SECTION 15951

BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

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PART I.    PART 1 - GENERAL

1.01    SECTION INCLUDES

A.    Pneumatic Tubing
B.    Wiring
C.    Control Valves and Actuators
D.    Control Dampers and Actuators
E.    Control Panels
F.    Sensors
G.    Flow Meter
H.    Pneumatic Control Components (Gauges, switches, relays, etc.)
I.    Electric Control Components (Switches, EP Valves, Thermostats, Relays, Smoke Detectors, etc.)
J.    Transducers
K.    Air Flow Measuring Stations
L.    Current Switches
M.    Nameplates
N.    Testing Equipment

1.02    RELATED DOCUMENTS

A.    Section [Insert Applicable Specification Section] - Basic Mechanical Requirements
B.    Section 15950 - Building Automation System (BAS) General
C.    Section 23 0900 – Building Automation System (BAS) General
D.    Section 15952 - BAS Operator Interfaces
E.    Section 23 0902 - BAS Operator Interfaces
F.    Section 15953 - BAS Field Panels
G.    Section 23 0903 - BAS Field Panels
H.    Section 15954 - BAS Communications Devices
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L.    Section 15958 - Sequences of Operation
M.    Section 23 0993 - Sequences of Operation
N.    Section 15959 - BAS Commissioning
O.    Section 23 0801 - BAS Commissioning

1.03    DESCRIPTION OF WORK

A.    Refer to Section 15950 [23 0900] for general requirements.
B.    Refer to other Division-15 sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not work of this section.
C.    Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
1. Control wiring between field-installed controls, indicating devices, and unit control panels.
2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
3. Wiring associated with indicating and alarm panels (remote alarm panels) and connections to their associated field devices.
4. All other necessary wiring for fully complete and functional control system as specified.

1.04 WORK BY OTHERS
A. Control Valves furnished under this section shall be installed under the applicable piping section under the direction of Section 15951 [23 0913] Contractor who will be fully responsible for the proper operation of the valve.
B. Control Dampers furnished under this section shall be installed under the applicable air distribution or air handling equipment section under the direction of Section 15951 [23 0913] Contractor who will be fully responsible for the proper operation of the damper.
C. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc. that will have wet surfaces, shall be installed under the applicable piping Section under the direction of Section 15951 [23 0913] Contractor who will be fully responsible for the proper installation and application.
D. Controlled Equipment Power Wiring shall be furnished and installed under Division 16. Where control involves 120V control devices controlling 120V equipment, Division 16 Contractor shall extend power wiring to the equipment and control panel. Section 15951 [23 0913] Contractor shall extend it from the equipment to the control device and provide transformers as necessary to step the voltage down.

PART II. PART 2 – PRODUCTS
2.00 Approved Vendors
A. The approved vendors are:
   1. Andover
   2. Automated Logic (ALC)

2.01 MATERIALS AND EQUIPMENT
A. General: Provide electronic [pneumatic,] [and] [electric] control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, clocks, controllers, sensors, and other components as required for complete installation and reviewed and approved by UC. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.
B. Instrument Pipe and Tube
   1. Hydronic and Instruments
      a) Connection to Main Piping: Pipe fitter to provide ½ inch minimum size threadedolet, ½” x 2 inch brass nipple, and ½” ball valve for connection to welded steel piping. Provide tee fitting for other types of piping.
      b) Remote Instruments: Adapt from ball valve to specified tubing and extend to remote instruments. Provide a union or otherwise removable fitting at ball valve so that connection to main can be cleaned with straight rod. Where
manifolds with test ports are not provided for instrument, provide tees with ¼” FPT branch with plug for use as test port. Adapt from tubing size to instrument connection.

c) **Line Mounted Instruments:** Extend rigid piping from ball valve to instrument. Do not use close or running thread nipples. Adapt from ball valve outlet to instrument connection size. Provide a plugged tee if pipe makes 90 degree bend at outlet of valve to allow cleaning of connection to main with straight rod without removing instrument.

d) **Instrument Tubing:** Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; or brass compression-type fittings. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder. Tubing OD size shall be not less than the larger of ¼” or the instrument connection size.

e) **Rigid Piping for Line Mounted Instruments:** Schedule 40 threaded brass, with threaded brass fittings.

2. **Low Pressure Air Instrument Sensing Lines**

a) **Connections:** Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.

b) **Tubing:** Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

C. **Communication Wiring:** All wiring shall be in accordance with manufacturer’s requirements, National Electrical Codes and Division 16 of this specification. All wire insulation shall be color-coded and labeled for ease of identification.

1. Contractor shall supply all communication wiring between Building Controllers, Routers, Gateways, AAC’s, ASC’s and local and remote peripherals (e.g., operator workstations, printers, and modems).

2. **Local Supervisory LAN:** For any portions of this network required under this section of the specification, contractor shall use Fiber or Category 5e of standard TIA/EIA (100/1000BaseT). Network shall be run with no splices and in separate conduit from any other wiring.

3. **Primary and Secondary Controller LANs:** Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any other wiring. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.

D. **Signal Wiring:** Contractor shall run all signal wiring in accordance with National Electric Codes, Division 16 of this Specification and within the allowances of UCB’s wiring guideline. All wire insulation shall be color-coded and labeled for ease of identification.

1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be per manufacturer’s requirements. Signal wiring shall be run with no splices and separate from all other wiring above thirty (30) volts.

2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

E. **Low Voltage Analog Output Wiring:** Contractor shall run all low voltage control wiring in accordance with National Electric Codes and Division 16 of this Specification. All wire insulation shall be color-coded and labeled for ease of identification.
1. Low voltage control wiring shall be per manufacturer’s requirements. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.

F. Control Panels: Provide control panels with suitable brackets for wall mounting for each control system. Locate panel adjacent to systems served.

1. Fabricate panels of 16-gage furniture-grade steel, or 6063-T5 extruded aluminum alloy, totally enclosed on four sides, with hinged door and keyed lock, with manufacturer's standard shop-painted finish and color.
2. Provide UL-listed cabinets for use with line voltage devices.
3. Control panel shall be completely wired prior to delivery and all electrical connections made to a labeled terminal strip. Control panel shall have standard manufacturer's color.
4. All gauges and control components shall be identified by means of nameplates.
5. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover.
6. Complete wiring and tubing termination drawings shall be mounted in or adjacent to panel.

2.02 CONTROL VALVES

A. General: Provide factory fabricated control valves of type, body material and pressure class indicated. They shall be two-way or three-way type for two-position or modulating service as scheduled, shown on drawings, or as specified in Sequence of Operation.

