor	Num, 1	F	Int, 10min
Space Temperature	SpcTemp	zone, air, temp, sensor	Num, 1	F	Int, 10min
Space Temperature Setpoint (effective)	SpcTempSp	zone, air, temp, effective, sp, hisMode:cov	Num, 0	F	COV, 30days
Occupied Cooling Setpoint	OccCoolSp	occ, cooling, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Occupied Heating Setpoint	OccHeatSp	occ, heating, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Unoccupied Cooling Setpoint	UnoccCoolSp	unocc, cooling, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Unoccupied Heating Setpoint	UnoccHeatSp	unocc, heating, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Standby Cooling Setpoint	StbyCoolSp	standby, cooling, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Standby Heating Setpoint	StbyHeatSp	standby, heating, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Effective Cooling Setpoint	EffCoolSp	cooling, zone, air, temp, effective, sp, hisMode:cov	Num, 0	F	COV, 30days
Effective Heating Setpoint	EffHeatSp	heating, zone, air, temp, effective, sp, hisMode:cov	Num, 0	F	COV, 30days
Space Humidity	SpcHum	zone, air, humidity, sensor	Num, 0	%RH	Int, 10min
Spcae Humidity Setpoint	SpcHumSp	zone, air, humidity, sp, hisMode:cov	Num, 0	%RH	Int, 10min
Space CO2	SpcCO2	zone, air, co2, sensor	Num, 0	ppm	Int, 10min
Space CO2 Setpoint	SpcCO2Sp	zone, air, co2, sp, hisMode:cov	Num, 0	ppm	Int, 10min
Dual Duct Systems					
Cold Deck Damper Position	CDDmprPos	air, damper, cmd, coldDeck	Num, 0	%	Int, 10min
Cold Deck Discharge Air Flow	CDDaFlow	discharge, air, flow, sensor, coldDeck	Num, 0	cfm	Int, 10min

Cold Deck Discharge Air Flow Setpoint	CDDaFlowSp	discharge, air, flow, effective, sp, coldDeck	Num, 0	cfm	Int, 10min
Hot Deck Damper Position	HDDmprPos	air, damper, cmd, hotDeck	Num, 0	%	Int, 10min
Hot Deck Discharge Air Flow	HDDaFlow	discharge, air, flow, sensor, hotDeck	Num, 0	cfm	Int, 10min
Hot Deck Discharge Air Flow Setpoint	HDDaFlowSp	discharge, air, flow, effective, sp, hotDeck	Num, 0	cfm	Int, 10min
Total Discharge Air Flow	TotDaFlow	discharge, air, flow, sensor, coldDeck	Num, 0	cfm	Int, 10min
Commissioning Points					
Single PID Throttling Range	VavPIDTr	vav, pid, throttlingRange, sp	Num, 0	%	COV, 30days
Single PID Integral	VavPIDInt	vav, pid, integral, sp	Num, 0	%	COV, 30days
Cooling Max Flow	CoolMaxFlow	cooling, max, flow, sp	Num, 0	cfm	COV, 30days
Cooling Min Flow	CoolMinFlow	cooling, min, flow, sp	Num, 0	cfm	COV, 30days
Cooling PID Throttling Range	CoolPIDTr	cooling, pid, throttlingRange, sp	Num, 0	%	COV, 30days
Cooling PID Integral	CoolPIDInt	cooling, pid, integral, sp	Num, 0	%	COV, 30days
Cooling Terminal Load	CoolTermLoad	cooling, load, sensor	Num, 0	%	Int, 10min
Heating Max Flow	HeatMaxFlow	heating, max, flow, sp	Num, 0	cfm	COV, 30days
Heating Min Flow	HeatMinFlow	heating, min, flow, sp	Num, 0	cfm	COV, 30days
Heating PID Throttling Range	HeatPIDTr	heating, pid, throttlingRange, sp	Num, 0	%	COV, 30days
Heating PID Integral	HeatPIDInt	heating, pid, integral, sp	Num, 0	%	COV, 30days
Heating Terminal Load	HeatTermLoad	heating, load, sensor	Num, 0	%	Int, 10min

Fan Powered Boxes					
Fan Command	FanCmd	fan, run, cmd	Bool	On/Off	COV, 30days
Fan Speed	FanSpd	fan, speed, cmd	Num, 0	%	Int, 10min
Fan High Speed	FanSpdHigh	fan, speed, high, run, cmd	Bool	On/Off	COV, 30days
Fan Medium Speed	FanSpdMed	fan, speed, med, run, cmd	Bool	On/Off	COV, 30days
Fan Low Speed	FanSpdLow	fan, speed, low, run, cmd	Bool	On/Off	COV, 30days

2.4 FCU
equip, hvac, fcu,
[elecHeat, hotWaterHeat, noHeat]
[chilledWaterCool, noCool]

Description	Point Name navName	Tags	Point Type	UoM	History
Occupied Mode	Occ	occupied, cmd	Bool	Occ/UnOcc	COV, 30days
Chilled Water Valve	ChWVlvPos	chilled, water, valve, cmd	Num, 0	%	Int, 10min
Common Water Valve (Seasonal Chilled/Hot)	ChWHWVlvPos	common, water, valve, cmd	Num, 0	%	Int, 10min
Discharge Air Temperature	DaTemp	discharge, air, temp	Num, 1	F	Int, 10min
Fan Command	FanCmd	fan, run, cmd	Bool	On/Off	COV, 30days
Fan Status	FanSts	fan, run, sensor	Bool	On/Off	COV, 30days
Fan Speed	FanSpd	fan, speed, cmd	enum	Off/Low/Med/High	COV, 30days
Hot Water Valve	HWVlvPos	hot, water, valve, cmd	Num, 0	%	Int, 10min
HVAC Mode	HVACMode	hvac, run, cmd	enum	Heat/Cool	COV, 30days
Space Temperature	SpcTemp	zone, air, temp, sensor	Num, 1	F	Int, 10min
Space Temperature Setpoint (effective)	SpcTempSp	zone, air, effective, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Occupied Cooling Setpoint	OccCoolSp	occ, cooling, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Occupied Heating Setpoint	OccHeatSp	occ, heating, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Unoccupied Cooling Setpoint	UnoccCoolSp	unocc, cooling, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Unoccupied Heating Setpoint	UnoccHeatSp	unocc, heating, zone, air, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
While the four occ/unocc heating/cooling setpoints above rarely change, their histories are needed in analytics to determine when temperatures have drifted too high or low.					

2.5 EF (Exhaust Fans)
equip, exhaust, fan

Description	Point Name navName	Tags	Point Type	UoM	History
Occupancy	Occ	occupied, cmd	Bool	Occ/UnOcc	COV, 30days
Exhaust Fan Enable	EFEnab	enable, cmd	Bool	Enabled/Disabled	COV, 30days
Exhaust Fan Command	EFCmd	fan, run, cmd	Bool	On/Off	COV, 30days
Exhaust Fan Status	EFSts	fan, run, sensor	Bool	On/Off	COV, 30days
Exhaust Fan Speed	EFSpd	fan, speed, cmd	Num, 0	%	Int, 10min
Exhaust Damper Command (open/closed)	EFDmprCmd	damper, cmd	Bool	Open/Closed	COV, 30days
Exhaust Damper Position	EFDmprPos	damper, cmd	Num, 0	%	Int, 10min
Exhaust Damper Status	EFDmprSts	damper, sensor	Bool	On/Off	COV, 30days
Energy Points - Electric		equip, elec, meter, exhaust, fan [siteMeter, submeterOf]			
VFD Energy Total (accumulated)	EFVFDEnergy	exhaust, fan, elec, energy, total, sensor, hisTotalized	Num, 0	kWh	Int, 10min
VFD Power Total	EFVFDPower	exhaust, fan, elec, power, total, active, sensor	Num, 0	kW	Int, 10min

