PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Control panels.

B. Control valves.

C. Control dampers.

D. Operators.

E. Flow measuring apparatus.

F. Humidistats.

G. Input/Output sensors and transmitters.

H. Output control devices.

I. Power Supplies.

J. Thermostats.

K. Time clocks.

L. Weather stations.

1.02 DEFINITIONS

A. BAS: Building Automation System.

B. Control Wiring: Includes conduit, wire and wiring devices to install complete control systems including motor control circuits, interlocks, thermostats, EP and IP switches and like devices. Includes all wiring from Intelligent Devices and Controllers to all sensors and points defined in the input/output summary shown on the drawings or specified herein and required to execute the sequence of operations

C. Cv: Design Valve Flow Coefficient.

D. DDC: Direct Digital Control.

E. EPDM: Ethylene Propylene Diene Monomer.

F. High voltage: 50 volts or higher.

G. Low voltage: Below 50 volts.

H. PTFE: Polytetrafluoroethylene.

I. TEFZEL: A modified ETFE (ethylene tetrafluoroethylene) fluoroplastic.

1.03 CONTRACTOR RESPONSIBILITIES

A. Reference Division 23 Section ”Electrical Coordination for Mechanical Equipment” for contractor responsibilities.

B. BAS Contractor:

1. Installation of the BAS shall be by the BAS Contractor or their subcontractors.
2. Low voltage control wiring.
3. Coordinate high voltage control wiring to instrumentation and control devices with Division 26. Where high voltage power is required for instrumentation and control devices that is in addition to what is shown on the drawings, the BAS contractor shall cover the cost of providing this wiring.
4. All interlock wiring regardless of voltage (e.g., exhaust fan interlocked to supply fan).
5. Coordinate with Division 26 that motor starters are provided with auxiliary contacts as required for interlocks.
6. Coordinate power wiring to BAS controllers and instrumentation and control devices with Division 26.
7. Coordinate installation of back-box rough-in for wall-mounted control devices sensors, etc. with Division 26. Coordinate with mechanical contractor all locations, quantities, and sizes required for installation by Division 26.
8. Perform startup and demonstration services as specified in Section “Direct Digital Control for HVAC”.

C. Sheet Metal Contractor:

1. Installation of automatic control dampers, smoke control dampers, and necessary blank off plates.
2. Access doors where and as required.

D. Mechanical Contractor:

1. Installation of immersion wells.
2. Installation of flow switches.
3. Installation of automatic control valves.
4. Installation of pressure tappings and associated shut-off cocks.
5. Coordinate conduit and wall box rough-in, power wiring and magnetic starter requirements for controls and mechanical equipment with Division 26.

1.04 SUBMITTALS

A. Refer to Division 01 for submittal procedures.

B. Product Data: Provide description and engineering data for each control system component. Include dimensions, capacities, size, performance characteristics, electrical characteristics, and finishes of materials.

C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.

D. Schedule for control valves and actuators, including the following:

1. Tag.
2. Quantity.
3. Model number.
4. Equipment served.
5. Flow at project design conditions.
6. Selected valve flow coefficient (Cv). For butterfly valves, submit the corresponding valve position at which the Cv is calculated.
7. Pressure differential drop across valve at project design flow conditions and selected Cv.
8. Maximum close-off pressure.
9. Valve Configuration (2-way/3-way).
10. Valve Normal Position and Fail Position (e.g., NO/FO; normally open/fail open).
11. Valve Size.
12. Line Size.
13. Valve Type.
14. Actuator Signal Type (Open/Close, Modulating 0-10 Vdc, 2-10 Vdc, 4-20 mA, etc.)
15. Torque required to close valve at pump shutoff head.
16. Selected actuator maximum torque output.

E. Manufacturer's Instructions: Provide for all manufactured components.

F. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.

G. Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.

H. Warranty: Submit manufacturer warranty and ensure forms have been filled out in Owner s name and registered with manufacturer.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

C. Control valves shall be manufactured in plants located in the United States or certified to meet the specified ASTM, ANSI and MSS standards.

D. Measurement devices and sensors shall be calibrated using NIST traceable standards.

1.06 WARRANTY

A. Correct defective Work within a one year period after Substantial Completion.

B. Provide extended warranty for control devices and equipment as specified herein.

PART 2 - PRODUCTS

2.01 CONTROL PANELS

A. Construction:

1. Panel shall be UL 508A listed.
2. NEMA 250, general purpose utility enclosures with enameled finished face panel.
3. NEMA 4X utility enclosure for outdoor or wash-down applications.
4. Provide common keying for all panels.

2.02 CONTROL VALVES

A. General:

1. Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. Each valve shall be equipped with proper packing to ensure there will be no leakage at the valve stem.
2. Pressure Ratings:

a) Valve body and packing rated to withstand the system static head plus the maximum pump head and the maximum temperature of the control medium (i.e. chilled water, steam, hot water, etc.).

1) Minimum pressure class 150 psig.

b) Two-way modulating valves and their operators shall have close-off pressure ratings exceeding the dead-head condition of the pump in the system it serves.

c) Two-way modulating valves with equal percentage flow characteristics and their operators shall be rated to safely operate within a differential pressure range between 2 and 50 psi across the valve without cavitating.

3. Sizing:

a) Hydronic Systems:

1) Two-Position: Line size or sized using a pressure differential of 1 psi. Size butterfly valves using the 90 degree flow coefficient (Cv).

2) Modulating: Select valves with an appropriate flow coefficient (Cv) to achieve a minimum design valve authority of 0.5 relative to the total pressure drop of the piping branch the valve controls. Calculate Cv based on the larger of the following:

a) 5-psig pressure drop at the design flow rate specified in the Schedules.

b) Twice the equipment design pressure drop as specified in the Schedules unless otherwise noted:

i) Specific Equipment Pressure Drop (ft H2O):

Chiller Head Pressure Control	5

c) Valve shall not be less than 1/2 Inch in size.

d) Size butterfly valves using the 60 degree of full open flow coefficient (Cv).

4. Flow Characteristics:

a) Hydronic Service:

1) Two-way valves: Equal percentage characteristic.

2) Chiller isolation valves: Linear characteristic.