B. Close-Off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

1. Water Valves:
   a) Two-way - 150% of total system (pump) head.
   b) Three-way - 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

2. Steam Valves:
   a) 150% of operating (inlet) pressure.

C. Water Valves: [The designer shall provide a schedule for the Controls Contractor listing the available pressure drop to be used for valve sizing for each control valve in the project, unless it is a reverse-return system. It is not acceptable to list a single pressure drop to be used for all valves. For a piping system in which modulated two-way valves are used, for example, the valves nearest the pump will have a larger available pressure drop than those farther away from the pump.]

   1. Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service, except where stated otherwise.

   2. Sizing Criteria:
      a) Two-position service: Full port line size.
      b) Two-way modulating service: Pressure drop across the valve in a wide-open position, with full flow through the valve, shall be equal to 50% of the available pressure differential between the mains, with a minimum of 4 psi.
      c) Three-way Modulating Service: Pressure drop across the valve in a wide-open position, with full flow through the valve, shall be equal to twice the pressure drop through the heat exchanger (load), with a 3 psi minimum.

3. Construction:
a) Valves ½” through ¾” globe style serving terminal units, AHU coils and baseboard radiation shall be:
   1) Honeywell VP-525A or C series:
      i. 2-way, N.O., VP-526A OR 2-way, N.O., VP-531A
      ii. 3-way, VP-527A
      iii. C series, 2-way, N.O. OR preapproved equal (Siemens Powermite599 Series (electric) or Siemens Powermite 599 (pneumatic))
   b) Valves 1" and 1¼” for sequencing applications may be:
      i. Powers VP-658 (2-way, N.O. or N.C.)
      ii. Powers VP-658WM (3-way), VP-591 also acceptable
   c) Valves 1" through 8” globe style for control of differential pressure shall be:
      1) Siemens 200 series electric actuators or pre-approved equal.
   d) Valves 2" through 12” butterfly style for control of condenser water temperature (cooling tower bypass) shall be:
      1) Siemens 2-way butterfly assemblies with Siemens electric actuators or pre-approved equal.
   e) Valves 2” through 12” single butterfly style two-position or modulated applications shall be:
      1) Johnson VF Series Powers/Siemens BV2W Series with electric actuator or pre-approved equal.

4. Water valves shall fail as specified in the Control Sequences section.
5. Evaporative Cooler Drain and Fill Valves:
   a) Valve normal position shall be as shown on the drawings.

6. For systems with glycol solutions, provide documentation that the valve components in contact with the fluid are compatible with it.

D. Water Valves – Pressure Independent:
1. Acceptable brands:
   a) Delta-P
   b) Belimo
   c) Danfoss

E. Steam Valves:
1. Body and trim materials shall be per manufacturer's recommendations for design conditions and service, except stainless steel seats are required for all applications. Equal percentage ports for modulating service.
2. Sizing Criteria:
   a) Two-position Service - pressure drop 10 to 20% of inlet psig.
   b) Modulating Service - 15 psig or less. Pressure drop 80% of inlet psig.
   c) Modulating Service - 16 to 50 psig. Pressure drop 50% of inlet psig.
   d) Modulating Service - over 50 psig. Pressure drop as scheduled on plans.
3. Steam valves shall fail normally open or closed as scheduled on plans or as follows:
   a) Low pressure heating - normally open.
   b) Heating coils in air handlers - normally open.
   c) Steam-to-water converters for heating water - normally closed.
   d) Steam-to-water converters for domestic hot water - normally closed.
   e) High-pressure applications - as scheduled.
4. Acceptable manufacturers as follows:
a) Globe style; terminal units, baseboard radiation.
   1) ½” through ¾”; Honeywell VP-525A (N.O., 2-way).
   2) Siebe VB-9223 (N.C., 2-way).
   3) Powers 591/593 (N.O. or N.C. 2-way) series.

b) Globe style; steam/water heat exchangers, AHU coils.
   1) 1” through 2”; Powers 591/593 series.
   2) 2 ½” through 4”; Powers 591/593 series, Fisher Easy-E series, Leslie Class DLOS-2.

c) Smart Steam Valves (for Mains): Keystone valves with Peaktronics DHC-100 series or pre-approved equal.

2.03 CONTROL DAMPERS

A. General: Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable air flow. Provide parallel or opposed blade dampers as recommended by manufacturers sizing techniques. For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service. Control dampers used for smoke dampers shall comply with UL 555S. Control Dampers used for fire dampers shall comply with UL 555.

B. For general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 fpm (7.62 m/s), differential pressure not greater than 2.5” w.c. (622 Pa):
   1. Performance: Test in accordance with AMCA 500.
   2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
   3. Blades: Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts with set screws, 16 gauge minimum thickness.
   6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
   7. Linkage: Concealed in frame.
   8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
   9. Leakage: Less than one percent based on approach velocity of 1500 ft./min. (7.62 m/s) and 1 inches wg. (249Pa).
   10. Maximum Pressure Differential: 2.5 inches wg. (622 Pa)
   11. Temperature Limits: -40 to 200 °F (-40 to 93 °C).
   12. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames appropriate for installation.

C. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6” w.c. (1493 Pa):
   1. Performance: Test in accordance with AMCA 500.
   2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. **Blades**: extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts, 14 gauge minimum extrusion thickness.

4. **Blade Seals**: Synthetic elastomeric, mechanically attached, field replaceable.

5. **Jamb Seals**: Stainless steel.

6. **Shaft Bearings**: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.

7. **Linkage**: Concealed in frame.

8. **Linkage Bearings**: Oil impregnated sintered bronze or graphite impregnated nylon.

9. **Leakage**: Less than 0.1 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa).

10. **Maximum Pressure Differential**: 6 inches wg. (622 Pa)

11. **Temperature Limits**: -40 to 200 °F (-40 to 93 °C).

12. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with appropriately intermediate frames.

D. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm, differential pressure not greater than 12” w.c.:

1. **Performance**: Test in accordance with AMCA 500.

2. **Frames**: Galvanized steel, 12-gauge minimum thickness, welded or riveted with corner reinforcement.

3. **Blades**: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 3/4 inch (19 mm) shafts with set screws

4. **Shaft Bearings**: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.

5. **Linkage**: 10-gauge minimum thickness galvanized steel clevis type crank arms, 3/16” x 3/4” (4.76 mm x 19 mm) minimum thickness tie rods.

6. **Linkage Bearings**: Oil impregnated sintered bronze or graphite impregnated nylon.

7. **Leakage**: Less than 0.2 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.

8. **Maximum Pressure Differential**: 12 inches wg. (2984 Pa)

9. **Temperature Limits**: -40 to 300 °F (-40 to 149 °C).

10. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts.

E. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm (12.7 m/s), differential pressure not greater than 4” w.c. (994 Pa):

1. **Performance**: Test in accordance with AMCA 500.

2. **Frames**: rolled 12 gauge steel strip for sizes 6 inch and smaller, rolled 14 gauge steel channel for larger sizes, galvanized or aluminum finish.

3. **Blades**: Steel construction, 12 gauge minimum thickness for dampers less than 18 inches (457 mm) in size, 10 gauge minimum thickness for larger dampers.

4. **Blade Seals**: Full circumference neoprene.
5. **Shaft**: ½ inch (12.7 mm) diameter zinc or cadmium plated steel.
6. **Shaft Bearings**: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
7. **Leakage**: Less than 0.2 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249 Pa) differential pressure.
8. **Maximum Pressure Differential**: 4 inches wg. (994 Pa)
9. **Temperature Limits**: -40 to 300 °F (-40 to 149 °C).

**F.** For general isolation and modulating control service in round ducts up to 60 inches in size at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6” w.c. (1492 Pa):
1. **Performance**: Test in accordance with AMCA 500.
2. **Frames**: rolled 10-gauge steel channel for sizes 48 inch and smaller, rolled 3/16 inch (4.76 mm) thick steel channel for larger sizes, galvanized or aluminum finish.
3. **Blades**: Steel construction, 10-gauge minimum thickness for dampers not greater than 48 inches in size, ¼ inch (6.35 mm) minimum thickness for larger dampers.
4. **Blade stops**: ½ inch x ¼ inch (12.7 mm x 6.35 mm) full circumference steel bar.
5. **Blade Seals**: Full circumference neoprene.
6. **Shaft**: zinc or cadmium plated steel, angle reinforcing as necessary.
7. **Shaft Bearings**: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
8. **Leakage**: Less than 0.4 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249 Pa) differential pressure.
9. **Maximum Pressure Differential**: 6 inches wg. (1492 Pa)
10. **Temperature Limits**: -40 to 250 °F (-40 to 121 °C).

### 2.04 ACTUATORS

**A. General**: Size actuators and linkages to operate their appropriate dampers or valves with a single actuator with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Multiple actuators for any single application must be preapproved by UCB. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied. Actuators relying on batteries for any operation are not acceptable.

**B. Damper Actuators**
1. Ambient Operating Temperature Limits: -10 to 150°F (-12.2 to 66 °C)
2. **Two Position Electric Actuators**: Low voltage or line voltage with spring return.
   a) **Acceptable Manufacturers**:
      1) Siemens
      2) Belimo
      3) Honeywell
      4) Johnson Controls
      5) Snyder Electric
      6) Substitutions: or approved equal
3. **Electronic Actuators**: Provide actuators with spring return for two-position (24v), 0-5 Vdc, 0-10 Vdc, 2-10Vdc, 4-20 mA, or PWM input (subject to restrictions) as required. Actuators shall travel full stroke in less than [90] seconds. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.
Provide stroke indicator. Actuators shall have positive positioning circuit. Where two actuators are required in parallel or in sequence provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override where indicated.

a) **Close-Off Pressure**: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure plus 50 percent for low pressure steam, and 10 percent for high pressure steam. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.

b) **Acceptable Manufacturers**: Subject to compliance with requirements approved manufacturers are as follows:
   1) Belimo
   2) Honeywell
   3) Invensys
   4) Johnson Controls
   5) Snyder Electric
   6) Substitutions: Must be pre-approved by UCB

C. **Quarter-Turn Actuators (for ball and butterfly valves):**

1. **Electric**
   a) **Motor**: Suitable for 120 or 240 Volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
   b) **Gear Train**: Motor output shall be directed to a self locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.
   c) **Wiring**: Power and control wiring shall be wired to a terminal strip in the actuator enclosure
   d) **Failsafe Positioning**: Actuators shall be spring return type for failsafe positioning.
   e) **Enclosure**: Actuator enclosure shall be NEMA-4 rated, and shall have a minimum of two threaded conduit entries. Provide an enclosure heater for actuators located outside of buildings.
   f) **Limit Switches**: Travel limit switches shall be UL and CSA approved. Switches shall limit actuator in both open and closed positions.
   g) **Mechanical Travel Stops**: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.
   h) **Manual Override**: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared handwheel type. For larger valves, the override shall be a fixed geared handwheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the handwheel is engaged for manual operation.
   i) **Valve Position Indicator**: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.
j) **Torque Limit Switches**: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.

k) **Position Controller**: For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 Vdc, 2-10 Vdc, and 135 Ohm potentiometer.

l) **Ambient Conditions**: Actuator shall be designed for operation from –140 to 150 °F ambient temperature with 0 to 100 percent relative humidity.

m) **Acceptable Manufacturers**:

   1) Belimo
   2) Honeywell
   3) Siemens
   4) Snyder Electric
   5) Substitutions: approved equal

2. **/Pneumatic Single- and Double-Acting Cylinder Type**:

   a) **Air Cylinder**: Shall consist of steel or aluminum cylinder, dual pistons, double rack and pinion gearing mechanism. Housing shall be protected both internally and externally with corrosion resistant coating. Actuator shall be equipped with piston guide rods or similar mechanism so that seals are not loaded as linear bearings. Single acting units shall have multiple symmetrically arranged springs to apply equal force to piston. Cylinder shall be configurable for direction of fail-safe mode in the field. Actuators shall be spring return type for failsafe positioning.

   b) **Position Indication**: Provide extended shaft position indicator that is removable for manual override of valve.

   c) **Two-Position Actuators**: Provide appropriate three-way or four-way solenoid valve mounted on the actuator. Solenoid valve electrical enclosure shall meet NEMA-4 requirements. Provide actuator with position switches where required.

   d) **Modulating Actuators**: Provide a rotary electronic positioner designed to accept 4-20 mA, 0-10 Vdc, 2-10 Vdc, or 135 Ohm potentiometer and operate integral 3-way or 4-way solenoid valve to position valve rotation angle as sensed by integral position feedback device to match signal input. Enclosure shall meet NEMA-4 requirements. Actuator linearity and resolution shall be 0.5% of span. Hysteresis and deadband shall be adjustable. Provide accessory mechanical or proximity type position switches and position transmitters where required. Actuators shall be spring return type for failsafe positioning. Provide an enclosure heater for positioners located outside of buildings.

2.05 **GENERAL FIELD DEVICES**

   A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.