2.6 Chiller
equip, chiller, chilledWaterPlantRef,
[absorption, reciprocal, screw, centrifugal],
[waterCooled, airCooled]

Description	Point Name navName	Tags	Point Type	UoM	History
Chiller Enable	ChlrEnab	chiller, enable, cmd	Bool	Enabled/Disabled	COV, 30days
Chiller Command	ChlrCmd	chiller, run, cmd	Bool	On/Off	COV, 30days
Chiller Status	ChlrSts	chiller, run, sensor	Bool	On/Off	COV, 30days
Chiller Compressor Stage Command	ChlrStg(1-n)Cmd	chiller, stage, cmd	Bool	On/Off	COV, 30days
Chiller Compressor Stage Status	ChlrStg(1-n)Sts	chiller, stage, sensor	Bool	On/Off	COV, 30days
Chiller Compressor Stage	ChlrStg	chiller, stage, sensor	Num, 0		Int, 10min
Chiller Load	ChlrLoad	chiller, load, sensor	Num, 0	%	Int, 10min
Tons	ChlrTons	chilled, water, power, sensor	Num, 0	tonref	Int, 10min
Condenser Water Isolation Valve	CWIsoVlvCmd	condenser, isolation, valve, cmd	Bool	Open/Closed	COV, 30days
Condesner Water Circulation Pump	CWCPCmd	condenser, circ, pump, cmd	Bool	On/Off	COV, 30days
Condenser Water Entering Temperature	CWETemp	condenser, water, entering, temp, sensor	Num, 1	F	Int, 10min
Condenser Water Leaving Temperature	CWLTemp	condenser, water, leaving, temp, sensor	Num, 1	F	Int, 10min
Chilled Water Isolation Valve	ChWIsoVlvCmd	chilled, isolation, valve, cmd	Bool	Open/Closed	COV, 30days
Chilled Water Entering Temperature	ChWETemp	chilled, water, entering, temp, sensor	Num, 1	F	Int, 10min
Chilled Water Leaving Temperature	ChWLTemp	chilled, water, leaving, temp, sensor	Num, 1	F	Int, 10min
Chilled Water Setpoint	ChWSp	chilled, water, leaving, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Chilled Water Pump Command	ChWP(1-n)Cmd	chilled, water, pump, run, cmd	Bool	On/Off	COV, 30days
Chilled Water Pump Speed	ChWP(1-n)Spd	chilled, water, pump, speed, cmd	Num,0	%	Int, 10min
Chilled Water Flow	ChWFlow	chilled, water, flow, sensor	Num, 0	gal/min	Int, 10min
Chilled Water Differential Presssure	ChWDP	chilled, water, delta, pressure, sensor	Num, 0	gal/min	Int, 10min
Oil Temp	ChlrOilTemp	oil, temp, sensor	Num, 1	F	Int, 10min
Oil Heater Command	ChlrOilHeatCmd	oil, heater, run, cmd	Bool	On/Off	COV, 30days
Oil Heater Status	ChlrOilHeatSts	oil, heater, run, sensor	Bool	On/Off	COV, 30days

Energy Points - Electric		equip, elec, meter, chiller			
Current	ChlrAmp	mag, current, sensor	Num, 0	A	Int, 10min
Volts	ChlrVolts	volt, mag, sensor	Num, 0	V	Int, 10min
Energy Total (accumulated)	ChlrEnergyTot	elec, energy, total, sensor, hisTotalized	Num, 0	kWh	Int, 10min
Power Total	ChlrPower	elec, power, total, active, sensor	Num, 0	kW	Int, 10min
Power Factor Total	ChlrPF	pf, total, sensor	Num, 0.01	unitless	Int, 10min

Energy Points - Water		equip, water, meter, chiller			
Chilled Water Temperature Entering	ChWEtemp	water, temp, entering, sensor	Num, 1	F	Int, 10min
Chilled Water Temperature Leaving	ChWLTemp	water, temp, leaving, sensor	Num, 1	F	Int, 10min
Chilled Water Flow	ChWFlow	water, flow, sensor	Num, 1	gal/min	Int, 10min
Chilled Water Volume (accumulated)	ChWVol	water, volume, total, sensor	Num, 0	gal	Int, 10min
Chilled Water Energy (accumulated)	ChWEnergy	water, energy, hisTotalized, sensor	Num, 0	btu	Int, 10min
Chilled Water Power	ChWPower	water, power, sensor	Num, 0	btu/h	Int, 10min

2.7 Boiler
equip, boiler, hotWaterPlantRef,
[condensing, automospheric]
[hot water, steam]
[oil, gas]

Description	Point Name navName	Tags	Point Type	UoM	History
Boiler Enable	BlrEnab	boiler, enable, cmd	Bool	Enabled/Disabled	COV, 30days
Boiler Command	BlrCmd	boiller, run, cmd	Bool	On/Off	COV, 30days
Boiler Status	BlrSts	boiller, run, sensor	Bool	On/Off	COV, 30days
Entering Water Temperature	BlrETemp	entering, water, temp, sensor	Num, 1	F	Int, 10min
Leaving Water Temperature	BlrLTemp	leaving, water, temp, sensor	Num, 1	F	Int, 10min
Boiler Leaving Setpoint	BlrLTempSp	leaving, water, temp, sp, hisMode:cov	Num, 0	F	COV, 30days
Boiler Isolation Valve	BlrIsoVlvCmd	isolation, valve, cmd	Bool	Open/Closed	COV, 30days
Boiler Circulation Pump	BlrCPCmd	pump, circ, run, cmd	Bool	On/Off	COV, 30days
Firing Rate	BlrFiringRate	boiler,firingRate, sensor	Num, 0	%	Int, 10min
Hot Water Pump Command	HWP(1-n)Cmd	hot, water, pump, run, cmd	Bool	On/Off	COV, 30days
Hot Water Pump Speed	HWP(1-n)Spd	hot, water, pump, speed, cmd	Num,0	%	Int, 10min
Systems with Heat Recovery					
Heat Recovery Circulation Pump Command	HRUCPCmd	pump, circ, run, cmd	Bool	On/Off	COV, 30days
Heat Recovery Circulation Pump Status	HRUCPSts	pump, circ, run, sensor	Bool	On/Off	COV, 30days
Energy Points - Gas		equip, gas, meter, boiler			
Gas Flow	BlrGasFlow	gas, flow, sensor	Num, 0	ccf/h	Int, 10min
Gas Volume (accumulated)	BlrGasVol	gas, volume, sensor, hisTotalized	Num, 0	ccf	Int, 10min
Gas Energy (accumulated)	BlrGasEnergy	gas, energy, sensor, hisTotalized	Num, 0	Mmbtu	Int, 10min
Gas Power	BlrGasPower	gas, power, sensor	Num, 0	MMbtu/h	Int, 10min
Energy Points - Water		equip, water, meter, boiler			
Boiler Water Temperature Entering	BlrETemp	water, temp, entering, sensor	Num, 1	F	Int, 10min
Boiler Water Temperature Leaving	BlrLTemp	water, temp, leaving, sensor	Num, 1	F	Int, 10min
Boiler Water Flow	BlrFlow	water, flow, sensor	Num, 1	gal/min	Int, 10min
Boiler Water Volume (accumulated)	BlrVol	water, volume, hisTotalized, sensor	Num, 0	gal	Int, 10min
Boiler Water Energy (accumulated)	BlrWEnergy	water, energy, hisTotalized, sensor	Num, 0	MMbtu	Int, 10min
Boiler Water Power	BlrWPower	water, power, sensor	Num, 0	MMbtu/h	Int, 10min