5. End Connections:

a) Reference the Control Valve Schedule in Part 3 for allowable end connections by pipe material.

b) Carbon steel and stainless steel valves shall comply with ASME B16.34.

c) Comply with ASME B16.10 for face-to-face and end-to-end dimensions.

d) Threads:

1) Comply with ASME B1.20.1.

2) Comply with ASME B16.4 for cast iron.

3) Comply with ASME B16.15 for cast copper alloys, including bronze and brass.

e) Flanges:

1) Comply with ASME B16.5 for steel.
2) Comply with ASME B16.1 for cast iron
3) Comply with ASME B16.24 for cast copper alloys, including bronze and brass.

f) Grooved Fittings:

1) Water services to 230 deg F and 250 psig.

B. Globe Pattern:

1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size and end connection by application.
2. Construction:

a) Up to 2 inches: Class 150, ASTM B62 bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.

1) Bronze body and bonnet shall conform to ASTM B62 up to pressure class 150. Conform to ASTM B61 for pressure class 200 and higher.

b) Over 2 Inches: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.

1) Iron body and bonnet shall conform to ASTM A126, class B.

c) Bonnet:

1) Bronze body, Class 125: Threaded type.
2) Bronze body, Class 150 or higher: Union type.
3) Iron body: Bolted type.

d) Disc Material:

1) PTFE.
2) Stainless steel.

e) Stem: Outside screw and yoke. Include extension for insulation.
f) Two-piece brass packing gland assembly, non-asbestos composition packing.

3. Rangeability: Minimum 50:1.
4. Leakage:

a) Up to 1-1/4 Inch: Minimum ANSI Class III per ANSI/FCI 70-2.
b) 1-1/2 Inch and Larger: Minimum ANSI Class IV per ANSI/FCI 70-2.

5. Design and Testing:

    a) MSS SP-80 for bronze.
    b) MSS SP-85 for cast iron.

C. Ball Pattern:

1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size by application.
2. Construction:

    a) Body:

        1) Bronze conforming to ASTM B61, B62, and B584.
        2) Forged brass with or without nickel plating conforming to ASTM B283.
        3) Cast carbon conforming to ASTM A216.
        4) Cast iron according to ASTM A126.
        5) Stainless steel conforming to ASTM A351.

    b) Up to 2 inches: Two-piece construction
    c) 2-1/2 inch to 3 inch: Three-piece construction.
    d) Stainless steel, blowout proof stem. Include extension for insulation.
    e) Replaceable PTFE seats and EPDM O-ring or PTFE packing seals.

3. Ball: Full port with characterized insert comprised of the following material:

    a) Stainless steel.
    b) Chrome-plated.
    c) Nickel-plated.

4. Rangeability: Minimum 50:1.
5. Leakage: Minimum ANSI Class IV per ANSI/FCI 70-2.
6. Design and Testing:

    a) MSS SP-72 for flanged ends.
    b) MSS SP-110 for threaded and grooved ends.

D. Butterfly Pattern:

1. Size: Reference the Control Valve Schedule in Part 3 for allowable valve size by application.
2. Construction:

    a) Body: Lug ends suitable for connecting to ASME B16.5 flanges, or grooved ends.

        1) Cast iron according to ASTM A126.
        2) Ductile iron according to ASTM A536.
        3) Cast steel according to ASTM A216.

    b) Disc:

1) Aluminum bronze.
2) Stainless steel.
3) One-piece nylon coated ductile iron disc. Nylon coated discs are not allowed for open loop condenser water systems.

c) Stem: 416 Stainless steel. Include extension for insulation.
d) Replaceable PTFE or EPDM seats and seals.

3. Rangeability: Minimum 20:1.
4. Leakage: Minimum ANSI Class IV, per ANSI/FCI 70-2.
5. Design and Testing: MSS SP-67 for Class 150 and MSS SP-68 for pressure classes above 150.

E. Manufacturers:

1. Belimo.
2. Bray.
3. Danfoss.
4. Fisher Controls.
5. Griswold Controls.
6. Honeywell.
7. Johnson Controls, Inc.
8. Kele.
9. Schneider Electric.
10. Siemens.
11. Victaulic (Tour & Andersson).

F. At the contractor's discretion, control valves and balancing valves may be combined into a single device. Submit pricing deduct as an alternate to the base bid.

1. Manufacturers:

a) Victaulic, TBV-TC/TCM Series.

G. Pressure Independent Control Valves (PICV):

1. Sizing:

a) Size valve and cartridge based on design flow rate through the circuit it serves. Choose the smallest valve rated by the manufacturer capable of delivering the design flow rate unless otherwise noted.

2. Construction:

a) Factory fabricated, Integrated valve body that incorporates an adjustable flow coefficient (Cv) chamber and separate pressure regulating chamber to maintain a constant differential pressure across the valve.
b) Field-adjustable: Capable of modifying the valve flow characteristics without removing the valve from the piping system.

c) Valve shall have a minimum of two integral ports factory installed capable of being used to measure pressure or temperature. If valve does not have these ports, contractor shall provide test ports on each side of valve for field verification.

d) 2 Inch and Smaller:

1) Forged brass body conforming to ASTM B283.

e) 2-1/2 Inch and Larger:

1) Ductile iron body conforming to ASTM A536.
2) Cast carbon body conforming to ASTM A216.
3) Stainless steel body conforming to ASTM A351.

f) Flow Regulator: Stainless steel.

g) Stem: Brass or stainless steel, blowout proof. Include extension for insulation.

h) Replaceable PTFE seats and EPDM O-ring or PTFE packing seals.

i) Characterizing Disc:

1) Ball Type: Full port with characterized insert comprised of the following material:

a) Stainless steel.
b) Chrome-plated.
c) Nickel-plated.

2) Plug Type: Brass, TEFZEL, or stainless steel characterizing disc.

3. Electronic Actuator:

a) Direct mounted, self-calibrating type designed for minimum 60,000 full-stroke cycles at rated force.

b) Supplied from the same manufacturer as the valve.

c) Include visible position indicator.

d) Overload Protection: Electronic overload or digital rotation-sensation circuitry.

e) Fail-Safe Operation: Mechanical, spring-return mechanism or Capacitance return.

f) Power Requirements: 24 VAC/DC motor; accepting a 0-10 Vdc or 4-20 mA signal.