   B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

   C. Field devices specified herein are generally ‘two-wire’ type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with ‘two-wire’ type transmitters, or if field device is to serve as input to more than one controller, or where the
length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide ‘four-wire’ type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

E. **Accuracy**: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

2.06 **TEMPERATURE SENSORS (TS)**

A. **Sensor range**: When matched with A/D converter of BC, AAC/ASC, or SD, sensor range shall provide a resolution of no worse than 0.3°F (0.16 °C) (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25°F over 5 years.

*Include and edit where matched sensors are required for the specific project.*

B. **Matched Sensors**: The following applications shall require matched sensors:

1. **Building Loop Connections**: Provide matched loop and building supply sensors where control sequence requires controlling to a temperature rise (differential).

2. **Hydronic Temperature Difference Calculations**: Provide matched supply and return temperature sensors where the pair is used for calculating temperature difference for use in load calculations or sequencing such as across chillers and plants.

3. **Air Handling Unit Sequencing**: Provide matched pair for the cooling and heating coil leaving sensors where the sequence includes calculating an offset from the supply air setpoint to maintain a leaving heating coil temperature.

C. **Room Temperature Sensor**: Shall be an element contained within a ventilated cover, suitable for wall mounting. Provide insulated base. Following sensing elements are acceptable:

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

2. Provide setpoint adjustment where indicated. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS (initial range of +/- 2°F).

3. Provide an occupancy override button on the room sensor enclosure where indicated. This shall be a momentary contact closure.

4. Provide current temperature indication via an LCD readout where indicated.

D. **Single-Point Duct Temperature Sensor**: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A. Sensor probe shall be 316 stainless steel.

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.2°F accuracy at calibration point

E. **Averaging Duct Temperature Sensor**: Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three square feet of cooling coil/duct face area. Temperature range as required for resolution indicated in paragraph A.

1. Sensing element shall be platinum RTD, or thermistor, +/- 0.2°F accuracy at calibration point.
F. **Liquid immersion temperature sensor** shall include brass thermowell, sensor and connection head for wiring connections. Temperature range shall be as required for resolution of 0.15°F.

   1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point. Temperature range shall be as required for resolution of 0.3°F.

   *Include and edit where surface-mount may be allowed in the project with prior approval by UCB*

G. **Pipe Surface-Mount Temperature Sensor:** Shall include metal junction box and clamps and shall be suitable for sensing pipe surface temperature and installation under insulation. Provide thermally conductive paste at pipe contact point. Temperature range shall be as require for resolution indicated in paragraph A.

   1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

H. **Outside air sensors** shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated in Paragraph A.

   1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

### 2.07 HUMIDITY TRANSMITTERS

A. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:

   1. **Input Range:** 0 to 100% RH.
   2. **Accuracy (% RH):** +/- 2% (when used for enthalpy calculation, dewpoint calculation or humidifier control) or +/- 3% (monitoring only) between 20-90% RH at 77°F, including hysteresis, linearity, and repeatability.
   3. **Sensor Operating Range:** As required by application
   4. **Long Term Stability:** Less than 1% drift per year.

B. **Acceptable Manufacturers:** Units shall be Vaisala HM Series. Substitutions shall be allowed per Division 1.

### 2.08 DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. **General Purpose - Water:** Two-wire transmitter, 4-20 mA output with zero and span adjustments. Plus or minus 0.5% overall accuracy, 450 psig (3103 KPa) maximum static pressure rating, 200 psid maximum overpressure rating for 6 through 60 psid range, 450 psid for 100 through 300 psid range.

B. **Industrial Application, Liquid, Steam and Gas:**

   1. **General:** Two-wire smart DP cell type transmitter, 4-20 mA or 1-5 Vdc user-selectable linear or square root output, adjustable span and zero, stainless steel wetted parts.
   2. **Environmental limits:** -40 to 250 °F (-40 to 121°C), 0 to 100% RH.
   3. **Accuracy:** less than 0.1 percent of span.
   4. **Output Damping:** Time constant user selectable from 0 to 36 seconds.
5. **Vibration Effect**: Less than ±0.1% of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.


7. **Approvals**: FM, CSA.

8. **Acceptable Manufacturers**: Rosemount Inc. 3051 Series, Foxboro, Johnson-Yokagawa, Setra, or Mamac. Substitutions shall be allowed per Division 1.

C. **General Purpose Low Pressure Air**: Generally for use in static measurement of duct pressure or constant volume air velocity pressure measurement where the range is applicable.

1. **General**: Loop powered two-wire differential capacitance cell-type transmitter.

2. **Output**: Two wire 4-20 mA output with zero adjustment.

3. **Overall Accuracy**: Plus or minus 1%.

4. **Minimum Range**: 0.1 in. w.c.

5. **Maximum Range**: 10 inches w.c.

6. **Housing**: Polymer housing suitable for surface mounting.

7. **Acceptable Manufacturers**: Ashcroft, Modus T30. Substitutions shall be allowed per Division 1.

8. **Static Sensing Element**: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.

9. **Range**: Select for specified setpoint to be between 25% and 75% full-scale.

D. **General Purpose Low Pressure/Low Differential Air**: Generally for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.

1. **General**: Loop powered, two-wire differential capacitance cell type transmitter.

2. **Output**: Two-wire 4-20 mA output with zero adjustment.

3. **Overall Accuracy**: Plus or minus 1%.

4. **Minimum Range**: 0 in. w.c.

5. **Maximum Range**: 0.1, 0.25, or 0.5 inches w.c.

6. **Housing**: Polymer housing suitable for surface mounting.

7. **Acceptable Manufacturers**: Ashcroft, Modus T30. Substitutions shall be allowed per Division 1.

8. **Static Sensing Element**: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.

9. **Range**: Select for specified setpoint to be between 25% and 75% full-scale.

E. **VAV Velocity Pressure**: Generally for use in variable volume air velocity pressure measurement where the range is applicable.

1. **General**: Loop powered two-wire differential capacitance cell type transmitter.

2. **Output**: Two-wire, 4-20 mA output with zero adjustment.

3. **Overall Accuracy**: Plus or minus 0.25%

4. **Minimum Range**: 0 in. w.c.

5. **Maximum Range**: 1 inch w.c.

6. **Housing**: Polymer housing suitable for surface mounting.

7. **Acceptable Manufacturers**:
   a) Ashcroft
   b) Modus
c) Setra.
d) Substitutions shall be allowed per Division 1.

8. **Range**: Select for minimum range that will accept the maximum velocity pressure expected.

### 2.09 VALVE BYPASS FOR DIFFERENTIAL PRESSURE SENSORS

A. Provide a three or five valve bypass kit for protection of DP sensors where the static on the pipe can cause an over pressure when connected to one port with the other at atmospheric pressure. Kit shall include high and low pressure isolation valves, high and low pressure vent valves (five valve kit) and a bypass valve contained in a NEMA-1 enclosure. Enclosure shall be mounted no higher than 6 feet above floor level.

