Facility Explorer System Division 23 Guide Specification

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Contents

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Instructions

Please Note: **This document is NOT for direct distribution to consultants or customers**. You should not simply give or transmit the document, as is, to your customers. This document is meant to be a tool to assist in writing, editing and reviewing customers' and consultants' specifications. The navigation and outline structure have been set up to allow our channels to "cut and paste" appropriate paragraphs and sentences from this document into the customers' specification documents, and to highlight Facility Explorer features and capabilities which will bring long term value to our customers.

Contact your channel account manager for assistance if you have questions.

Overview

Division 23 09 23, Direct-Digital Control Systems for HVAC/Building Management System, is the core section around BAS and the Facility Explorer products. This part of the Guide Spec document has been updated to include language that covers the capabilities of new Facility Explorer products and new features that have been added over the past several revisions to the product line.

The following document contains many "fields" that require selection or editing. Most commonly, these "fields" are identified with yellow highlighting and special "Note:" text.

Example:

> Note: Item b. is optional, edit as required.

It is highly recommended that you have the Navigation pane open for quick and easy navigation to key sections of interest.

Please Note: We are still reviewing and revising Div 23 09 13, Instrumentation and Control Devices for HVAC, the section of the spec around the input/output devices and peripherals. Likewise, there will be further updates and revisions to Div 23 09 93, Sequences of Operations for HVAC Controls.

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DIVISION 23 – HEATING, VENTILATING, AND AIR-CONDITIONING

23 00 00 HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

23 09 00 Instrumentation and Control for HVAC

23 09 13 Instrumentation and Control Devices for HVAC

23 09 13.13 Actuators and Operators

A. General Requirements

1. Actuators shall be electronic or pneumatic, or both, as detailed in the following sections.
2. The manufacturer shall be ISO 9001 certified.

B. Electronic Damper Actuators

1. Spring Return Actuators:
   a. Spring Return Actuators shall be manufactured, brand labelled and distributed by Johnson Controls or an approved equivalent.
   b. Regulatory Agency Listing: cULus ,CSA C22.2 No. 24-93, and CE marked
   c. Direct-Coupled Design: Requires no crankarm or linkage for mounting to a shaft.
   d. Coupling: toothed V-bolt clamp and nuts with toothed cradle.
   e. Reversible Mounting: Provides either clockwise or counterclockwise operation.
   f. Power Failure Operation: Mechanical spring return system drives load to the home position. Other forms of internal energy storage for power failure operation are not acceptable
   g. Spring Return Actuators shall utilize the following motor technology:
      i. Modulating types: Microprocessor-controlled brushless DC motors
      ii. On/Off types: DC brush motor
   h. Spring Return Actuators shall comply with enclosure ratings of NEMA type 2 or IP54 mounted in any orientation.
   i. Spring Return Actuators shall eliminate the need for electrical ground wires for double-insulated construction.
   j. Spring Return Actuators shall be furnished with integral cables with colored and numbered conductors for simplified wiring.
   k. Spring Return Actuators shall be sized for the torque required to seal the damper at load conditions.
   l. Spring Return Actuators shall be available in parallel operation that are capable of being mechanically or electrically paralleled.
   m. Proportional actuators shall be user configurable without the use of external computer software or programming tools. Calibration, input signal range selection, and control logic reversal shall be selectable with an external mode selection switch.
   n. Spring Return Actuators shall operate in the following temperature ranges:
      iii. For a 70 lb·in. torque actuator range must be -40°F to 140°F (-40°C to 60°C)
      iv. For a 177 lb·in. torque actuator range must be -40°F to 131°F (-40°C to 55°C)
   o. Spring Return Actuators shall be provided with the following power requirements:
      i. Modulating types:
         a) 27 lb·in. torque and below: 5VA maximum

b) 70 lb·in. to 19 lb·in.torque: has a 8VA maximum

c) 89 lb·in. to 71 lb·in.torque: has a 10VA maximum

d) 90 lb·in. to 177 lb·in.torque: has a 16VA maximum

ii. Two-position types:

a) 27 lb·in. torque and below: has a 5VA maximum

b) 70 lb·in. to 19 lb·in.torque: has a 7VA maximum

c) 71 lb·in. to 177 lb·in.torque: has a 25VA maximum

2. Non-Spring Return Actuators

a. Non-Spring Return (NSR) actuators shall be manufactured, brand labelled or distributed by Johnson Controls or an approved equivalent. The NSR actuators are manufactured under International Standards Organization (ISO) 9001 Quality Control Standards to ensure quality.

b. NSR actuators shall comply with the following regulatory agency listings: cULus, CSA C22.2 No 24-93, and CE marked. APAC actuators are excluded from this regulatory information.

c. NSR actuators shall be provided with a 5 year warranty from the date of sale covering defects in material or workmanship. .