4. PICVs shall be individually flow tested and factory verified with calibrated instruments to deviate not more than ± 5 percent through the selected operating pressure range. A calibrated performance tag shall be provided with each valve that verifies the flow in 10 degree rotation increments up to full rated flow.

5. Accuracy: PI control valve shall accurately control the flow from 0 to 100 percent rated flow within an operating pressure differential range of 5 to 50 psi across the valve.

6. Leakage: Minimum ANSI Class IV per ANSI/FCI 70-2. Valve shall be equipped with proper packing to ensure there will be no leakage at the valve stem.
7. Design and Testing:
    a) MSS SP-72 for flanged ends.
    b) MSS SP-110 for threaded and grooved ends.
8. PI control valves shall be provided with electronic actuator driven by a 24VAC/DC motor from a 0-10Vdc or 4-20 mA signal.
9. Extended Warranty: Minimum of 5 years from date of shipment.
10. Manufacturers:
    a) Belimo.
    b) Bray.
    c) Danfoss.
    d) Flow Control Industries.
    e) Griswold Controls.
    f) Honeywell.
    g) Johnson Controls.
    h) Oventrop.
    i) Victaulic (Tour & Andersson).

H. Solenoid-Operated Control Valves:
1. Construction:
    a) Factory fabricated, heavy duty assembly.
    b) Body and Trim:
        1) Bronze
        2) Stainless steel.
    c) Replaceable PTFE seats and disc.
    d) Solenoid Enclosure: NEMA 250, Type 4.
2. Action:
    a) As indicated on the drawings.
    b) Manual override capable.
3. Operator: Spring return with normal position and power requirements as indicated on the drawings.
    a) Reference Valve Operators section below for additional requirements.

2.03 CONTROL DAMPERS

A. Dampers shall be factory fabricated and sized as shown on drawings and as specified.

B. Individual damper sections shall not be larger than 48 inches x 60 inches. Provide a minimum of one damper actuator per section.

C. Performance: Test in accordance with AMCA 500-D.

1. Pressure Drop: Unless otherwise scheduled or indicated on the Drawings, size control dampers as follows:

a) Modulating Dampers: Provide dampers with linear flow characteristics. Size modulating dampers based on the smaller of the following.

1) Maximum velocity of 1,500 feet per minute.
2) Maximum Full-open air pressure drop of 0.1 inches W.C.

b) Two Position Dampers: Dampers shall be full duct size and selected to minimize pressure drop.

2. Leakage:

a) Motorized dampers for outdoor, exhaust and relief air and for shaft and stairway vents shall be Class I leakage and shall not exceed 4.0 CFM/square foot in full closed position at 1 inch W.G. pressure differential across damper.
b) Motorized dampers for other applications shall be Class II leakage.

D. Frames: Galvanized steel, extruded aluminum, or stainless steel, welded or riveted with corner reinforcement.

1. Use minimum 16 gauge for rectangular dampers.
2. Use minimum 20 gauge for round dampers.
3. For aluminum frames, use 1/8 inch thick material.
4. All damper frames shall have a flange for duct mounting.
5. Reference Part 3 Execution for application of the material type.

E. Blades: Galvanized steel, extruded aluminum, or stainless steel, maximum blade size 6 inches wide, 48 inches long, attached to minimum 1/2 inch shafts with set screws.

1. Use minimum 16 gauge for rectangular dampers.
2. Use minimum 16 gauge for round dampers.
3. For aluminum blades, use 1/8 inch thick material.
4. The blades shall be suitable for the air velocities to be encountered in the system.
5. Dampers longer than the maximum blade length shall be fabricated in sections.
6. Reference Part 3 Execution for application of the material type.

F. Blade Seals: Synthetic elastomeric inflatable or Neoprene, mechanically attached, field replaceable.

1. Installed along the top and bottom of the frame and on all mating surfaces.

G. Jamb Seals: Spring stainless steel.

1. Installed inside the frame sides.

H. Shaft Bearings: One of the following as recommended by manufacturer for the application:

1. Oil impregnated sintered bronze.
2. Graphite impregnated nylon sleeve with thrust washers at bearings.
3. Lubricant free, stainless steel, single row, ground, flanged, radial, antifriction type with extended inner race.
4. Molded synthetic bearings.

I. Linkage Bearings: One of the following as recommended by manufacturer for the application:

1. Oil impregnated sintered bronze
2. Graphite impregnated nylon.

J. Maximum Pressure Differential: 6 inches wg.

K. Temperature Limits: -40 to 200 degrees F.

L. Manufacturers:

1. Greenheck.
2. CESCO.
3. Pottorff.
4. Nailor.
5. Ruskin.

M. Reference the Damper Schedule in Part 3 for basis of design damper model and material for the application.

2.04 OPERATORS

A. General:

1. Voltage: Voltage selection shall be as required to achieve the required torque for the application.

a) Reference Part 3 for Damper Operator Voltage Schedule.

2. Type: Motor operated, with or without gears. Motor type shall be continuous duty.
3. Construction:

a) For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.

b) For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.

c) For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

4. Field Adjustment:

a) Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.

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

5. Two-Position Actuators: Single direction, spring return or reversing type. End-switches shall be integral to the actuator to determine actuator status.

6. Modulating Actuators:

a) Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.

b) Control Input Signal:

1) Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.

2) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10-Vdc or 2- to 10-Vdc and 4- to 20-mA signals.

3) Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.

c) Programmable Multi-Function:

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.

7. Position Feedback:

a) Where indicated on the controls drawings, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.

b) Where indicated on the controls drawings, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
c) Actuator shall contain position indicator and graduated scale indicating open and closed travel limits.

8. Integral Overload Protection:

a) Provide against overload throughout the entire operating range in both directions.
b) Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

9. Attachment:

a) Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to device without the need for connecting linkages.
b) Attach actuator to device drive shaft in a way that ensures maximum transfer of power and torque without slippage.

10. Temperature and Humidity:

a) Temperature: Suitable for operating temperature range encountered by application.
b) Humidity: Suitable for humidity range encountered by application, non-condensing.