### 2.10 DIFFERENTIAL PRESSURE SWITCHES (DPS)

A. **General Service - Air**: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing.

B. **General Service - Water**: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0°F to 160°F operating temperature range.

### 2.11 PRESSURE SWITCHES (PS)

A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150% of rated pressure.

B. **Acceptable Manufacturers**: Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls. Substitutions shall be allowed per Division 1.

### 2.12 TRANSDUCERS

A. **Standard Capacity Electronic-to-Pneumatic (E-P) Transducers**: E-P transducers shall be Voltage-to-Pneumatic (V-P) type, Current-to-Pneumatic (I-P) type:
   1. **Electrical Power Supply**: 24 Vac or 24 Vdc.
   2. **Pneumatic Air Supply**: 30 psig (2.07 bar) maximum.
   3. **Air Capacity**: 1100 scim @ 20 psig (300 cm³/sec @ 1.4 bar).
   4. **Air Consumption**: Zero at steady state.
   5. **Output Span**: 0-20 psig (0-1.4 bar).
   6. **Input**: 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-15 Vdc, or 3-15 Vdc input.
   7. **Enclosure**: Polymer designed for surface or panel mount.
   8. **Air Connections**: ¼” (6.35 mm) barbed.
   9. **Failure Mode on Power Loss**: Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.

B. **Acceptable Manufacturers**: Mamac EP-313-020, Johnson Controls. Substitutions shall be allowed per Division 1.

### 2.13 PHASE-VOLTAGE-FREQUENCY MONITOR

*Include only when requested by UCB.*

A. Provide with two (2) sets of alarm relay outputs:
1. One monitored by the BAS
2. One monitored by UCB

B. Provide Motor Saver Model MS250A or equal.

2.14 CURRENT SWITCHES (CS)

*UCB prefers using current transducers; unless there is a specific application for current switches.*

A. **Clamp-On Design Current Operated Switch** (for Constant Speed Motor Status Indication)
   1. **Range:** 1.5 to 150 amps.
   2. **Trip Point:** Adjustable.
   3. **Switch:** Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
   4. **Lower Frequency Limit:** 6 Hz.
   5. **Trip Indication:** LED
   6. **Approvals:** UL, CSA
   7. **Max. Cable Size:** 350 MCM
   8. **Acceptable Manufacturers:** Veris Industries H-708/908; Inc., RE Technologies SCS1150A-LED. Substitutions shall be allowed per Division 1.

B. **Clamp-on Wire Through Current Switch (CS/CR) (for Constant Speed Motors):**
   Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A).
   Acceptable Manufacturers shall be Veris Industries, Inc., Model # H938/735; or RE Technologies RCS 1150. Substitutions shall be allowed per Division 1.
   1. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing similar with override switch to Kele RIBX. Substitutions shall be allowed per Division 1.

C. **Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication**
   1. **Range:** 1.5 to 135 Amps.
   2. **Trip Point:** Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.
   3. **Switch:** Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
   4. **Frequency Range:** 5-75 Hz
   5. **Trip Indication:** LED
   6. **Approvals:** UL, CSA
   7. **Max. Cable Size:** 350 MCM
   8. **Acceptable Manufacturers:** Veris Industries, Inc. H-904. Substitutions shall be allowed per Division 1.

D. **Clamp-On Wire Through Current Switch (CS/CR) (for Variable Speed Motors):**
   Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A).
   Acceptable manufacturer shall be Veris Industries, Inc., Model # H934. Substitutions shall be allowed per Division 1.
E. **Variable Speed Status:** Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent ramp up to 60 Hz, versus operation at low speed. The belt break scenario shall be indicated as a loss of status and the operation at low speed shall indicate normal status.

### 2.15 CURRENT TRANSDUCER (CT)

**A. Clamp-On Design Current Transducer (for Motor Current Sensing)**
1. **Range:** 1-10 amps minimum, 20-200 amps maximum
2. **Trip Point:** Adjustable
3. **Output:** 0-5 VDC.
4. **Accuracy:** ±0.2% from 20 to 100 Hz.
5. **Acceptable Manufacturers:**
   a) Veris # 7222, 822, 922
   b) Substitutions shall be allowed per Division 1.

### 2.16 OUTDOOR AIR STATIC PRESSURE SENSING TIP

**A. Pressure sensor:** Pressure sensing tip shall be designed to minimize the effects of wind and resulting velocity pressure up to 80 mph. Acceptable manufacturers shall be Dwyer A-306. Substitutions shall be allowed per Division 1.

**B. Low Air Pressure Surge Dampener:** 30-second time constant. Acceptable manufacturer shall be Modus SD030. Substitutions shall be allowed per Division 1.

### 2.17 CONTINUOUS LEVEL TRANSMITTERS

**A. Ultrasonic Type**
1. Provide a non-contacting, temperature compensating, narrow beam, ultrasonic type level transmitter with adjustable span and zero.
2. **Output:** 4-20 mA.
3. **Transducer Materials:** PC/ABS, Polypropylene, PVC and/or Teflon.
4. **Electrical Enclosure:** NEMA-4X, -6.
5. **Approvals:** UL, CE or CSA.
6. **Accuracy:** ±.5% of calibrated span.
7. **Acceptable Manufacturers:** Flowline EchoSpan, Princo Instruments, & Greyline. Substitutions shall be allowed per Division 1.

**B. Capacitance Type**
1. Provide a loop powered, continuous capacitance type level transmitter with adjustable span and zero.
2. **Output:** 4-20 mA.
3. **Probe:** Fluoropolymer coated stainless steel rod or cable. Provide cable probe with end attachment hardware or weight.
4. **Electrical Enclosure:** NEMA-4, -7.
5. **Approvals:** UL or CSA.
6. **Accuracy:** ±1% of calibrated span.
7. **Process Connection:** MPT or ANSI Flange as required.
8. **Acceptable Manufacturers:** Drexelbrook, Endress & Hauser. Substitutions shall be allowed per Division 1.
2.18 INSERTION TYPE TURBINE METER FOR WATER SERVICE

A. Turbine Insertion Flow Meter sensing method shall be impedance sensing (iron magnetic and non-photoelectric), with volumetric accuracy of +/- 2% of reading over middle 80% of operating range, and +/- 4% of reading over the entire operating range. Turbine Insertion Flow Meter shall have maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak). All wetted metal parts shall be constructed of 316 stainless steel. Flow meter shall meet or exceed all of the accuracy, head loss, flow limits, pressure and material requirements of the AWWA standard C704-70 for the respective pipe or tube size. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 V, and current output of 4-20 mA.