Actuators sold in the APAC region shall comply with an 18 month warranty policy.

d. NSR actuators shall be of direct-coupled design and require no crank arm or linkage for mounting to a shaft.

e. NSR actuators shall be of a design that converts the damper version to the valve version without the use of special tools.

f. NSR actuators shall be configured for direct mounting and will not require any damper linkage. Actuators can be mounted directly with a universal clamp to the following:

i. Round damper shaft from 3/8 in. (10mm) up to 1 in. to 1/16 in. (27mm)

ii. Square damper shaft from 3/8 in. (10mm) up to 3/4 in. (19mm)

g. NSR actuators shall offer multiple shaft coupling methods:

i. For units above 80 lb·in a toothed V-bolt clamp and nuts with a toothed cradled shall be used

ii. For units 80 lb·in. and below use a single-cup-point set screw and toothed cradle shall be used

h. NSR actuators shall be furnished with a Minimum IP (ingress protection) enclosure ratings as follows:

i. Actuator for types with covered wiring terminals shall be furnished as NEMA type 2/IP42 mounted in any orientation.

ii. Actuators for types without a covered wiring terminal shall be furnished with a NEMA type 1/IP30 or IP40.

iii. Actuators for types with integrated cables shall be furnished as NEMA type 2/IP42

mounted in any orientation.

iv. NSR actuators shall be furnished with a minimum IP (ingress protection) rating of no lower than IP42, but also be available in NEMA5/IP54.

i. NSR actuators shall be able to operable in a temperature range of -4°F to 122°F (-20°C to 50°C) except for VAV and similar indoor applications in which 32°F to 122°F (0°C to 50°C) is acceptable.

j. NSR actuators shall be sized for the torque required to seal the damper at load conditions. For NSR actuators in parallel operation, actuators shall be available that are capable of being mechanically or electrically paralleled automatically

k. NSR proportional actuators shall be user configurable without requiring the use of external computer software or programming tools.

l. NSR actuators shall be provided with the following power requirements:

i. 24 V with models available for both 24 VAC and 24 VDC operation (maximum)

ii. For NSR actuators above 80 lb·in. a maximum of 7.5 VA at 24 VAC

iii. For NSR actuators 80 lb·in. or below a maximum of 3.5 VA at 24 VAC

23 09 13.23 Sensors and Transmitters

A. General Requirements

1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements. Exact OEM equivalents of specified sensors and transmitters shall be acceptable if clearly identified in submittals.

B. Temperature Sensors

1. General Requirements

a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.

b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD. Thermistor sensors of 10,000 or 2,250 ohms resistance may be substituted based on the application.

c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion.

Point Type	Accuracy
Chilled Water	+ .5°F
Room Temp	+ .5°F
Duct Temperature	+ .5°F
All Others	+ .75°F

2. Room Temperature Sensors

a. Room sensors shall be constructed for either surface or wall box mounting.

b. Room sensors shall have the following options when specified:

i. Setpoint warmer/cooler

ii. Individual heating/cooling setpoint
iii. Momentary override request for activation of after-hours operation
iv. Analog thermometer

3. Room Temperature Sensors with Integral Display
   a. Room sensors shall be constructed for either surface or wall box mounting.
   b. Room sensors shall have an integral LCD display and the following capabilities when specified:
      i. Display room air temperatures
      ii. Display and adjust room comfort setpoint
      iii. Display and adjust fan operation status
      iv. Setpoint override request via setpoint adjust dial or buttons
      v. Timed override request via occupancy override with status indication for activation of after-hours setpoint operation
      vi. Occupancy sensor status
      vii. Toggle between Degrees F and Degrees C
      viii. Toggle between temperature and humidity where specified
4. Thermowells
   a. Thermowell manufacturer shall have models available in stainless steel, brass body, and copper bulb.
   b. When thermowells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and sensor.
   c. Thermowells shall be pressure rated and constructed in accordance with the system working pressure.
   d. Thermowells and sensors shall be mounted in a direct mount (no adapter) offering faster installation or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.
   e. Thermowells constructed of 316 stainless steel shall comply with Canadian Registration Number (CRN) pressure vessel rating.
5. Outside Air Sensors
   a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall be provided with a solar shield.
   b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
   c. Temperature transmitters shall be of NEMA 3R (IP54) or NEMA 4 (IP65) construction and rated for ambient temperatures.
   d. The outdoor sensor shall be capable of being mounted on a roof, pole or side of a building utilizing its preassembled mounting bracket.
   e. Outside air relative humidity sensors 0-100% full range of accurate measurement. Operating temperature -4 to 140°F (-20 to 60°C).
   f. Outside air temperature sensors operating temperature range -40 to 140°F, +/- .55°F (+/- .3°C).
6. Duct Mount Sensors
   a. Duct mount sensors shall mount in an electrical box through a hole in the duct, positioned to provide ease of accessibility for repair or replacement.
   b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be provided.