Energy Points - Heat Recovery Water		equip, water, meter, boiler, hru			
Heat Recovery Water Temp Entering	HRUWEtemp	water, temp, entering, sensor	Num, 1	F	Int, 10min
Heat Recovery Water Temp Leaving	HRUWLTemp	water, temp, leaving, sensor	Num, 1	F	Int, 10min
Heat Recovery Water Flow	HRUWFlow	water, flow, sensor	Num, 0	gal/min	Int, 10min
Heat Recovery Water Volume (accumulated)	HRUWVol	water, volume, hisTotalized, sensor	Num, 0	gal	Int, 10min
Heat Recovery Water Energy (accumulated)	HRUWEnergy	water, energy, hisTotalized, sensor	Num, 0	MMbtu	Int, 10min
Heat Recovery Water Power	HRUWPower	water, power, sensor	Num, 0	MMbtu/h	Int, 10min

2.8 Fans (individual)
Discharge Fan
equip, discharge, fan
Return Fan
equip, return, fan
Exhaust Fan
equip, exhaust, fan
Relief Fan
equip, relief, fan
FCU Fan
equip, fcu, fan
Cooling Tower
equip, coolingTower, fan

Description	Point Name navName	Tags	Point Type	UoM	History
Fan Command	FanCmd	fan, run, cmd	Bool	On/Off	COV, 30days
Fan Status	FanSts	fan, run, sensor	Bool	On/Off	COV, 30days
Fan Speed	FanSpeed	fan, speed cmd, hisMode:cov	enum	Off/Low/Med/High	COV, 30days
Fan VFD Speed	FanVFDSpd	fan, speed, cmd	Num, 0	%	Int, 10min
Fan VFD Frequency	FanVFDFreq	fan, freq, sensor	Num, 0	Hz	Int, 10min
Fan Speed Low	FanSpdLow	fan, speed, low, run, cmd	Bool	On/Off	COV, 30days
Fan Speed Medium	FanSpdMed	fan, speed, medium, run, cmd	Bool	On/Off	COV, 30days
Fan Speed High	FanSpdHigh	fan, speed, high, run, cmd	Bool	On/Off	COV, 30days

VFD Energy Total (accumulated)	VFDEnergy	fan, elec, energy, total, sensor, hisTotalized	Num, 0	kWh	Int, 10min
VFD Power Total	VFDPower	fan, elec, power, total, active, sensor	Num, 0	kW	Int, 10min

Pumps (individual)
Chiller Circ Pump
equip, pump, chiller, circ, primary
ChW Pump
equip, pump, chilled, secondary
Boiler Circ Pump
equip, pump, boiler, circ, primary
HW Loop Pump
equip, pump, hot, secondary
DHW Loop Pump
equip, pump, domestic, hot
GHW Pump
equip, pump, glycol, hot
CT Pump
equip, pump, coolingTower
CW Pump
equip, pump, condenser

Description		Tags	Point Type	UoM	History
Pump Enable	PumpEnab	pump, enable, cmd	Bool	Enabled/Disabled	COV, 30days
Pump Command	PumpCmd	pump, run, cmd	Bool	On/Off	COV, 30days
Pump Status	PumpSts	pump, run, sensor	Bool	On/Off	COV, 30days
Pump VFD Speed	PumpVFDSpd	pump, speed, cmd	Num, 0	%	Int, 10min
Pump VFD Frequency	PumpVFDFreq	pump, freq, sensor	Num, 0	Hz	Int, 10min
Energy Points - Electric		equip, elec, meter, pump			
VFD Energy Total (accumulated)	VFDEnergy	pump, elec, energy, hisTotalized, sensor	Num, 0	kWh	Int, 10min
VFD Power Total	VFDPower	pump, elec, power, active, hisTotalized, sensor	Num, 0	kW	Int, 10min
Energy Points - Water		equip, water, meter, chiller			
Water Temperature Entering	Etemp	water, temp, entering, sensor	Num, 1	F	Int, 10min
Water Temperature Leaving	LTemp	water, temp, leaving, sensor	Num, 1	F	Int, 10min
Water Flow	Flow	water, flow, sensor	Num, 1	gal/min	Int, 10min
Water Volume (accumulated)	Vol	water, volume, hisTotalized, sensor	Num, 0	gal	Int, 10min
Water Energy (accumulated)	WtrEnergy	water, energy, hisTotalized, sensor	Num, 0	MMbtu	Int, 10min
Water Power	WtrPower	water, power, sensor	Num, 0	MMbtu/h	Int, 10min

2.9 Electric Meter
equip, elec, meter,
[siteMeter, submeterOf]

Description	Point Name navName	Tags	Point Type	UoM	History
Energy Points - Electric					
Energy Total (accumulated)	EnergyTot	elec, total, energy, sensor, hisTotalized	Num, 0	kWh	Int, 10min
Power Total	Power	elec, total, power, active, sensor	Num, 0	kW	Int, 10min
Power Factor Total	PF	elec, total, pf, sensor	Num, 0.01unitless	unitless	Int, 10min
Power Quality Points					
Current A	Current_A	elec, phase, current, sensor	Num, 1	A	Int, 10min
Current B	Current_B	elec, phase, current, sensor	Num, 1	A	Int, 10min
Current C	Current_C	elec, phase, current, sensor	Num, 1	A	Int, 10min
Volts AN	Volts_AN	elec, phase, volts, sensor	Num, 0	V	Int, 10min
Volts BN	Volts_BN	elec, phase, volts, sensor	Num, 0	V	Int, 10min
Volts CN	Volts_CN	elec, phase, volts, sensor	Num, 0	V	Int, 10min
Volts AB	Volts_AB	elec, phase, volts, sensor	Num, 0	V	Int, 10min
Volts BC	Volts_BC	elec, phase, volts, sensor	Num, 0	V	Int, 10min
Volts CA	Volts_CA	elec, phase, volts, sensor	Num, 0	V	Int, 10min
Power Factor A	PF_A	elec, phase, pf, sensor	Num, 0.01	unitless	Int, 10min
Power Factor B	PF_B	elec, phase, pf, sensor	Num, 0.01	unitless	Int, 10min
Power Factor C	PF_C	elec, phase, pf, sensor	Num, 0.01	unitless	Int, 10min
Energy A (accumulated)	Energy_A	elec, phase, energy, sensor, hisTotalized	Num, 0	kWh	Int, 10min
Energy B (accumulated)	Energy_B	elec, phase, energy, sensor, hisTotalized	Num, 0	kWh	Int, 10min
Energy C (accumulated)	Energy_C	elec, phase, energy, sensor, hisTotalized	Num, 0	kWh	Int, 10min
Power A	Power_A	elec, phase, power, active, sensor	Num, 0	kW	Int, 10min
Power B	Power_B	elec, phase, power, active, sensor	Num, 0	kW	Int, 10min
Power C	Power_C	elec, phase, power, active, sensor	Num, 0	kW	Int, 10min

2.10Gas Meter
equip, gas, meter,
[siteMeter, submeterOf]

Description	Point Name navName	Tags	Point Type	UoM
Gas Flow	GasFlow	gas, flow, sensor	Num, 0	ccf/h
Gas Volume (accumulated)	GasVol	gas, volume, sensor, hisTotalized	Num, 0	ccf
Gas Energy (accumulated)	GasEnergy	gas, energy, sensor, hisTotalized	Num, 0	MMbtu
Gas Power	GasPower	gas, power, sensor	Num, 0	MMbtu/h