11. Enclosure:

a) Suitable for ambient conditions encountered by application.
b) NEMA 4 for indoor wash-down or wet locations.
c) NEMA 4X, Belimo ZS-300, or equivalent; for outdoor applications.
d) Provide actuator enclosure with heater and control where required by application.

12. Stroke Time:

a) Coordinate with stroke time indicated on the control drawings.
b) Unless otherwise noted, select operating speed to be compatible with equipment and system operation.

B. Damper Operators:

1. Controls contractor shall size damper operator.
2. Sizing: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.

a) Provide sufficient number of operators to achieve unrestricted movement throughout damper range.

b) Provide one operator for maximum 20 sq ft damper section or maximum 7 in-lb/sq ft damper area.

3. Fail Positions:

a) Spring return to normal position as indicated on freeze, fire, temperature, or loss of power protection. Normal positions are indicated on the control drawings.

1) Return air damper, normally open.
2) Outside air damper, normally closed.
3) Exhaust/Relief air damper, normally closed.

b) Operator shall fail in place for all other applications not listed under spring return.

C. Valve Operators

1. Sizing: Select operator with sufficient torque capacity to operate the valve under all conditions and to guarantee tight shut-off of as specified against system pressure encountered.

a) Operators for Hydronic Control Valves: Capable of closing valve against system pump dead head.

2. Fail Positions:

a) Spring return to normal position as indicated on freeze, fire, temperature, or loss of power protection.

1) Pre-heat coil, normally open.
2) Other devices needing fail safe operation to account for freeze protection, power failure, overheating or moisture damage, reference control drawing points list for normal position.

b) Operator shall fail in place for all other applications not listed under spring return.

D. Manufacturers:

1. Damper Operators:

a) Belimo.
b) Honeywell.
c) Johnson Controls.
d) Schneider Electric (Invensys).
e) Siemens.

2. Valve Operators:

a) Belimo.
b) Bray.
c) Danfoss.

d) Fisher Controls.
e) Honeywell.
f) Johnson Controls.
g) Schneider Electric (Invensys).
h) Siemens.

2.05 FLOW MEASURING APPARATUS

A. Airflow Measuring Stations

1. Sensor quantity and spacing shall comply with the Equal-Area or Log-Tchebycheff method as defined in the ASHRAE Handbook of Fundamentals.
2. Element Construction: Non-corrosive material such as stainless steel, aluminum, or cadmium-plated.
3. Stations and insertion elements utilizing thermal dispersion technology shall utilize hermetically sealed thermistors for each sensor and shall be factory calibrated to NIST traceable standards.
4. Stations and insertion elements using velocity pressure shall be tested and certified in accordance with AMCA 611.
5. Air Inlet Measuring Stations:
    a) Intended for location within an air inlet to equipment, such as a hood or louver.
    b) Elements:
        1) Element constructed of 316 stainless steel, factory mounted in a circular puck constructed of 14 gauge galvanized steel. Housing shall meet NEMA 1.
        2) Element shall not induce a measurable pressure drop, adversely affect fan performance or amplify the sound level within the fan system by its presence in the airstream.
        3) Element shall not be affected by the presence of moisture, dirt, or debris in the airstream and shall be unaffected by gusting wind.
        4) Density corrected for ambient temperature variances and atmospheric pressure due to altitude.
    c) Range: Minimum 100 to 2,400 fpm.
    d) Accuracy: Plus/minus 5.0 percent of reading within the calibrated airflow range.
    e) Manufacturers:
        1) Air Monitor Corporation.
        2) Approved equal.
6. Fan Inlet Air Flow Measuring Stations:
    a) Located in the fan cone inlet with a minimum of two sensing elements.
    b) Traverse Type Elements:

1) The elements shall not induce a measurable pressure drop, adversely affect fan performance or amplify the sound level within the fan system by its presence in the airstream.

c) Surface Mount Probes:

1) Thermal Dispersion Type: Two surface mounted thermal dispersion probes mounted on opposite ends of the fan cone shall monitor the airflow.

d) Range: Minimum 100 to 10,000 fpm.
e) Accuracy: Plus/minus 3.0 percent of the measured airflow range.
f) Manufacturers:

1) Air Monitor Corporation.
2) Ebtron.
3) Johnson Controls.
4) Ruskin.
5) Sensocon.

7. Duct Air Flow Measuring Stations

a) Located in a configuration and size equal to that of the duct it is installed.
b) The airflow traverse probe shall not induce a measurable pressure drop, nor amplify the sound level within the duct by its presence in the airstream.
c) Flow Straightener: Provide flow straightener as required by manufacturer of construction as needed to meet the application.
d) Range: Minimum 400 to 4,000 fpm.
e) Accuracy: Plus/minus 2.0 percent of the measured airflow.
f) Manufacturers:

1) Air Monitor Corporation.
2) Ebtron.
3) Johnson Controls.
4) Ruskin.
5) Sensocon.

8. Signal Processor:

a) Microprocessor-based, field programmable, capable of local display of the measured airflow rate.
b) Factory calibrated to NIST traceable standards.
c) Accuracy: 0.1 percent of full scale, including linearity, hysteresis, dead band, and repeatability.
d) Output: 0 to 10 Vdc or 4-20 mA scaled output signal for remote monitoring.

B. Water Flow Meter: Provide Water Flow Meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”.

C. BTU Meter: Provide BTU Meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”

D. Gas Flow Meter: Furnish gas flow meter as specified in Division 23 Section, “Meters and Gauges for HVAC Piping.”

2.06 HUMIDISTATS

A. Room Humidistats:

1. Performance Characteristics:

a) Throttling range: Adjustable 2 percent relative humidity.
b) Accuracy: Plus/minus 3 percent over the operating range.

1) Accuracy shall include temperature effects.

c) Operating range: 20 to 80 percent.
d) Drift: Less than 1 percent per year.

2. Construction:

a) Wall-mounted enclosure: Plastic, NEMA 250, Type 1.
b) Cover: Set point indication.

3. Output: Linear, proportional type over shielded cable pair, 4 - 20 mA or 0 – 10 Vdc signal..

B. Limit Duct Humidistat:

1. Insertion, two position switch type.
2. Performance Characteristics:

a) Throttling range: Adjustable 2 percent relative humidity.
b) Accuracy: Plus/minus 5 percent over the operating range.