7. Averaging Sensors

a. For ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

b. For plenum applications, such as mixed air temperature measurements, a continuous averaging sensor or a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.

c. Capillary supports at the sides of the duct shall be provided to support the sensing string.

8. Acceptable Manufacturers: Johnson Controls, Minco.

Note: Include other manufacturers, as appropriate.

C. Humidity Sensors

1. The sensor shall be a solid-state type, relative humidity sensor of the Thin Film Capacitance or Bulk Polymer Design. The sensor element shall resist service contamination.

2. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.

3. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH at 77°F unless specified elsewhere.

4. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R (IP54) or NEMA 4 (IP65) enclosure with sealtite fittings.

5. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.

6. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

7. Acceptable Manufacturers: Johnson Controls, Greystone, and Vaisala.

D. CO_2 Sensors

1. Where shown on the drawings, CO_2 sensors shall have the following features:

a. Jumper selectable: 0-20mA, 4-20mA & 0-10 VDC output

b. Liquid Crystal Display (LCD)

2. The CO_2 sensors shall have the ability to monitor and output the following variables as required by the systems sequence of operations:

a. Zone CO_2

3. The CO_2 shall transmit the information back to the controller via jumper selectable 0-20mA, 4-20mA & 0-10 VDC output signals:

a. The CO_2 sensors shall provide a maximum output current of 25mA; Maximum output voltage of 12.5V.

b. The CO_2 sensors shall be FCC compliant to CFR47 Part 15 subpart B Class A.

4. The CO_2 sensors shall be available with:

a. CO_2 response time (0-63%) of 1 minute

b. Less than 0.083% of full scale/°F temperature dependence of CO_2 output

c. Long term CO_2 stability ±5% of full scale for 5 years

d. CO_2 measurement accuracy of ±(40ppm + 2.0% of reading)

e. CO_2 non-linearity of less than 1.0% of full scale

5. The CO_2 sensors may include the following items:

a. Relay output module

b. LCD module

c. Analog temperature module with linear 0-10 VDC output for 32-122F

E. Differential Pressure Transmitters

1. General Air and Water Pressure Transmitter Requirements:

a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.

c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.

d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

2. Low Differential Water Pressure Applications (0” - 20” WC):

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

i. .01-20” WC input differential pressure range

ii. 4-20 mA output

iii. Maintain accuracy up to 20 to 1 ratio turndown

iv. Reference Accuracy: +0.2% of full span

c. Acceptable Manufacturers: Setra and Mamac.

3. Medium to High Differential Water Pressure Applications (Over 21” WC):

a. The differential pressure transmitter shall meet the low-pressure transmitter specifications with the following exceptions:

i. Differential pressure range 10” WC to 300 PSI

ii. Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability)

b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

c. Acceptable Manufacturers: Setra and Mamac.

4. Building Differential Air Pressure Applications (-1” to +1” WC):

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

i. -1.00 to +1.00 WC input differential pressure ranges. (Select range appropriate for system application)

ii. 4-20 mA output

iii. Maintain accuracy up to 20 to 1 ratio turndown

iv. Reference Accuracy: +0.2% of full span

v. Acceptable Manufacturers: Johnson Controls or approved equal

5. Low Differential Air Pressure Applications (0” to 2.5” WC):

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications.

i. (0.00 - 1.00” to 5.00”) WC input differential pressure ranges (select range appropriate for system application)

ii. 4-20 mA, 0-5 VDC, 0-10 VDC output

iii. Maintain accuracy up to 20/1 ratio turndown

iv. Reference Accuracy: +0.25%, or 0.5% of full span

c. Acceptable Manufacturers: Johnson Controls and Ruskin

6. Medium Differential Air Pressure Applications (5” to 21” WC):

a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements.

i. Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability

ii. Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 psig.)