1. Install in water systems with a minimum of 10 pipe diameters unobstructed flow.
2. Acceptable Manufacturers: Onicon Corp. and Hersey. Substitutions shall be allowed per Division 1.

2.19 FLOW METER FOR STEAM

A. Flow Computer: KEP Supertrol II with MODBUS RTU Communication Card
B. Maximum Fluid Temperature: 800 °F (427 °C)
C. Wetted Parts: Stainless Steel
D. Housing: NEMA 4X
E. Turndown: 10:1 minimum.
F. Accuracy: 1% of calibrated span
G. Body: Wafer style or ANSI flanged to match piping specification.
H. Acceptable Manufacturers: Veris Accelebar and Onicon Vortex. Substitutions shall be allowed per Division 1.

2.20 VORTEX SHEDDING FLOW METER FOR LIQUID AND GAS SERVICE

A. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc
B. Maximum Fluid Temperature: 800 °F (427 °C)
C. Wetted Parts: Stainless Steel
D. Housing: NEMA 4X
E. Turndown: 10:1 minimum.
F. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for gases.
G. Body: Wafer style or ANSI flanged to match piping specification.

2.21 AIRFLOW MEASURING STATIONS (AFMS)

A. Pitot Tube Grids: Provide an array of velocity pressure sensing elements with averaging manifolds and air straightening vanes packaged in a sheet metal casing. Distribute sensing elements in accordance with ASHRAE for traversing ducts. Provide taps to connect tubing from instrumentation. Label AFM with drawing number designation, design flow, velocity pressure, and pressure drop. Application of pitot grids shall be allowed only where minimum expected flow is greater than 30% or maximum flow
B. Vortex Shedding Grid: Provide an array of vortex shedding elements designed to produce stable ‘Karmen Vortices’ that are linear with air velocity. Provide the electronics
to totalize the pulses and output average velocity proportional to an output signal of 4-20mA.

1. Sensor Accuracy: ±1.5%
2. Electronics Accuracy: ±0.5%
3. Range: Select minimum range to accommodate the expected flow range of the project
4. Temperature Limits: 20-140°F
5. Acceptable Manufacturer: Tek-Air Systems Inc. ‘Vortek’ Model. Substitutions shall be allowed per Division 1.

2.22 AIR VELOCITY PRESSURE SENSORS (INSERTION TYPE)

A. Single or Multi-Point Averaging (as indicated): Sensing tip shall be for insertion into duct with mounting flange and push on tube connections. Material shall be suitable to the application.

2.23 CO2 SENSORS/TRANSMITTERS (CO2)

A. CO2 sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.
B. Accuracy: ±36ppm at 800 ppm and 68°F.
C. Stability: 5% over 5 years.
D. Output: 4-20 mA, 0-10 Vdc or relay.
E. Mounting: Duct or Wall as indicated.
F. Acceptable Manufacturer: Vaisala, Inc. GMD20 (duct) or GMW20 (wall).

The following applies to repair or minor modification of existing pneumatic systems.

2.24 PNEUMATIC CONTROL COMPONENTS

A. Analog Pressure Gauges: Gauges shall be pneumatic type, minimum 1-1/2" in (38 mm) diameter, with white face and black numerals. Surface-mounted gauges shall have chrome plated trim and be a minimum of 2-1/2" in (64 mm ) diameter.
B. Pneumatic Actuated Pressure Switches (PE) (for 30 psig max pressure control systems): Pressure ranges and sensitivity of PEs shall match control system sequence of operation. Switch operation shall be externally adjustable over the operating pressure range (nominal 0-20 psig, 0 to 138 KPa ). PE switches shall be SPDT type, rated for the particular application, and shall be UL listed. PE shall be as manufactured by Penn. Substitutions shall be allowed as per Division 1
C. Pilot Positioners: Operating span adjustment range is from 3 to 13 psi (21 to 91 kPa). Positioner shall be furnished with a mounting bracket for attachment directly to the actuator./

2.25 ELECTRIC CONTROL COMPONENTS

A. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley. Substitutions shall be allowed per Division 1.
B. Electric Solenoid-Operated Pneumatic Valves (EP): EP valves shall be rated for a minimum of 1.5 times their maximum operating static and differential pressure. Valves shall be ported 2-way, 3-way, or 4-way and shall be normally closed or open as required by the application. EPs shall be sized for minimum pressure drop, and shall be UL and
CSA listed. Furnish and install gauges on all inputs of EPs. Furnish an adjustable air pressure regulator on input side of solenoid valves serving actuators operating at greater than 30 psig.

1. **Coil Enclosure:** Indoors shall be NEMA-1, Outdoors and NEMA-3, 4, 7, 9.
2. **Fluid Temperature Rating:** Valves for compressed air and cold water service shall have 150°F (66°C) minimum rating. Valves for hot water or steam service shall have fluid temperature rating higher than the maximum expected fluid temperature.
3. **Acceptable Manufacturers:** EP valves shall be as manufactured by ASCO or Parker. Substitutions shall be allowed per Division 1.
4. **Coil Rating:** EP valves shall have appropriate voltage coil rated for the application (i.e., 24 VAC, 120 VAC, 24 VDC, etc.).

C. **Low Temperature Detector (‘Freezestat’) (FZ):** Low temperature detector shall consist of a ‘cold spot’ element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8" x 20' (3.2mm x 6.1m), junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPST (4 wire, 2 circuit) with manual reset. Temperature range 15 to 55°F (-9.4 to 12.8°C), factory set at 38°F.

D. **Surface-Mounted Thermostat:** Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150°F (10 to 65°C), and a minimum 10°F fixed setpoint differential.

E. **Low Voltage Wall Thermostat:** Wall-mounted thermostat shall consist of SPDT sealed mercury contacts, operating temperature range of 50 to 90°F (10 to 32°C), switch rating of 24 Vac (30 Vac max.), and both manual and automatic fan operation in both the heat and cool modes.

F. **Control Relays:** All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.
   1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
      a) AC coil pull-in voltage range of +10%, -15% or nominal voltage.
      b) Coil sealed volt-amperes (VA) not greater than four (4) VA.
      c) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
      d) LED pilot light indication of power-to-coil and coil retainer clips.
      e) Coil rated for 50 and 60 Hz service.
      f) **Acceptable Manufacturers:** Relays shall be Potter Brumfield, Model KRPA. Substitutions shall be allowed per Division 1.
   2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC. Substitutions shall be allowed per Division 1.
   3. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.