1) Accuracy shall include temperature effects.

c) Operating range:

1) High Limit Type: Minimum 50 to 95 percent.

d) Drift: Less than 1 percent per year.

3. Construction:

a) Enclosure: Metal, NEMA 250, Type 1.

2.07 INPUT/OUTPUT SENSORS AND TRANSMITTERS

A. General:

1. Performance Requirements:

a) Device must be compatible with project DDC controllers.
b) Elements used shall be general-purpose type.

c) Provide transmitters or transducers with sensors as required, with range suitable for the system encountered.

1) Transmitters and transducers shall have offset and span adjustments.
2) Shock and vibration shall not harm the transmitter or transducer.
3) Transmitters and transducers shall have a zeroing capability of readjusting the transmitter zero.

d) Accuracy requirements shall include the combined effects of linearity, hysteresis, repeatability, and the transmitter.

2. Output: Linear, proportional type over shielded cable pair, 4 - 20 mA or 0 – 10 Vdc signal.
3. Input Power: Low voltage, nominal 24 Vdc.

B. Temperature Sensors:

1. General: Temperature sensing elements shall have characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy. Sensor shall be UL 873 listed for temperature equipment.
2. Performance Requirements:

a) Thermistor:

1) Accuracy (All): Plus/minus 0.36 degrees F minimum.
2) Temperature Differential Accuracy: Plus/minus 0.15 degrees F minimum.
3) Resolution: Plus/minus 0.2 degrees F minimum.
4) Heat Dissipation Constant: 2.7 mW per degree C.
5) Drift: 0.04 degree F after 10 years within temperature range.

b) RTD:

1) Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
2) Accuracy (All): Plus/minus 1 degree F minimum, unless otherwise noted below.

a) Room Sensor Accuracy: Plus/minus 0.5 degrees F minimum.
b) Chilled Water Accuracy: Plus/minus 0.5 degrees F minimum.
c) Temperature Differential Accuracy: Plus/minus 0.15 degrees F minimum.

3) Resolution: Plus/minus 0.2 degree F.
4) Drift: 0.04 degrees F after 10 years within temperature range.

c) Sensing Range:

1) Provide limited range sensors if required to sense the range expected for a respective point.

d) Wire Resistance:

1) Use appropriate wire size to limit temperature offset due to wire resistance to 1.0 degree F or use temperature transmitter when offset is greater than 1.0 degree F due to wire resistance.
2) Compensate for wire resistance in software input definition when feature is available in the DDC controller.

3. Outside Air Sensors: Watertight inlet fitting shielded from direct rays of the sun.
4. Room Temperature Sensors:

a) Construct for surface or wall box, or enclosure with insulated backing suitable for exterior wall mounting.
b) Button Sensor for High Finish Spaces: Where noted on the drawings or scheduled, provide cable type, button probe sensor designed for flush mounting in wall or ceiling with the following features:

1) 6 inch leads.
2) 1/2 inch plastic spacer with locking nut.
3) Finish as specified on the drawings. If not specified, provide Plastic, field paintable finish.

c) Provide the following features:

1) Setpoint reset slide switch, dial wheel, or push-button interface with an adjustable temperature range.
2) Momentary override request push button for activation of after-hours operation.
3) Integral digital display with the following:

a) Indication of space temperature.
b) Setpoint adjustment to accommodate room setpoint.
c) Manual occupancy override and indication of occupancy status.

5. Temperature Averaging Elements:

a) Use on duct sensors for ductwork 10 sq ft or larger.
b) Use averaging elements where prone to stratification with sensor length range between 16-22 ft.
c) Provide for all mixed air and heating coil discharge sensors regardless of duct size.

6. Insertion Elements:

a) Use in ducts not affected by temperature stratification or smaller than 10 sq ft.
b) Provide dry type, insertion elements for liquids, installed in immersion wells, with minimum insertion length of 2.5 inches for pipe sizes greater than 4 inches.
c) Immersion Well Housing: 1/2 inch NPT brass or stainless steel. Stainless steel required for piping 6 inch and larger.

C. Humidity Sensors:

1. Elements: Accurate within 3 percent full range with linear output.

a) Accuracy shall include temperature effects.

2. Resolution: Plus/minus 1 percent.
3. Drift: Less than 1 percent full scale per year.
4. Sensing Range: 0 to 100 percent relative humidity.
5. Room Sensors: Provide housing with integral sensor. Housing shall be plastic, NEMA 250, Type 1. Provide with insulated backing suitable for exterior wall mounting.

a. Cover: Provide display indicating sensed humidity value.

6. Duct Sensors: Insertion type probe with mounting plate. Housing shall be metal, NEMA 250, Type 1.
7. Outside Air Sensors: With element guard and mounting plate.

D. Pressure Transmitters:

1. Duct Static Pressure:

a. Type: Unidirectional, fixed range.

a) Performance Characteristics:

1) Accuracy: Plus/minus one percent of full scale.
2) Thermal Effects: Temperature compensated over a minimum 40 to 120 F range. Zero and span shift of plus/minus 0.06 percent or less of full scale per degree F.
3) Sensing Range: Select sensor so that the high end of the nominal sensor range is not less than 150 percent and not more than 300 percent of maximum expected input.
4) Long Term Thermal Stability: Plus/minus one percent full scale per year.

b) Construction:

1) Insertion or traverse type sensor suitable for use in flat oval, rectangular, and round duct configurations.
2) Insertion length selected as appropriate for duct size.
3) Traverse sensors shall have at least one pickup point every 6 inches.
4) Element: Variable capacitance sensing technology.

5) Housing: Fire retardant glass-filled polyester, brass, stainless steel, or aluminum.