2.11CHWS (Chiller Water System)
equip, chilledWaterPlant

Description	Point Name navName	Tags	Point Type	UoM	History
Chilled Water Flow	ChWFlow	chilled, flow, sensor	Num, 1	gal/min	Int, 10min
Chilled Water Volume (accumulated)	ChWVol	chilled, volume, sensor, hisTotalized	Num, 0	gal	Int, 10min
Chilled Water Supply Temp	ChWSupTemp	chilled, water, leaving, temp, sensor	Num, 1	F	Int, 10min
Chilled Water Supply Temp Setpoint	ChWSupTempSp	chilled, water, leaving, temp, sp	Num, 0	F	COV, 24 hr
Chilled Water Return Temp	ChWRetTemp	chilled, water, entering, temp, sensor	Num, 1	F	Int, 10min
Chilled Water Pressure Delta	ChWDP	chilled, water, pressure, delta, sensor	Num, 0	psi	Int, 10 min
Chilled Water Pressure Delta Setpoint	ChWDPSp	chilled, water, pressure, delta, sp	Num, 0	psi	COV, 24 hr
Energy Points - Water		equip, water, meter, chilledWaterPlant, [siteMeter, submeterOf]			
Chilled Water Temperature Entering	ChWEtemp	chilled, water, temp, entering, sensor	Num, 1	F	Int, 10min
Chilled Water Temperature Leaving	ChWLTemp	chilled, water, temp, leaving, sensor	Num, 1	F	Int, 10min
Chilled Water Flow	ChWFlow	chilled, water, flow, sensor	Num, 1	gal/min	Int, 10min
Chilled Water Volume (accumulated)	ChWVol	chilled, water, volume, sensor, hisTotalized	Num, 0	gal	Int, 10min
Chilled Water Energy (accumulated)	ChWEnergy	chilled, water, energy, sensor, hisTotalized	Num, 0	MMbtu	Int, 10min
Chilled Water Power	ChWPower	chilled, water, power, sensor	Num, 0	MMbtu/h	Int, 10min
Chilled Water Building Loop Pumps		equip, chilled, water, pump, secondary			
Building Loop Pump Enable	ChWPEnab	chilled, water, pump, enable, cmd	Bool	Enabled/Disabled	COV, 30days
Building Loop Pump Command	ChWPCmd	chilled, water, pump, run, cmd	Bool	On/Off	COV, 30days
Building Loop Pump Status	ChWPSts	chilled, water, pump, run, sensor	Bool	On/Off	COV, 30days
Building Loop Pump VFD Speed	ChWPVFDSpd	chilled, water, pump, speed, cmd	Num, 0	%	Int, 10min
Building Loop Pump VFD Frequency	ChWPVFDFreq	chilled, water, pump, freq, sensor	Num, 0	Hz	Int, 10min
Building Loop Return Valve Command	ChWRetVlvCmd	chilled, water, return, isolation, valve, cmd	Bool	Open/Closed	COV, 30days
Building Loop Return Valve Sensor	ChWRetVlvSts	chilled, water, return, valve, sensor	Bool	On/Off	COV, 30days
Energy Points - Electric		equip, elec, meter, chilled, water, pump, [siteMeter, submeterOf]			
VFD Energy Total (accumulated)	ChWPVFDEnergy	chilled, water, pump, elec, energy, total, sensor, hisTotalized	Num, 0	kWh	Int, 10min
VFD Power Total	ChWPVFDPower	chilled, water, pump, elec, power, total, active, sensor	Num, 0	kW	Int, 10min

2.12Chilled Water Heat Exchanger
equip, chilled, water, heatExchanger

Chilled Water Heat Exchanger Enabled	HxChWEnab	enable, cmd	Bool	Enabled/Disabled	COV, 30days
Chilled Water Heat Exchanger Command	HxChWCmd	run, cmd	Bool	On/Off	COV, 30days
Chilled Water Heat Exchanger Runtime	HXChWRun	chilled, water, total, sensor	Num, 1	h	Int, 10min
Chilled Water Entering Temperature	HxChWETemp	chilled, water, entering, temp	Num, 1	F	Int, 10min
Chilled Water Leaving Temperature	HxChWLTemp	chilled, water, leaving, temp	Num, 1	F	Int, 10min
Chilled Water Isolation Valve	HxChWIsoVlvCmd	chilled, water, isolation, valve, cmd	Bool	Open/Closed	COV, 30days
Chilled Water Circulation Pump Command	HxChWCPCmd	chilled, water, circ, pump, run, cmd	Bool	On/Off	COV, 30days
Chilled Water Circulation Pump Status	HxChWCPSts	chilled, water, circ, pump, run, sensor	Bool	On/Off	COV, 30days
Condenser Water Entering Temperature	HxCWETemp	condenser, entering, water, temp	Num, 1	F	Int, 10min
Condesner Water Leaving Temperature	HxCWLTemp	condenser, leaving, water, temp	Num, 1	F	Int, 10min
Condesner Water Isolation Valve	HxCWIsovlvCmd	condenser, isolation, valve, cmd	Bool	Open/Closed	COV, 30days
Condenser Circ Pump Command	HxCWCPCmd	condenser, water, circ, pump, cmd	Bool	On/Off	COV, 30days
Condenser Circ Pump Status	HxCWCPSts	condenser, water, circ, pump, sensor	Bool	On/Off	COV, 30days

2.13HWS (Hot Water System)
equip, hotWaterPlant,

Description	Point Name navName	Tags	Point Type	UoM	History
Hot Water Flow	HWFlow	hot, water, flow, sensor	Num, 1	gal/min	Int, 10min
Hot Water Volume (accumulated)	HWVol	hot, water, volume, sensor, hisTotalized	Num, 0	gal	Int, 10min
Hot Water Supply Temp	HWSupTemp	hot, water, leaving, temp, sensor	Num, 1	F	COV, 15min
Hot Water Supply Temp Setpoint	HWSupTempSp	hot, water, leaving, temp, sp	Num, 0	F	COV, 24 hr
Hot Water Return Temp	HWRetTemp	hot, water, entering, temp, sensor	Num, 1	F	Int, 10min
Hot Water Differential Pressure	HWDP	hot, water, pressure, delta, sensor	Num, 1	psi	Int, 10 min
Hot Water Differential Pressure Setpoint	HWDPSp	hot, water, pressure, delta, sp	Num, 1	psi	COV, 24 hr
Energy Points - Water		equip, meter, hotWaterPlant, [siteMeter, submeterOf]			
Hot Water Temperature Entering	HWEtemp	hot, water, temp, entering, sensor	Num, 1	F	Int, 10min
Hot Water Temperature Leaving	HWLTemp	hot, water, temp, leaving, sensor	Num, 1	F	Int, 10min
Hot Water Flow	HWFlow	hot, water, flow, sensor	Num, 1	gal/min	Int, 10min
Hot Water Volume (accumulated)	HWVol	hot, water, volume, sensor, hisTotalized	Num, 0	gal	Int, 10min
Hot Water Energy (accumulated)	HWEnergy	hot, water, energy, sensor, hisTotalized	Num, 0	MMbtu	Int, 10min
Hot Water Power	HWPower	hot, water, power, sensor	Num, 0	MMbtu/h	Int, 10min
Building Hot Water Loop Pumps		equip, secondary, hot, water, pump,			
Building Loop Pump Enable	HWPEnab	hot, water, pump, enable, cmd	Bool	Enabled/Disabled	COV, 30days
Building Loop Pump Command	HWPCmd	hot, water, pump, run, cmd	Bool	On/Off	COV, 30days
Building Loop Pump Status	HWPSts	hot, water, pump, run, sensor	Bool	On/Off	COV, 30days
Building Loop Pump VFD Speed	HWPVFDSpd	hot, water, pump, speed, cmd	Num, 0	%	Int, 10min
Building Loop Pump VFD Frequency	HWPVFDFreq	hot, water, pump, freq, sensor	Num, 0	Hz	Int, 10min
Energy Points - Electric		equip, elec, meter, pump, hotWaterPlant, [siteMeter, submeterOf]			
VFD Energy Total (accumulated)	HWPVFDEnergy	hot, water, pump, elec, energy, total, sensor, hisTotalized	Num, 0	kWh	Int, 10min
VFD Power Total	HWPVFDPower	hot, water, pump, elec, power, total, active, sensor	Num, 0	kW	Int, 10min