iii. Thermal Effects: <+.033 F.S./Deg. F. over 40°F to 100°F (calibrated at 70°F.)

b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

c. Acceptable manufacturers: Johnson Controls and Ruskin

F. Flow Monitoring

1. Air Flow Monitoring

a. Fan Inlet Air Flow Measuring Stations

i. At the inlet of each fan and near the exit of the inlet sound trap, airflow sensors shall be provided that shall continuously monitor the fan air volumes or velocity pressure.

ii. Each sensor shall be surface mount type. Unit shall be capable of monitoring and reporting the airflow and temperature at each fan inlet location through two or four sensing circuits. If a static pressure manifold is used, it shall incorporate dual offset static tips on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as + 20° in the approaching air stream.

iii. Devices creating fan performance degradation, resulting in additional energy consumption, caused from pressure drop associated with probes or mounting apparatus in the center of the fan inlet are not allowed. The device shall not induce a significant pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Sensor circuit casings shall be constructed of U.L. 94 flame rated high impact ABS and include a stainless steel thermistor cap that maintains the precise calibrated flow over the heated and ambient measurement points.

iv. Acceptable manufacturers: Johnson Controls, Air Monitor Corp., Tek-Air Systems, Inc., or Dietrich Standard

b. Single Probe Air Flow Measuring Sensor

i. The single probe airflow-measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a thermal dispersion and utilize one temperature sensor and a heated thermistor. The sensor pair shall measure the air temperature and airflow velocity.

c. Duct Air Flow Measuring Stations

i. Furnish and install, at locations shown on plans or as in accordance with schedules, an equalized air measuring probe system piped to a high performance pressure transducer or an electronic type airflow temperature measuring station.

ii. Each device shall be designed and built in order to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.

iii. Assembly shall be AMCA tested and capable of measuring a range from 70 to 5,000 FPM (22 to 1524 MPM).

iv. Equalized air measuring assembly shall measure to ±3% average and consist of 6063T5 extruded aluminum step sensing blade(s) with anodized finish, plenum-rated polyethylene pressure tubing, brass barbed fittings, mounting hardware and a glass-on-silicone capacitance sensor pressure transducer capable of measuring up to five field-selectable pressure ranges up to 2.5 in. WC.

v. The transducer shall be accurate to ±0.5%, or 0.25% of full scale and be contained in a National Electrical Manufacturer's Association (NEMA) 4 (IP-65) enclosure. Transducer shall be factory mounted and piped to high and low pressure ports through fittings made of brass.

vi. All sensor tubing shall terminate in solid brass barbed fittings.

vii. Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be present on each unit casing, listing model number, size, area, and airflow capacity.

viii. Air straightener shall be provided for sizes over 17 square feet (1.6 sq meter).

ix. Airflow measuring station assemblies shall be fabricated of galvanized steel or aluminum casing of appropriate thickness for slip fits or with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 5000 feet per minute.

x. Equalized air measuring probe assemblies shall be, in all respects, equivalent to Johnson Controls® AD-1250 or AD-1251 airflow measuring systems.

xi. Electronic air measuring station shall be capable of monitoring and reporting the airflow and temperature at each measuring location through one or more measuring probes containing multiple sensor points and a control transmitter that outputs a 4-20 mA linear signal.

xii. Probe(s) shall be constructed of an airfoil shaped aluminum extrusion containing the sensor circuit(s).

xiii. Each sensor circuit shall consist of coated thermistors, for temperature and velocity, mounted to a Printed Circuit Board (PCB). Multiplexer board shall be encased to prevent moisture damage.

xiv. Shielded CAT5e communications cable shall be Underwriters Laboratories Inc.® (UL) plenum-rated with RJ45 terminal connectors. Dust boot covers and gold-plated contacts shall link probes to electronic controller.

xv. Control transmitter shall be capable of processing independent sensing points and shall operate on a fused 24 VAC supply.

xvi. Control transmitter shall feature a 16 x 2 character alphanumeric LCD screen, digital offset/gain adjustment, continuous performing sensor/transmitter diagnostics, and a visual alarm to detect malfunctions.

xvii. All electronic components of the assembly shall be Restriction of Hazardous Substances (RoHS) Directive compliant equal to Johnson Controls AD-1252.