2. Hydronic Pressure:

a. Type: Unidirectional, fixed range.

a) General Sensor Performance Characteristics:

1) Accuracy: Plus/minus 1.0 percent of full scale.
2) Thermal Effects: Temperature compensated minimum 30 to 150 F range. Zero and span shift of plus/minus 0.02 percent or less of full scale per degree F
3) Long Term Thermal Stability: Plus/minus 0.5 percent full scale per year.
4) Range: Select sensor so that the scheduled differential pressure setpoint is near the midrange of the sensor pressure range.

b) Performance Characteristics for Chiller/Boiler Equipment Differential Pressure:

1) Application: Variable-Primary Flow Systems.
2) Accuracy: Plus/minus 0.05 percent of full scale.
3) Thermal Effects: Temperature compensated minimum 30 to 150 F range. Zero and span shift of plus/minus 0.02 percent or less of full scale per degree F.
4) Long Term Thermal Stability: Plus/minus 0.125 percent full scale per year for minimum 5 years.
5) Range: Select sensor so that the scheduled differential pressure setpoint is near the midrange of the sensor pressure range.
6) Manufacturers:

a) Rosemount, 3051S
b) Approved equal.

c) Construction:

1) Suitable for the media temperature and pressure.
2) Chiller/Boiler differential sensor shall have push button zero and span adjustments. No internal mechanical linkages shall be used in the transmitter.
3) Element: Diaphragm type, stainless steel.
4) Housing: Fire retardant glass-filled polyester, stainless steel, or aluminum.

3. Gas Pressure:

a) Type: Uni-directional, fixed range.
b) Performance Characteristics:

1) Accuracy: 0.35% full scale.
2) Operating Temperature Range: -40 to 260 F.

3) Long Term Drift: Plus/minus 0.2% full scale per year.
4) Sensor Output: 4-20 mA.
5) Range: Select sensor so that the scheduled pressure setpoint is near the midrange of the sensor pressure range.

c) Construction:

1) Suitable for the media temperature and pressure.
2) Sensor Element: 17-4 PH or 316L stainless steel.
3) Housing: Stainless steel with FKM, EPDM or all welded seals.

E. Equipment Operation Sensors:

1. Status Inputs for Airside Equipment:

a) Type: Fixed range differential pressure switch with adjustable setpoint.
b) Performance Characteristics:

1) Range: Not greater than two times the design fan static pressure.

c) Construction:

1) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered.
2) Provide Insertion tube for use in duct configurations. Insertion length selected as appropriate for duct size.
3) Contact Type: Single-pole, single-throw (SPST). Provide multiple poles or throw contacts to meet additional alarms required.

2. Status Inputs for Hydronic Equipment:

a) Differential Pressure Switch: Fixed range type with adjustable setpoint.

1) Range: Not greater than two times the design equipment differential pressure.
2) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered.
3) Contact Type: Single-pole, single-throw (SPST). Provide double-throw contacts to meet additional alarms required.

b) Flow Switch:

1) Thermal dispersion flow switch enclosed in insertion device, of material suitable for fluid encountered and magnetic setpoint coordinated with the desired flow rate.

a) Range: Sensitivity suitable for the maximum and minimum design flow rates of the system in which it is installed.

b) Enclosure: Comply with NEMA enclosure ratings, suitable for the ambient conditions encountered, with LED status indicators for visual switch indication.
c) Contact Type: Automatic reset upon regain of flow.

3. Status Inputs for Electric Motors:

a) Analog Current Transducer:

1) Type: Split core design, cable of being installed or removed without dismantling the primary bus cables.
2) Performance Characteristics:

a) Accuracy: Plus/minus 2 percent of selected range.
b) Range: Multi-range device, suitable for the amperage encountered with internal zero and span adjustment.
c) Analog output signal: Generate a proportional control signal relative to the amount of current through the primary bus cables.

3) Construction:

a) 24 V or Self-powered (passive).
b) Provide with integral command relay.
c) Device shall accept overcurrent up to twice its trip into range.
d) Enclosure: UL 94 approved thermoplastic, rated for V-0. No metal parts shall be exposed other than the terminals.

b) Binary Current Sensing Relay:

1) Type: Split core with current transformers, adjustable and set to 175 percent of rated motor current.
2) Self-powered (passive) with solid-state circuitry and a dry contact output.
3) Adjustable trip point.
4) Contact Type: Single-pole, double-throw (SPDT).
5) LED indicating the on or off status.
6) A conductor of the load shall be passed through the window of the device.
7) Device shall accept overcurrent up to twice its trip into range.

F. Carbon Monoxide Detectors:

1. Factory calibrated, single or multichannel dual level detectors, using solid state sensors with three year minimum life. Sensor replacement shall take maximum 15 minutes. Suitable over temperature range of 23 to 130 degrees F.

2. Provide individual indicators and contractors for each level, initially calibrated for 25 ppm and 200 ppm.
3. Maximum response time to 100 ppm CO calibration gas: Two minutes.
4. Accuracy: Plus/minus 5 ppm or plus/minus 5 percent of reading, whichever is lower.
5. Drift: Certified by manufacturer to drift no more than 5 percent per year.
6. Calibration: Certified by manufacturer to require calibration no more frequently than once per year.

G. Nitrogen Dioxide Sensors:

1. Single or multichannel dual level detectors, using solid state sensors with three year minimum life. Sensor replacement shall take maximum 15 minutes. Suitable over temperature range of 23 to 130 degrees F.
2. Provide individual indicators and contractors for each level, initially calibrated for 1 ppm and 3 ppm.
3. Accuracy: Plus/minus 5 percent of reading.

H. Carbon Dioxide Sensors:

1. General: Provide non-dispersive infrared (NDIR) CO2 sensors with integral transducers and linear output.
    a) Linear, CO2 Concentration Range Display: 0 to 2000 ppm.
    b) Full Scale Accuracy: Plus/minus 75 ppm at concentrations of both 600 and 1,000 ppm when measured at sea level at 77 degrees F.
    c) Maximum Response Time: 1 minute.
    d) Analog Output: 0-10 Vdc or 4-20 mA.
    e) Rated Ambient Conditions:
        1) Air Temperature: Range of 32 to 122 degrees F.
        2) Relative Humidity: Range of 0 to 95 percent (non-condensing).
2. Calibration Characteristics:
    a) Factory calibrated and certified by the manufacturer to require calibration not more frequently than once every 5 years.
    b) Automatically compensating algorithm for sensor drift due to sensor degradation.
    c) Sensor shall be temperature compensated throughout entire operating range.
    d) Maximum Drift: 2 percent per year.
3. Construction:
    a) Sensor Chamber: Non-corrosive material for neutral effect on carbon dioxide sample.
    b) Duct Mounting: Provide duct mounted sensors with duct probe designed to protect sensing element from dust accumulation and mechanical damage.

c) Wall/Surface Mounting: Construct for surface or wall box or enclosure suitable for wall mounting.