2.14Domestic Hot Water
equip, domestic, hotWaterPlant

Description	Point Name navName	Tags	Point Type	UoM	History
Water Flow	DHWFlow	domestic, hot, water, flow, sensor	Num, 0	gal/min	Int, 10min
Water Volume (accumulated)	DHWVol	domestic, hot, water, volume, sensor, hisTotalized	Num, 0	gal	Int, 10min
Supply Temperature	DHWSupTemp	domestic, hot, water, leaving, temp, sensor	Num, 1	F	Int, 10min
Supply Temperature Setpoint	DHWSupTempSp	domestic, hot, water, leaving, temp, sp	Num, 0	F	Int, 10min
Return Temperature	DHWRetTemp	domestic, hot, water, entering, temp, sensor	Num, 1	F	Int, 10min
Differential Pressure	DHWDP	domestic, hot, water, pressure, delta, sensor	Num, 1	psi	Int, 10 min
Differential Pressure Setpoint	DHWDPSp	domestic, hot, water, pressure, delta, sp	Num, 1	psi	COV, 24 hr
DHW Building Loop Pumps		equip, domestic, secondary, hot, water, pump			
Building Loop Pump Enable	DHWPEnab	domestic, hot, water, pump, enable, cmd	Bool	Enabled/Disabled	COV, 30days
Building Loop Pump Command	DHWPCmd	domestic, hot, water, pump, run, cmd	Bool	On/Off	COV, 30days
Building Loop Pump Status	DHWPSts	domestic, hot, water, pump, run, sensor	Bool	On/Off	COV, 30days
Building Loop Pump VFD Speed	DHWPVFDSpd	domestic, hot, water, pump, speed, cmd	Num, 0	%	Int, 10min
Building Loop Pump VFD Frequency	DHWPVFDFreq	domestic, hot, water, pump, freq, sensor	Num, 0	Hz	Int, 10min
Heat Exchanger		equip, domestic, hot water, heatExchanger			
DHW Heat Exchanger Enabled	HxDHWEnab	domestic, heatExchanger, enable, cmd	Bool	Enabled/Disabled	COV, 30days
DHW Heat Exchanger Command	HxDHWCmd	domestic, heatExchanger, run, cmd	Bool	On/Off	COV, 30days
DHW Heat Exchanger Runtime	HxDHWRun	domestic, heatExchanger, total, sensor	Num, 1		Int, 10min
DHW Water Entering Temperature	HxDHWETemp	domestic, heatExchanger, entering, water, temp	Num, 1	F	Int, 10min
DHW Water Leaving Temperature	HxDHWLTemp	domestic, heatExchanger, leaving, water, temp	Num, 1	F	Int, 10min
DHW Water Isolation Valve	HxDHWIsoVlvCmd	domestic, heatExchanger, isolation, valve, cmd	Bool	Open/Closed	COV, 30days
DHW Circulation Pump Command	HxDHWCPCmd	domestic, heatExchanger, water, circ, pump, cmd	Bool	On/Off	COV, 30days
DHW Circulation Pump Status	HxDHWCPSts	domestic, heatExchanger, water, circ, pump, sensor	Bool	On/Off	COV, 30days
HWS Water Entering Temperature	HxHWSETemp	domestic, heatExchanger, primary, entering, water, temp	Num, 1	F	Int, 10min
HWS Water Leaving Temperature	HxHWSLTemp	domestic, heatExchanger, primary, leaving, water, temp	Num, 1	F	Int, 10min
HWS Water Isolation Valve	HxHWSIsoVlvCmd	domestic, heatExchanger, primary, isolation, valve, cmd	Bool	Open/Closed	COV, 30days
HWS Circ Pump Command	HxHWSCPCmd	domestic, heatExchanger, primary, water, circ, pump, cmd	Bool	On/Off	COV, 30days
HWS Circ Pump Status	HxHWSCPSts	domestic, heatExchanger, primary, water, circ, pump, sensor	Bool	On/Off	COV, 30days

Energy Points - Water		equip, water, meter, domestic, hot			
Domestic Hot Water Temperature Entering	DHWEtemp	domestic, water, temp, entering, sensor	Num, 1	F	Int, 10min
Domestic Hot Water Temperature Leaving	DHWLTemp	domestic, water, temp, leaving, sensor	Num, 1	F	Int, 10min
Domestic Hot Water Flow	DHWFlow	domestic, water, flow, sensor	Num, 1	gal/min	Int, 10min
Domestic Hot Water Volume (accumulated)	DHWVol	domestic, water, volume, sensor, hisTotalized	Num, 0	gal	Int, 10min
Domestic Hot Water Energy (accumulated)	DHWEnergy	domestic, water, energy, sensor, hisTotalized	Num, 0	MMbtu	Int, 10min
Domestic Hot Water Power	DHWPower	domestic, water, power, sensor	Num, 0	MMbtu/h	Int, 10min
Energy Points - Heat Recovery Water		equip, water, domestic, meter, hru			
Heat Recovery Water Temperature Entering	HRUWEtemp	domestic, water, temp, entering, sensor	Num, 1	F	Int, 10min
Heat Recovery Water Temperature Leaving	HRUWLTemp	domestic, water, temp, leaving, sensor	Num, 1	F	Int, 10min
Heat Recovery Water Flow	HRUWFlow	domestic, water, flow, sensor	Num, 1	gal/min	Int, 10min
Heat Recovery Water Volume (accumulated)	HRUWVol	domestic, water, volume, total, sensor	Num, 0	gal	Int, 10min
Heat Recovery Water Energy (accumulated)	HRUWEnergy	domestic, water, energy, sensor, hisTotalized	Num, 0	MMbtu	Int, 10min
Heat Recovery Water Power	HRUWPower	domestic, water, power, sensor	Num, 0	MMbtu/h	Int, 10min

2.15Cooling Tower
equip, coolingTower
[openLoop, closedLoop]