xviii. Installation Considerations

- The maximum allowable pressure loss through the Flow and Static Pressure elements shall not exceed .04" WC at 1000 feet per minute, or .11" WC at 2000 feet per minute. Each unit shall measure the airflow rate within an accuracy of plus 3-5% as determined by AMCA.
- Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be 1.5 inches to facilitate matching connecting ductwork.
- Where control dampers are provided as part of the airflow measuring station, parallel blade precision controlled volume dampers integral to the station and complete with actuator, and linkage shall be provided.
- Stations shall be installed in strict accordance with the manufacturer's published requirements, and in accordance with ASME Guidelines affecting non-standard approach conditions.

xix. All air measuring devices shall be tested according to AMCA Standard 610.

xx. Acceptable manufacturers: Johnson Controls, Air Monitor Corp., Tek-Air, Ruskin, and Dietrich Standard.

d. Static Pressure Traverse Probe

i. Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.

ii. Acceptable manufacturers: Cleveland Controls

e. Shielded Static Air Probe

i. Where indicated on plans or in schedules a shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding.

f. Water Flow Monitoring

i. Water flow meters shall be electromagnetic type with integral microprocessor-Based electronics. The meter shall have an accuracy of 0.25%.

ii. Acceptable manufacturers: Onicon

G. Power Monitoring Devices

1. Current Measurement (amps)

a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.

b. Current Transformer – A split core current transformer shall be provided to monitor motor amps.

i. Operating frequency – 50 - 400 Hz

ii. Insulation – 0.6 Kv class 10Kv BIL

iii. UL recognized

iv. Five amp secondary

v. Select current range as appropriate for application

vi. Acceptable manufacturers: Setra

c. Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:

i. 6X input over amp rating for AC inrushes of up to 120 amps

ii. Manufactured to UL 1244

iii. Accuracy: +.5%, Ripple +1%

iv. Minimum load resistance 30kOhm

v. Input 0-20 amps

vi. Output 4-20 mA

vii. Transducer shall be powered by a 24 VDC regulated power supply (24 VDC +5%)

viii. Acceptable manufacturers: Setra

H. Refrigerant Leak Detectors

1. The refrigerant leak detector shall be a standalone device and shall provide SPDT switch contacts to directly energize the refrigeration room exhaust ventilation fans. The detector shall include a sensor or sensors connected to a control panel. Two relay contacts at the control panel shall provide trouble and alarm indication to the Facility Management System. The alarm relay contact shall also directly energize the exhaust fans.

2. The refrigerant leak detector shall sense the type of refrigerant used in the specified chillers. Multiple sensors shall be required to detect different refrigerants and/or provide proper sensing coverage for the area of the refrigeration room.

3. Acceptable manufacturers: Johnson Controls, MSA Instruments

I. Smoke Detectors

1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 26 for installation under Division 23. All wiring for air duct detectors shall be provided under Division 26, Fire Alarm System.

J. Status and Safety Switches

1. General Requirements

a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the Building Management System (BMS) when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. Current Sensing Switches

a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.

b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.

c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

d. Acceptable manufacturers: Johnson Controls or approved equal

3. Air Filter Status Switches

a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.

b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.

c. Provide appropriate scale range and differential adjustment for intended service.

d. Acceptable manufacturers: Johnson Controls, Cleveland Controls

4. Air Flow Switches

a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

b. Acceptable manufacturers: Johnson Controls, Cleveland Controls

5. Air Pressure Safety Switches

a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.

b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.

c. Acceptable manufacturers: Johnson Controls, Cleveland Controls

6. Water Flow Switches

a. Water flow switches shall be equal to the Johnson Controls P74.

7. Low Temperature Limit Switches

a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.

b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.

c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

d. The low temperature limit switch shall be equal to Johnson Controls A70.

K. Control Relays

1. Control Pilot Relays

a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.

b. Mounting Bases shall be snap-mount.

c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.

d. Contacts shall be rated for 10 amps at 120VAC.

e. Relays shall have an integral indicator light and check button.

f. Acceptable manufacturers: Johnson Controls, Lectro

2. Lighting Control Relays

a. Lighting control relays shall be latching with integral status contacts.

b. Contacts shall be rated for 20 amps at 277 VAC.

c. The coil shall be a split low-voltage coil that moves the line voltage contact armature to the On or Off latched position.

d. Lighting control relays shall be controlled by:

i. Pulsed Tristate Output – Preferred method

ii. Pulsed Paired Binary Outputs

iii. A Binary Input to the Facility Management System shall monitor integral status contacts on the lighting control relay. Relay status contacts shall be of the “dry-contact” type.

e. The relay shall be designed so that power outages do not result in a change-of-state, and so that multiple same state commands will simply maintain the commanded state. Example: Multiple Off command pulses shall simply keep the contacts in the Off position.