G. **General Purpose Power Contactors:** NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1 enclosure. Manufacturer shall be Square ‘D’, Cutler-Hammer or Westinghouse.

H. **Control Transformers:** Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. Primary and
secondary sides shall be fused in accordance with the NEC. Transformer shall be proper size for application, and mounted in minimum NEMA-1 enclosure.

1. Transformers shall be manufactured by:
   a) Westinghouse
   b) Square ‘D’
   c) Jefferson
   d) Veris x100, x040, x020
   e) Substitutions shall be allowed per Division 1.

I. **Time Delay Relays (TDR):** TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a dustproof enclosure.

1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
2. TDRs shall be UL and CSA listed, Crouzet type. Substitutions shall be allowed per Division 1.

J. **Electric Push Button Switch:** Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley. Substitutions shall be allowed per Division 1.

K. **Pilot Light:** Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley. Substitutions shall be allowed per Division 1.

L. **Electric Selector Switch (SS):** Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley. Substitutions shall be allowed per Division 1.

2.26 **REFRIGERANT MONITOR**

A. **General:** Contractor shall provide a refrigerant sensitive infrared-based stationary refrigerant gas leak monitor system designed to continuously measure refrigerants. Refrigerant monitor shall be coordinated to detect refrigerant types here if known or delete refrigerants used in chiller equipment installed under Section Insert appropriate Section. The alarm system shall comply with ANSI/ASHRAE 15-1994 and local code requirements.

B. The refrigerant monitor shall be capable of monitoring multiple refrigerant gas compounds at multiple locations in concentrations of 0 PPM to a minimum of 1000 PPM. The Monitor shall have a low range resolution of 1 PPM in the range of 1 PPM through 100 PPM. Readings above 100 PPM must be accurate to within ±5% of reading. Accuracy shall be maintained within ambient environmental ranges of 0ºC. through 50ºC., (32ºF. through 122ºF.) and 5% through 90% relative humidity, non-condensing.

C. The refrigerant monitor shall automatically and continuously monitor the areas through a sample draw type tubular pick up system with an internal pump and filter. The installation of the monitoring control and the tubing shall be in strict accordance with the manufactures instructions. The location, routing, and final position of the sample tubes shall be submitted to the engineer with all necessary shop drawings and monitor specifications and installation instructions. Tubing size, tubing material, and tube length limitations shall be within the specifications of the monitor manufacture. The location and
The method of tube support and hangers must be identified on the shop drawings. Each of the sampling tubes shall have end of line filters.

D. The analyzer will be based on infrared detection technology, and will be factory tested and calibrated for the specified refrigerant or refrigerants. Factory certification of the calibrations shall be provided with the O&M manuals. The analyzer shall provide a menu driven or automatic method of checking both zero, span calibration for each sensor, and allow for adjustment.

E. The analyzer will be based on infrared detection technology, and will be factory tested and calibrated for the specified refrigerant or refrigerants. Factory certification of the calibrations shall be provided with the O&M manuals. The analyzer shall provide a menu driven or automatic method of checking both zero, span calibration for each sensor, and allow for adjustment.

F. The monitor shall be equipped with 4 outputs. Three relays shall energize at an adjustable user defined set point based on refrigerant concentration levels. The relay threshold adjustment shall be protected by keyed or password access controls. Adjustments and observations shall be made at the front panel operator interface. The relay threshold values can be viewed without a password. The digital display will continuously display the refrigerant concentration level and alarm status. The fourth output shall indicate a monitor malfunction alarm. The monitor shall also have an analog output that will provide a linear scaled reference to the refrigerant concentration in parts per million. The analog output signal shall be an industry standard DC voltage, or mA current signal.

G. The monitor shall have a NEMA-4 moisture resistant enclosure with a gasketed, hinged front cover. Conduits and tube connections shall be located on the bottom of the enclosure. The enclosure shall have a rust and corrosion resistant finish.

H. The following alarm modes will be provided by the refrigerant monitor:

1. ALARM LEVEL ONE – Low level of refrigerant concentration at one of the sampling points has detected the presence of a possible refrigerant leak. The initial alarm threshold shall be set to 5 PPM (adj.) and increased if there are nuisance alarms. This alarm level shall be displayed on the refrigerant monitor interface panel, indicating which sensor has triggered the alarm, and the associated concentration of refrigerant in PPM. This event will also send an Alarm Level One signal to the BAS through a digital output from the monitor relay. This alarm will remain active until the refrigerant concentration is reduced below set point.

2. ALARM LEVEL TWO – This alarm shall indicate that one of the sensors has detected a refrigerant concentration that is approaching dangerous levels in the area being monitored. This alarm shall be set to 25% below the maximum calculated refrigerant level specified in ANSI/ASHRAE 15-1994 and ASHRAE 34-1992. This alarm will be displayed on the monitor interface, and will indicate which of the sensors has caused the alarm, and the highest concentration in PPM. This event will also activate the beacon and audible alarm mounted on the refrigerant monitoring enclosure. This alarm will also be sent to the BAS through the digital output of the relay. In this mode the audible alarm can be silenced, but the beacon shall remain active until the fault is cleared.

3. ALARM LEVEL THREE – This alarm shall be set at the maximum calculated refrigerant level specified in ANSI/ASHRAE 15-1994 and ASHRAE 34-1992 whichever is the lowest concentration. The refrigerant monitor interface will display which sensor has caused the alarm, and the associated concentration in PPM. This event will also activate the beacon and audible alarm mounted on the refrigerant monitoring enclosure. If the audible alarm had been silenced by an earlier alarm, the activation of this level three alarm will cause the audible alarm to be activated again. The relay in the refrigerant monitoring panel shall activate the space ventilation system, and will disable all combustion or flame-producing equipment via hardwired control interlocks. In addition, this event will de-energize the energy source for any hot surface (850°F or 454°C) located in the space. Interlocks must also be provided to close any normally open doors or openings to the space for proper ventilation and isolation during this alarm condition. This alarm level will also
signal the BAS through the digital output through the same relay. In this mode, the audible alarm can be silenced, but the beacon shall remain active until the fault is cleared.

H. All alarm conditions shall be report to the BAS system as follows:

1. ALARM LEVEL ONE - The lowest refrigerant alarm level shall detect the presence of refrigerant in low concentrations and energize a relay to signal a low level alarm to the BAS operator terminal(s). The alarm shall display an alarm message stating that there is a potential refrigerant leak in the designated area.

2. ALARM LEVEL TWO - The second refrigerant level alarm shall be a high refrigerant alarm alert. This alarm shall energize a relay to signal the BAS system indicating a high level alarm on the BAS operator terminal(s). This BAS alarm shall state that high levels of refrigerant have been detected in the designated area.