Description	Point Name navName	Tags	Point Type	UoM	History
Cooling Tower Enabled	CTEnab	enable, cmd	Bool	Enabled/Disabled	COV, 24
Condenser Water Entering Temperature	CTCWETemp	condenser, water, entering, temp, sensor	Num, 1	F	Int, 10min
Condenser Water Leaving Temperature	CTCWLTemp	condenser, water, leaving, temp sensor	Num, 1	F	Int, 10min
Sump Temperature	CTSumpTemp	sump, temp, sensor	Num, 1	F	Int, 10min
Sump Heater Command	CTSumpHtrCmd	sump, heating, run, cmd	Bool	On/Off	COV, 24
Sump Heater Status	CTSumpHtrSts	sump, heating, run, sensor	Bool	On/Off	COV, 24
Fan Enabled	CTFanEnab	fan, enable, cmd	Bool	Enabled/Disabled	COV, 24
Fan Command	CTFanCmd	ran, run, cmd	Bool	On/Off	COV, 24
Fan Status	CTFanSts	fan, run, sensor	Bool	On/Off	COV, 24
Fan VFD Speed	CTFanSpd	fan, speed, cmd	Num, 0	%	Int, 10min
Fan VFD Freqency	CTFanVFDFreq	fan, freq, sensor	Num, 0	Hz	Int, 10min
Pump Enabled	CTCPEnab	circ, pump, enable, cmd	Bool	Enabled/Disabled	COV, 24
Pump Command	CTCPCmd	circ, pump, run, cmd	Bool	On/Off	COV, 24
Pump Status	CTCPSts	circ, pump, run, sensor	Bool	On/Off	COV, 24
Pump VFD Speed	CTCPVFDSpd	circ, pump, speed, cmd	Num, 0	%	Int, 10min
Pump VFD Frequency	CTCPVFDFreq	circ, pump, freq, sensor	Num, 0	Hz	Int, 10min
Pump Isolation Valve	CTIsoVlvCmd	isolation, valve, cmd	Bool	On/Off	COV, 24
Bypass Valve	CTBypVlvPos	bypass, valve, cmd	Num, 0	%	Int, 10min
Energy Points - Electric		equip, elec, meter, coolingTower, fan [siteMeter, submeterOf]			
Fan VFD Energy Total (accumulated)	CTFanVFDEnergy	fan, elec, energy, total, sensor, hisTotalized	Num, 0	KWh	Int, 10min
Fan VFD Power Total	CTFanVFDPower	fan, elec, power, total, active, sensor	Num, 0	kW	Int, 10min
Energy Points - Electric		equip, elec, meter, coolingTower, pump [siteMeter, submeterOf]			
Pump VFD Energy Total (accumulated)	CTPVFDEnergy	pump, elec, energy, total, sensor, hisTotalized	Num, 0	KWh	Int, 10min
Pump VFD Power Total	CTPVFDPower	pump, elec, power, total, active, sensor	Num, 0	kW	Int, 10min

PART 3 - EXECUTION

3.1 INTEGRATION

1. Approved Summary list shall be incorporated into the BAS system, including controls logic trees and Graphics User Interface

2.

END OF 23 09 02

SECTION 230923 - CONTROL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control valves and actuators for DDC systems.

B. Related Requirements:
1. Section 230900 "Energy Management System and Building Automation System for HVAC and Lighting Control" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230719 “HVAC Piping Insulation” for requirements that relate to valve insulation.

C. Control valves shall not be used as manual isolation or service valves. Use appropriate full port valves for equipment and sectional header isolation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
1. Include diagrams for power, signal, and control wiring.
2. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:
1. Schedule and design calculations for control valves and actuators, including the following:
a. Flow at project design and minimum flow conditions.
b. Pressure differentials drop across valve at project design flow condition.
c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional designer, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Determine control valve sizes and flow coefficients by ISA 75.01.01.

F. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

G. Insulation Requirements for all valve bodies shall comply with Pipe Insulation under 230719. Insulation on all actuator valve bodies shall be constructed to be water resistant and removable for servicing and repair. The removable section shall be constructed so as not interfere with actuator or linkage operation and provided fasteners for reinstallation without the need for any additional material or tools.

H. Selection Criteria:
1. Control valves shall be suitable for operation at following conditions:
   a. Chilled Water: 40-60 degrees F. and 50 psig.
   b. Heating Hot Water: <40-200 degrees F and 50 psig.
   c. Dual Temperature Water: <40-200 degrees F and 50 psig.
2. Fail positions unless otherwise indicated:
   a. Chilled Water: Last position.
   b. Heating Hot Water: Open.
   c. Dual Temperature Water: Open
3. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.
4. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow unless otherwise indicated.
5. Control valve assemblies shall be provided and delivered from a single manufacturer as a complete assembly.
6. The manufacturer shall warrant all components for a period of 5 years from the date of production with the first two years unconditional.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Single Port and Characterized Disk:
1. Pressure Rating for NPS 1-1/4 and Smaller: Nominal 600 psig.
2. Pressure Rating for NPS 1-1/4 through NPS 2: Nominal 400 psig.
3. Pressure Rating for NPS 2-1/2 through NPS 6: In accordance with ANSI 125, Class B.
4. Close-off Pressure NPS 2 and Smaller: 200 psig .
5. Close-off Pressure NPS 2-1/2 through NPS 6: ANSI Class 125B: 175 psid ; ANSI Class 250: 310 psid.
6. Process Temperature Range: Zero to 250 deg F.
7. Body and Tail Piece NPS 2 and Smaller Nickel plated (forged) brass.
8. Body and Tail Piece NPS 2-1/2 through NPS 6: Cast iron GG25.
9. End Connections NPS 2 and Smaller: Threaded (NPT) female ends.
10. End Connections NPS 2-1/2 through NPS 6: Flanged ANSI Class 125B.
11. Ball NPS 3/4 and Smaller: Chrome-plated brass.
12. Ball NPS 1 through NPS 6:- Stainless steel.
13. Stem and Stem Extension:
    a. Material to match ball.
    b. Blowout-proof design.

14. Ball Seats: PTFE (Tefzel), (2) EPDM O-rings.
15. Stem Seal: Lubricated EPDM O-rings (2).
16. Characterizing Disc NPS 2 and Smaller: Tefzel.
17. Characterizing Disc NPS 2 through NPS 6: Stainless steel.
18. Flow Characteristic: Equal percentage.
19. Leakage: 0%.

B. Ball Valves with Two Ports and Characterized Disk:
1. Pressure Rating for NPS 1-1/4 and Smaller: Nominal 600 psig.
2. Pressure Rating for NPS 1-1/4 through NPS 2: Nominal 400 psig.
3. Close-off Pressure: 200 psig (1379 kPa).
4. Process Temperature Range: Zero to 250 deg F.
5. Body and Tail Piece: Nickel plated (forged) brass.
6. End Connections: Threaded (NPT) female ends.
7. Ball NPS 3/4 and Smaller: Chrome-plated brass.
8. Ball: NPS 1 through NPS 6:- Stainless steel.
9. Stem and Stem Extension:
    a. Material to match ball.
    b. Blowout-proof design.
10. Ball Seats: PTFE (Tefzel), EPDM O-rings.
11. Stem Seal: Lubricated EPDM O-rings.
12. Flow Characteristics for A-Port: Equal percentage.
13. Flow Characteristics for B-Port: Modified for constant common port flow.
14. Leakage (control port): 0%.

C. Pressure-Independent Ball Valves NPS 2 and Smaller:
1. Performance:
    a. Pressure Rating for NPS 3/4 and Smaller:360 psig
    b. Pressure Rating for NPS 1 through NPS 6: In accordance with ANSI 125, Class B.
    c. Close-off pressure for NPS 3/4 and Smaller: 75 psig
    d. Close-off Pressure NPS 2 and Smaller: 200 psig.
    e. Close-off Pressure NPS 2-1/2 through NPS 6: ANSI Class 125B: 175 psid; ANSI Class 250: 310 psid.
    f. Process Temperature Range for NPS 3/4 and Smaller: Between 36 to 212 deg F.
    g. Process Temperature Range for NPS 6 and Smaller: Between 14 to 250 deg F.
    h. End Connections NPS 2 and Smaller: Threaded (NPT) female ends.
    i. End Connections NPS 2-1/2 through NPS 6: Flanged ANSI Class 125B.
2. Body for NPS 2 and Smaller: Forged brass, nickel plated, and with threaded ends.
3. Body for NPS 2-1/2 through NPS 6: Cast iron GG25.
4. Ball: Stainless steel.
5. Stem and Stem Extension: Stainless steel, blowout-proof design.
6. Ball Seats: PTFE (Tefzel), EPDM O-rings.
7. Stem Seal: Lubricated EPDM O-rings.
8. NPS 3/4 and Smaller: An integral pressure regulator located upstream of characterized ball to regulate pressure, to maintain a constant pressure differential over the operating pressure differential range of 5 to 50 psig maintaining the flow with an accuracy of +/- 5% due to system pressure fluctuations. Two internal P/T ports shall be incorporated for differential pressure verification. Replaceable cartridges are not permitted.
9. NPS 6 and Smaller: An ultrasonic flow meter (accuracy +/- 2%) shall be integrated with a characterized control valve providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psig (7 to 350 kPa). The flow meter shall incorporate an algorithm to automatically compensate for the glycol compensation.
10. Control valve shall be equal percentage flow characteristic, other than where noted as a linear flow characteristic. Flow settings shall be field-modifiable, and may be modified inline.