2.08 OUTPUT CONTROL DEVICES

A. Control Relays:

1. Provide relay with contact rating, configuration, and coil voltage that is suitable for the application.
2. Provide NEMA 1 enclosure when relay is not installed in a local control panel.
3. Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator.
4. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus/minus 200 percent minimum from setpoint.

B. Fan Speed Controllers:

1. Solid-state model providing field-adjustable proportional control of motor speed. Equip with filtered circuit to eliminate radio interference.

2.09 POWER SUPPLIES

A. Reference Division 23 Section "Direct Digital Controls for HVAC" for DC power supply requirements.

B. Control power transformers shall meet NEMA/ANSI standards.

C. Control power transformers shall be UL listed for Class 2 current-limited service or provided with over-current protection on both primary and secondary circuits for Class 2 current-limited service.

D. Connected load on the transformer shall not exceed 80 percent of the transformer's rated capacity.

E. The core and windings shall be completely encased in a UL approved thermoplastic. No metal parts shall be exposed other than the terminals.

F. Performance Characteristics:

1. Accuracy: Plus/minus 1 percent at 5.0 A full scale output.

G. Provide a disconnect switch for each transformer.

2.010 THERMOSTATS

A. General:

1. Programmable, with the following features:

a) LCD or LED display screen.
b) Button our touch-screen Interface.
c) 7-day programmable scheduling.
d) Temperature information display.
e) Setpoint display and adjust.
f) Override.
g) Lockout.

2. Non-programmable with the following features:

a) LCD or LED display screen.
b) Button our touch-screen Interface:
c) Temperature information display.
d) Setpoint display and adjust.
e) Operation mode display and adjust.
f) Fan switch setting (Off/Auto/Low/Med/High), configured with the fan system it serves.
g) Override.
h) Remote temperature sensor interface terminal.
i) Lockout.

3. Performance Requirements:

a) Accuracy: Plus/minus 1.0 degree F minimum.
b) Resolution: Plus/minus 0.2 degrees F.
c) Range:

1) Operating Temperature: 32 degrees F to 122 degrees F minimum.
2) Operating Humidity: 0 percent to 95 percent relative humidity, non-condensing.
3) Setpoint Control:

a) Cooling: 54 degrees to 100 degrees F.
b) Heating: 40 degrees to 90 degrees F.

d) Multi-stage as required to match unit cooling and heating stages scheduled on the drawings.

B. Electric Room Thermostats:

1. Type: 24 volts, two position switch, programmable with setback/setup temperature control.
2. Covers: Locking with set point adjustment and indication.
3. Setpoint functional range: 45 degrees F to 90 degrees F.

C. Line Voltage Thermostats:

1. Integral manual On/Off/Auto selector switch, single or two pole as required.
2. Dead band: Maximum 2 degrees F.
3. Covers: Locking with set point adjustment and indication.
4. Setpoint functional range: 45 degrees F to 90 degrees F.

5. Rating: Motor load.

D. Room Thermostat Accessories:

1. Thermostat Covers: Plastic.
2. Insulating Bases: For thermostats located on exterior walls.
3. Adjusting Key: As required for device.
4. Aspirating Boxes: Where indicated for thermostats requiring flush installation.
5. Integrated sensors: At the contractor's option, the following sensors may be provided with the thermostat in a single device. Refer to the drawings where additional sensors are required. Refer to "Input/Output Sensors" section of this specification for language governing performance of the integrated sensors.

    a) Humidity sensor.
    b) Carbon dioxide sensor.

E. Immersion Thermostat:

1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint and adjustable throttling range.

F. Airstream Thermostat:

1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint in middle of range and adjustable throttling range.
2. Averaging service remote bulb element: minimum 20 feet or length as required to fit duct.

G. Electric Low Limit Thermostat:

1. Snap acting, single pole, single throw, manual or automatic reset switch as indicated on the drawings that trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint,

    a) Provide double-throw contacts (one for direct equipment control, one for BAS system notification) where additional alarms are scheduled.

2. Bulb length: Minimum 1 foot for every 1 square foot of coil cross sectional area.
3. Provide one thermostat for every 20 sq ft of coil surface.
4. Setpoint shall be adjustable.

H. Electric High Limit Thermostat:

1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above setpoint,

2. Bulb length: Minimum 1 foot for every 1 square foot of coil cross sectional area.
3. Provide one thermostat for every 20 sq ft of coil surface.
4. Setpoint shall be adjustable.

I. Fire Thermostats:

1. UL labeled, factory set in accordance with NFPA 90A.
2. Normally closed contacts, manual reset.
3. Fixed or adjustable settings to operate at not less than 75 degrees F above normal maximum operating temperature.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

3.02 INSTALLATION

A. Cooperate with other contractors performing work on this project as necessary to achieve a complete and coordinated installation. Each Contractor shall consult the Drawings and Specifications for all trades to determine the nature and extent of others work.

B. General Workmanship:

1. Install equipment, piping, and wiring/raceway parallel to building lines wherever possible.
2. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
3. Install all equipment in readily accessible locations.
4. All installations shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
5. Install all products in accordance with manufacturer's instructions.

C. Sensors:

1. Mount sensors rigidly and adequately for the environment within which the sensor operates.
2. Provide thermistor type temperature sensors for temperature ranges between minus 30 degrees F to 230 degrees F. Provide RTD type temperature sensors for extended ranges beyond minus 30 degrees F to 230 degrees F.
3. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing. Coordinate installation of room/space sensors with architect and other trades to ensure a neat and orderly installation.
4. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
5. Sensors used in mixing plenums and hot and cold decks shall be of averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
6. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 foot of sensing element for each square foot of coil area.
7. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 feet downstream.
8. Install temperature, humidity, and smoke detectors for both supply air and return air applications a minimum of 10’-0” downstream or upstream of the air handling unit and prior to any branch duct takeoffs.
9. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
10. Install outdoor air temperature sensors on north wall, complete with sun shield where shown on the plans. If not shown, locate sensors in an accessible location, a minimum of 15 feet away from exhaust or relief air locations.
11. Differential air static pressure.
    a) Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
    b) Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor or the plenum.
    c) Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building. Pipe the high-pressure port to a location suitable to sense common building pressure or as indicated on the drawings.