3. FAULT ALARM – Reports a high level alarm to the BAS operator terminal(s) that there is a fault in the refrigerant monitoring alarm system.

The following only applies for smoke control applications. UCB will provide details for interface to Simplex system.

2.27 /SMOKE CONTROL/FIREMAN'S OVERRIDE PANEL

A. Integral enunciator/control panel part of complete engineered and UUKL 864 listed system.

B. Provide clear, laminated graphic schematically representing the building air systems. Status LEDs shall be associated with graphic representations of fans. Override switches shall be provided as required by NFPA 110 to allow override of the fans and dampers applicable to the code requirements.

C. Interface with Fire Alarm System (Simplex) as required to implement the requirements specified in the Sequence of Operations.

2.28 NAMEPLATES

A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 thick, black, with white center core, and shall be minimum 1" x 3", with minimum 1/4" high block lettering. Nameplates for devices smaller than 1" x 3" shall be attached to adjacent surface.

B. Each nameplate shall identify the function for each device.

C. For pump Variable Speed Drives (VSDs), provide an engraved nameplate at the VSD indicating the location of the controlling Remote Differential Pressure (RDP) transmitter(s). Location shall include the ‘Plan’ room number as well as the actual ‘Building’ room number.

2.29 TESTING EQUIPMENT

A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range).
PART III.  PART 3 - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of National Electric Code and all local codes.

B. Main Control Air Piping: All main air piping between the compressors and the control panels shall be copper, run per ASTM B88

C. Branch Control Air Piping: Accessible tubing is defined as that tubing run in mechanical equipment rooms; inside mechanical equipment enclosures, such as heating and cooling units, instrument panels; across roofs, in pipe chases, etc. Inaccessible tubing is defined as that tubing run in concrete slabs; furred walls; or ceilings with no access.

1. Provide copper tubing with maximum unsupported length of 3'-0", for accessible tubing run exposed to view. Polyethylene tubing may be used in lieu of above, when run within adequately supported, rigid enclosure, such as metallic raceways, or EMT. Terminal single-line connections less than 18 in length may be copper tubing, or polyethylene tubing run inside flexible steel protection. Accessible tubing run in concealed locations, such as pipe chases, suspended ceilings with easy access, etc. may be copper or polyethylene bundled and sheathed tubing.

2. Provide copper or polyethylene tubing for inaccessible tubing, other than in concrete pour. If polyethylene tubing is used, install in EMT or vinyl-jacketed polyethylene tubing.

3. Pressure test control air piping at 30 psi (207 kPa) for 24 hours. Test fails if more than 2 psi loss occurs.

4. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support tubing neatly.

5. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

D. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.

1. Wiring System: Install complete wiring system for electric control systems. Conceal wiring except in mechanical rooms and areas where other conduit and piping are exposed. Installation of wiring shall generally follow building lines. Install in accordance with National Electrical Code and Division 16 of this Specification. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.

2. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, labeled with device served. Install in neat workmanlike
manner, securely fastened. Install in accordance with National Electrical Code and Division 16 of this Specification.

3. Communication wiring shall be run in separate conduit from all other wiring. Signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.

4. All WAN and LAN Communication wiring shield shall be terminated as recommended by controller manufacturer. All WAN and LAN Communication wiring shall be orange jacketed and labeled with a network number, device ID at each termination and shall correspond with the WAN and LAN system architecture and floor plan submittals.

5. All communications wiring shall be in conduit unless pre-approved by UCB.

6. All low-voltage wiring external to control panels shall be in conduit, unless pre-approved. Conduit type, sizing, and installation requirements shall conform to NEC and Division 16.

**The following only applies when a pre-approved exception to conduit has been granted.**

Installation of wiring shall generally follow building lines. Run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring rings) away from areas of normal access. Tie and support conductors neatly with suitable nylon ties. Conductors shall not be supported by the ceiling system or ceiling support system. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Wiring shall not be laid on the ceiling or duct. Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking. Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.

7. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings. Preferred identification system: BRADY

**E. Control Valves:** Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.

**F. Freezestats:** Install freezestats in a serpentine fashion where shown on drawing. Provide one foot of element for each square foot of coil face area. Where coil face area exceeds required length of element, provide multiple devices, wired in parallel for normally open close on trip application, wired in series for normally closed, open on trip application. Adequately support with coil clips.

**G. Space Temperature Sensors:** Sensors shall be located as indicated on drawings.

1. Mount non-adjustable sensors with centerline 60” above finished floor. Sensors with adjustable setpoints and/or override switches must be mounted 36” to 48” above finished floor; coordinate with UCB.

2. Coordinate location of sensor with work of other trades so sensor does not conflict with or is obstructed by such items as blackboards, bleachers, bookcases, etc.

3. Conceal all control wiring to sensors located in new finished spaces; the use of wiremold is prohibited.
4. Thermostats located in Locker Rooms, Team Rooms, Storerooms, and Corridors shall be flush mounted type.

H. **Averaging Temperature Sensors**: Cover no more than three square feet per linear foot of sensor length except where indicated. Generally where flow is sufficiently homogeneous/adequately mixed at sensing location, consult AE for requirements.

I. **Airflow Measuring Stations**: Install per manufacturer’s recommendations in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFM station manufacturer.

J. **Fluid Flow Sensors**: Install per manufacturer’s recommendations in an unobstructed straight length of pipe.

K. **Relative Humidity Sensors**: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

L. **Differential Pressure Transmitters**: Provide valve bypass arrangement to protect against over pressure damaging the transmitter.

M. **Flow Switches**: Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.

N. **Phase-Voltage-Frequency Monitor**: Electrical contractor shall provide and install. Control contractor shall coordinate installation of control wiring with electrical contractor.

O. **Current Switches for Motor Status Monitoring**: Adjust so that setpoint is below minimum operating current and above motor no load current.

P. **Supply Duct Pressure Transmitters**:
   1. **General**: Install pressure tips with at least 4 ‘round equivalent’ duct diameters of straight duct with no takeoffs upstream. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer’s installation instructions. Locate the transmitter at an accessible location to facilitate calibration.
   2. **VAV System ‘Down-Duct’ Transmitters**: Locate pressure tips approximately 2/3 of the hydraulic distance to the most remote terminal in the air system. UCB must approve final location.

Q. **Test Ports**: Provide test ports in ductwork at each temperature and humidity sensor location to facilitate sensor calibration. Test ports shall be 3/4” diameter minimum and accessible via a 2” x 4” junction box with insulated cover.

R. **Cutting and Patching Insulation**: Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

END OF SECTION 15951