11. Coil Optimization: Two immersion temperature sensors for supply and return coil water temperatures shall be incorporated into the valve assembly. Software shall control the valve to avoid the coil differential temperature from falling below a programmed setpoint. Real-time data and configuration of valve] operating parameters shall be available by BTL listed BACnet MS/TP, BACnet/IP, MODBUS or HTTP. Monitored points shall include inlet and outlet coil water temperatures, absolute flow, absolute valve position, absolute coil power and total heating/cooling energy in BTU/hr. Configuration points shall include valve, flow and power settings. Historical trend data shall be stored for up to 13 months and be retrievable in a standard date-time stamped format.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Two-Way Butterfly Valves:
1. Performance:
   a. Bi-directional bubble tight shutoff at 250 psig.
   b. Comply with MSS SP-67 or MSS SP-68.
   c. Rotation: Zero to 90 degrees.
   d. Linear or modified equal percentage flow characteristic.
2. Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216/A216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
3. Disc: 316 stainless steel.
4. Shaft: 316 or 17-4 PH stainless steel.
5. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
6. Shaft Bushings: Reinforced PTFE or stainless steel.
7. Replaceable seat, disc, and shaft bushings.
8. Corrosion-resistant nameplate indicating:
   a. Manufacturer's name, model number, and serial number.
   b. Body size.
   c. Body and trim materials.
   d. Flow arrow.

B. Commercial-Grade, Three-Way Butterfly Valves:
1. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
2. Performance:
   a. Bi-directional bubble tight shutoff at 250 psig.
   b. Comply with MSS SP-67 or MSS SP-68.
   c. Rotation: Zero to 90 degrees.
   d. Linear or modified equal percentage flow characteristic.
3. Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216/A216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:
   a. Manufacturer's name, model number, and serial number.
   b. Body size.
   c. Body and trim materials.
   d. Flow arrow.

2.4 GLOBE-STYLE CONTROL VALVES

A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 (DN 25) and larger.
4. Replaceable seats and plugs.
5. Furnish each control valve with a corrosion-resistant nameplate indicating the following:
   a. Manufacturer's name, model number, and serial number.
   b. Body and trim size.
   c. Arrow indicating direction of flow.
6. Control valve assemblies shall be provided and delivered from a single manufacturer as a complete assembly.
7. The manufacturer shall warrant all components for a period of 5 years from the date of production with the first two years unconditional.

B. Two-Way Globe Valves NPS 2 and Smaller:
1. Globe Style: Single port.
2. Body: Bronze with ANSI Class 250 rating.
3. End Connections: Threaded.
4. Bonnet: Screwed.
5. Packing: EPDM O-ring.
6. Plug, Seat, and Stem: Brass.
7. Process Temperature Range: 20 to 280 deg F.
8. Ambient Operating Temperature: Minus 22 to 122 deg F.
9. Leakage: ANSI Class VI.
10. Equal percentage flow characteristic.

C. Three-Way Globe Valves NPS 2 and Smaller:
1. Globe Style: Mix flow pattern.
2. Body: Bronze with ANSI Class 250 rating.
3. End Connections: Threaded.
4. Bonnet: Screwed.
5. Packing: EPDM O-ring.
6. Plug, Seat, and Stem: Brass.
7. Process Temperature Range: 20 to 280 deg F.
8. Ambient Operating Temperature: Minus 22 to 122 deg F.
9. Leakage: ANSI Class VI.
10. Modified equal percentage flow characteristic.

D. Two-Way Globe Valves NPS 2-1/2 to NPS 6:
1. Globe Style: Single port.
2. Body: Cast iron complying with ASME B61.1, Class 125.
3. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
4. Bonnet: Bolted.
5. Packing: PTFE cone-ring.
6. Plug: Top or bottom guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Rating: 35 to 281 deg F.
9. Leakage: 0.1 percent of maximum flow.
10. Rangeability: Varies with valve size between 6 and 10 to 1.
11. Modified linear flow characteristic.

E. Industrial-Grade Straight-Through Globe Valves NPS 1 and Larger:
1. Globe Style: Single port.
2. Body: Cast iron or cast steel.
3. End Connections for NPS 2: Threaded.
4. End Connections for NPS 2-1/2 and Larger: Raised face flanged.

5. Bonnet: Bolted.
6. Packing: PTFE V-ring.
7. Plug: Cage guided and unbalanced.
8. Plug, Seat, and Stem: 416 stainless-steel plug and seat, 17-4 PH stainless-steel cage and 316 stainless-steel stem.
9. Valve Stem: Thread and pin stem to plug.
10. Valve Stem Finish: Polished to 5 microinches rms or less.
11. Plug and Seat Surfaces: Hardened facing.
12. Process Temperature Range: Zero to 450 deg F.
13. Ambient Operating Temperature: Minus 20 to plus 150 deg F.
14. Leakage: FCI 70-2, Class IV.
15. Flow Characteristic: Equal percentage.

2.5 SOLENOID VALVES

A. Description:
1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.
2. Size to close against the system pressure.
3. Manual override capable.
4. Heavy-duty assembly.
5. Body: Brass.
6. Seats and Discs: NBR or PTFE.
7. Solenoid Enclosure: NEMA 250, Type 4.

2.6 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Agency Listings: ISO 9001, UL 873 or UL 60730, CE and CSA.

B. The valve assembly (control valve and actuator) shall be provided and delivered froma single manufacturer.

C. The manufacturer shall warrant all components for a period of 5 years from the date of production with the first two years unconditional.

D. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

E. Actuators for Steam Control Valves: Shutoff against 1.5 times steam design pressure.

F. Position indicator and graduated scale on each actuator.

G. Type: Motor operated, with or without gears, electric and electronic.

H. Voltage: Voltage selection delegated to professional designing control system.

I. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

J. Function properly within a range of 85 to 120 percent of nameplate voltage.

K. Field Adjustment:
1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.

2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

L. Two-Position Actuators: Single direction, spring return or reversing type.

M. Modulating Actuators:
1. Operation: Capable of stopping at all points across full range and starting in either direction from any point in range.
2. Control Input Signal:
   a. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10-V signals. (EMS Prefer to remove this range to standardize range.)
   b. Programmable Multi-Function: (EMS Prefers this option. It will be better data for future AI data analytics for energy savings)
      1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
      2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
      3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

N. Position Feedback:
1. Where indicated, equip modulating actuators with a position feedback through voltage signal for remote monitoring. (e.g. VAV damper, hydronic valve position, non-safety related indication only applications where other feedback sensors are available.)
2. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

O. Fail-Safe:
1. Where indicated, provide actuator to fail to an end position.
2. Mechanical spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Electronic fail-safe shall incorporate an active balancing circuit to maintain equal charging rates among the Super Capacitors. The power fail position shall be proportionally adjustable between 0 to 100% in 10 degree increments with a 2 second operational delay.

P. Integral Overload Protection:
1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

Q. Valve Attachment:
1. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
2. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
3. V-bolt dual nut clamp with a V-shaped toothed cradle; directly couple and amount to the valve bonnet stem, or ISO-style direct-coupled mounting pad.

R. Temperature and Humidity:
1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

S. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA Type 1 for indoor installation in an equipment enclosure.
3. NEMA Type 2 for indoor and protected applications.
4. NEMA Type 4 or Type 4X for outdoor and unprotected applications.
5. Provide actuator enclosure with heater and control where required by application.