1) Panel mount the transducer adjacent to its associated building automation system controller. Provide an independent manometer gauge next to transducer for calibration.

d) The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

e) All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.

f) All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.

12. Adjust flow switch to meet sensitivity required to ensure minimum flow through the equipment.

13. Verify location and mounting height of thermostats, humidistats, and exposed control sensors with plans and room details before installation. Align with adjacent lighting switches and humidistats.

a) Install devices to meet ADA requirements unless otherwise noted on the plans.

14. Mount freeze protection thermostats using flanges and element holders.

a) Install thermostat completely across the surface the thermostat serves.

15. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.

16. Provide separable sockets for liquids and flanges for air bulb elements.

17. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

18. Install shutoff valves in the high and low pressure reference lines connecting to hydronic pressure sensors and switches. Install a shunt valve across the high and low reference pressure ports for servicing. Valves may be ordered as an integral option with the sensor.

D. Control Valves:

1. Do not install brass valves in open-loop systems.

2. 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.

3. Install flanges or unions to allow valve removal and installation.

4. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.

5. Valve Orientation:

a) 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.
b) Install valves in a position to allow full stem movement.
c) 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.

6. Provide valves with position indicators where sequenced with other controls.
7. Tag valves in accordance with Division 23 Section, "Identification for HVAC Piping and Equipment."
8. Install a pressure/temperature port on each side of pressure independent control valves (PICVs) which are not factory provided with integral ports.

E. Control Dampers:

1. Install dampers with extruded aluminum or stainless steel frames and blades in corrosive environments and areas with high humidity.
2. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.
3. Clearance:

a) Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
b) Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

4. Service Access:

a) Dampers and actuators shall be accessible for visual inspection and service.
b) Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Division 23 Section, “Air Duct Accessories.”.

5. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting.
6. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.
7. Provide mixing dampers of parallel blade construction arranged to mix streams. Where shown on the drawings, provide separate minimum outside air damper section adjacent to return air dampers with separate damper motor.
8. Provide isolation (two position) dampers of parallel blade construction.

9. Provide opposed blade damper configuration for all other applications.
10. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
11. After installation of low-leakage dampers and seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

F. Operators:

1. Mount and link control damper actuators according to manufacturer's instructions.
    a) To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 degrees open position, manually close the damper, and then tighten the linkage.
    b) Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
    c) Provide all mounting hardware and linkages for actuator installation.
2. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 degree available for tightening the damper seals.
3. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer.

G. Control Panels:

1. Install control panels where shown on the drawings and where required to house controllers for the controlled systems and equipment.
2. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
3. Coordinate 120V power requirements with Division 26 to panels used for the building automation system and transformers for low voltage power to controllers.

H. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.

I. Provide an insulation standoff on control devices, cables, and other items that do not require flush mounting to ductwork, piping, or equipment.

3.03 MAINTENANCE

A. Refer to Division 01 closeout requirements for additional requirements relating to maintenance service.

B. Provide service and maintenance of control system for one year from Date of Substantial Completion.

C. Provide complete service of controls systems, including call backs, and submit written report of each service call.

3.04 STARTUP AND DEMONSTRATION

A. Control Dampers and Valves:

1. Stroke and adjust control valves and dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
2. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
3. For control valves and dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
4. Verify that all two-position dampers and valves operate properly and that the normal positions are correct.
5. Verify that all modulating dampers and valves are functional, that the start and span are correct, that direction and normal positions are correct, and that they achieve proper closure.

B. PI Control Valves:

1. Field verify installation and operating differential pressure range of all PI control valves.
2. Verify total system flow to be within plus/minus 10 percent of system design.
3. Individual field adjustments for the PI control valve assembly shall be performed using the PI control valve manufacturer’s documented procedures.

3.05 DAMPER SCHEDULE

SERVICE	RUSKIN MODEL	MATERIAL
Outside, Exhaust and Relief Air Control, Stairway and Shaft Vents	CD-50	Aluminum
Fire/Smoke Damper for Smoke Control	FSD-60	Galvanized Steel
All Other	CD-356	Galvanized Steel

3.06 DAMPER OPERATOR VOLTAGE SCHEDULE

SERVICE	VOLTAGE
Interlocked with HVAC fans	120V
Multi-section dampers	120V
Large dampers (> 60 inches in any dimension)	120V
All other operators control wiring	24V

1. Note: Coordinate with Division 26 if 120V power is required for operator to achieve appropriate torque requirements for damper actuation.

3.07 CONTROL VALVE SCHEDULES

A. Allowable Valve Type and Size by Control Application:

VALVE TYPE	CONTROL APPLICATION	
	MODULATING	TWO-POSITION
Globe	≤ 4 IN	≤ 2 IN
Characterized Ball	≤ 4 IN	≤ 4 IN
Butterfly	> 4 IN	≥ 2-1/2 IN

B. Allowable Valve Body Material by Service Application:

VALVE BODY MATERIAL	SERVICE APPLICATION	
	CLOSED LOOP	OPEN LOOP
Bronze	Allowed	Allowed
Brass	Allowed	Not Allowed
Iron	Allowed	Allowed

C. Allowable End Connection by System Material:

1. Copper Tube:
   a) 2-1/2 Inch and smaller: Threaded ends.
2. Steel Pipe:
   a) 2 Inch and Smaller: Threaded.
   b) 2-1/2 Inch and Larger:
      1) Flanged.
      2) Grooved ends for water systems.

D. Allowable End Connection by Size Schedule:

VALVE TYPE	END CONNECTION TYPE		
	THREADED	FLANGED	GROOVED
Globe	≤ 2-1/2 IN	≤ 4 IN	N/A
Characterized Ball	≤ 2-1/2 IN	≤ 3 IN	N/A
Butterfly	N/A	≥ 2-1/2 IN	≥ 2-1/2 IN

END OF SECTION

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