T. Stroke Time:
1. Select operating speed to be compatible with equipment and system operation.

PART 3 - EXECUTION

3.1 CONTROL VALVE APPLICATIONS

A. Control Valves:
1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
2. Unless otherwise noted, select valves as follows,
   a. Pressure-independent ball valves for systems controlled with VFDs.
   b. Ball valves with single port and characterized disk for all NPS 2” and smaller.
   c. Globe valves for all NPS 2-1/2” and larger applications.
   d. Butterfly valves, as required, for sizes larger than NPS 6” or outdoor chiller plant operation.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:
1. Pipe wrenches, pliers, and other grooved tools that will cause injury to or mar surfaces of rods, nuts, and other pa are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:
   a. Laboratory exhaust airstreams.
   b. Process exhaust airstreams.
3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.

D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 4.

E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 2.

F. Valve Orientation:
   1. Install valves with actuators per manufactures recommendations for the specific application.
   2. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
   3. Install valves in a position to allow full stem movement.
   4. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.
3. Assure actuator indicators are visible.

H. Threaded Valves:
1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:
1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

J. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

K. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same cable designation at each end for operators to determine continuity ~~at~~ and also the unique wire designations to match points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

L. Install engraved phenolic nameplate with valve identification on valve..

3.5 CHECKOUT PROCEDURES

A. Control Valve Checkout:
1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. For pneumatic products, verify air supply for each product is properly installed. (retrofit applications only)
5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner. (retrofit applications only)
6. Verify that control valves are installed correctly for flow direction.
7. Verify that valve body attachment is properly secured and sealed.
8. Verify that valve actuator and linkage attachment are secure.
9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10. Verify that valve ball, disc, and plug travel are unobstructed.
11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to zero percent (closed) back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent open, 50 percent , and zero percent open at proper air pressures. (retrofit applications only)

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

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END OF SECTION 230923.11

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Air-vent piping.

B. Section includes the following hydronic system specialties:
   1. Air Control Devices
   2. Hydronic Piping Specialties
   3. Hydronic Balance Valves

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Pressure-seal fittings.
   2. Chemical treatment.
   3. Air Control Devices
   4. Hydronic Piping Specialties
   5. Hydronic Balance Valves

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

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

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. The producer of automatic or manual balancing fittings shall have current ISO 9001 certification.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   1. Hot-Water Heating Piping: 150 psig at 200 deg F.
   2. Chilled-Water Piping: 150 psig at 200 deg F.
   3. Dual-Temperature Heating and Cooling Water Piping: 150 psig at 200 deg F.
   4. Air-Vent Piping: 200 deg F.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Copper or Bronze Pressure-Seal Fittings:
   1. Housing: Copper.
   2. O-Rings and Pipe Stops: EPDM.
   3. Tools: Manufacturer's special tools.
   4. Minimum 200-psig working-pressure rating at 250 deg F.

E. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.

F. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

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

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

H. Steel Pressure-Seal Fittings:

1. Housing: Steel.
2. O-Rings and Pipe Stop: EPDM.
3. Tools: Manufacturer's special tool.
4. Minimum 300-psig working-pressure rating at 230 deg F.

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

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

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

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 DIELECTRIC FITTINGS

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

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

C. Dielectric Flanges:
1. Description:
a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
1. Description:
a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.

e. Washers: Phenolic with steel backing washers.

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

2.6 AIR CONTROL DEVICES

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

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.
5. Patterson.

C. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

D. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

2.7 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.
5. See Automatic Flow Control Valves for wye-strainers provided as part of coil connection kits.

B. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.

3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

2.8 HYDRONIC BALANCE VALVES

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. IMI Flow Design, Inc
2. Bell & Gossett
3. Griswold Controls
4. Pro Hydronic Specialties

B. Automatic Flow Control Valves
1. Body: Brass or bronze Y-body, integral chrome plated brass-body ball valve, and "O" ring type union fitting.
2. Internal wear surfaces of the valve cartridge shall be 303 stainless steel.
3. The internal flow cartridge body shall have machined threads so the spring free height may be compensated for without the use of fixed shims.
4. The internal flow cartridge shall be permanently marked with a code to identify the gpm and spring range.
5. All valves 1/2" to 2" shall be factory leak tested at 100 psi air under water.
   a. Minimum Ratings:
      1) 1/2" through 2" pipe size: 400 PSIG at 250°F
      2) 2 1/2" through 14" pipe size: 600 PSIG at 250°F.
6. Flow Verification: The differential pressure across the Automatic Flow Control Valve shall be measured for verification and to deter mine the amount of system over heading (excess pressure) or under pumping.
7. Test Kit: The kit consists of a 4 1/2" gauge with three ball valves calibrated at 150 psi & 1000 kpa, two 10' hoses with shut-off valves and a pair of GA 18 std. P/T adapters.

C. Calibrated Balance (Ball Style) Valve (2 ½" – 4")
1. Body: Valve body shall be constructed out of cast iron and rated for 175 PSIG working pressure.
2. Valve shall include a ball valve constructed in brass.
3. Valve body shall include two extended pressure/temperature ports.
4. Valve body shall include a drain valve port with drain valve and hose end connection with cap.
5. Valve shall utilize a calibrated nameplate with a memory stop.
6. Valve shall utilize a reduced port design that provides velocity head recovery.
7. Valve temperature range shall be from -4°F (-20°C) to 250°F (121°C).

D. Calibrated Balance (Globe Style) Valve (4" – 12")
1. Body:
   a. Valve body shall be constructed of cast iron, rated for 175 PSIG working pressure (flanged), with ANSI Class 125# flanged connections.
   b. Valve body shall be constructed of ductile iron and rated for 300 PSIG working pressure (grooved) with grooved end connections.
2. Valve shall be a multi-turn globe style valve.
3. Valve shall include a brass disc.
4. Valve disc shall have a soft seat design made of EPDM.
5. Valve body shall include two pressure/temperature ports.
6. Valve shall utilize a calibrated nameplate with position indicator from 0 to 100% open.
7. Valve shall include a memory button to allow for positioning the valve to the appropriate set position after closing.
8. Valve temperature range shall be from -4°F (-20°C) to 250°F (121°C).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be the following:
1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:
1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

E. Condensate-Drain Piping:
1. Roof - Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Inside building - Schedule 40 PVC plastic pipe and fittings and solvent-welded joints. Do not install PVC piping in return air plenums.

F. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

G. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

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

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeve seals for piping penetrations of concrete walls and slabs.

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

W. Paint (oil based) steel piping before installing.

3.3 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2and Smaller: Use dielectric nipples [unions].

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

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with the following requirements for maximum spacing of supports.

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

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

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

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

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

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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

H. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

I. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with ball valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections.

3.7 HYDRONIC BALANCE VALVE INSTALLATION

A. Installation
1. Install flow control valves on the return lines of coils as indicated on the plans. A balancing valve on supply side is not acceptable.
2. The standard ports and handles shall clear 1” thick insulation. Handle and port extensions are required for over 1” thick insulation. Do not insulate flow control valves used on heating coils.
3. Install, on the supply side of coils, a Y or a T-strainer (20 mesh) with brass blow down valve with 3/4” hose-end connection with cap. Inline (basket) strainer is not acceptable.
4. All valves shall be installed in accordance with manuafacturer’s instructions.

B. Packaging
1. All fittings needed for each individual coil shall be shipped from the factory and labeled to indicate the appropriate terminal.
2. The packages for individual terminals shall further be grouped according to individual floors or regions of the building for easy routing to the appropriate location.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve,

or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

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

END OF SECTION 232113