L. Electronic Signal Isolation Transducers

1. A signal isolation transducer shall be provided whenever an analog output signal from the BMS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.
2. The signal isolation transducer shall provide ground plane isolation between systems.
3. Signals shall provide optical isolation between systems.
4. Acceptable manufacturers: Advanced Control Technologies

M. Electronic/Pneumatic Transducers

1. Electronic to Pneumatic transducers shall provide:
   a. Output: 3-15 psig
   b. Input: 4-20 mA or 0-10 VDC
   c. Manual output adjustment
   d. Pressure gauge
   e. External replaceable supply air filter
2. Acceptable manufacturers: Johnson Controls, Mamac

N. Thermostats – Electric

1. Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer’s standard finish.
2. Acceptable Manufacturers: Penn, Emerson, Honeywell

23 09 13.33 Control Valves

A. Ball Valves, 1/2 through 2 in.

1. Ball Valves shall have forged brass bodies.
2. Valves shall have available either Chrome Plated Brass Balls or 300 Series Stainless Steel Balls in all sizes.
3. Valves shall have available either Nickel Plated Brass Stems or 300 Series Stainless Steel Stems with a blow-out proof stem design in all sizes.
4. Valves shall have Graphite reinforced Polytetrafluoroethylene (PTFE) seats with Ethylene Propylene Diene Monomer (EPDM) O-ring backing.
5. Stem seals shall be double EPDM O-rings.
6. Flow Characterization Disk shall be manufactured from Amodel AS-1145HS Polyphthalamide Resin and rated for 50 psi maximum differential pressure and shall be inserted against the casting of the valve.
7. All ball valves with internal pipe thread end connections shall be rated to 580 psi maximum static pressure at 203°F (95°C) fluid temperature.
8. All ball valves with sweat end connections or press end connection shall be rated to 300 psig maximum static pressure at 203°F (95°C) fluid temperature.
9. All valves shall be rated for service with hot water, chilled water and 50% glycol solutions.

10. Ball Valves with stainless steel balls and stems shall be rated for use with 15 psig saturated steam.
11. Flow Characteristics shall be equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
12. Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
13. Valves shall be maintenance free.
14. Valves shall be provided with a 5 year equipment warranty.
15. Valves shall be rated for 200 psi differential closeoff pressure.
16. Valve actuators shall be UL-recognized or CSA-certified.
17. Valves shall be Johnson Controls VG1000 Series ball valves or approved equal.

B. Ball Valves, ½ in. to 1 in. with integrated controller

1. Ball valves shall have forged brass bodies.
2. Valves shall be available in either chrome plated brass balls or 300 series stainless steel balls in all sizes. Note that the FX-PCV is currently only available with brass trim.
3. Valves shall be available in all sizes with either a nickel plated brass stems or 300 series steel stems with a blow-out proof stem design. Note that the FX-PCV is currently only available with brass trim.
4. Valves shall have graphite reinforced PTFE seats with EPDM O-ring backing.
5. Stem seals shall be double EPDM O-rings.
6. Flow characterization disks shall be manufactured from Amodel AS-1145HS Polypthalamide Resin and rated for 50 psid maximum differential pressure and shall be inserted against the casting of the valve. The valves shall be installed in any flow direction because of the non-directional disk design.
7. Flow characteristics shall be of equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
8. Valves with internal pipe thread end connections shall be rated to 580 psi maximum static pressure at 203°F (95°C) fluid temperature.
9. Valves with sweat end connections or press end connection shall be rated to 300 psig (kPa) maximum static pressure at 203°F (95°C) fluid temperature.
10. Valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
11. Ball valves with stainless steel balls and stems shall be rated for use with 15 psig (103 kPa) saturated steam. Note that the FX-PCV cannot be used for steam applications.
12. Ball valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70–2, Class 4 and 1% maximum flow, bypass port.
13. Ball valves shall be maintenance free.
14. Ball valves shall be provided with a 5 year warranty from the date of sale. Valves sold in the APAC region shall comply with an 18 month warranty policy.
15. Ball valves shall be rated for 200 psid (1,378 kPa) close off pressure.
16. Ball valves shall be UL–recognized or CSA-certified. APAC valves shall be excluded from this regulatory information.
17. Ball valves shall be Johnson Controls VG1000 Series Ball Valves or approved equal.

C. Ball valves ½ in. through 1 in with integrated controllers and actuators

The specifications apply to Ball valves ½ in. through 1 in. with integrated controller or actuators.

1. The actuator or controller shall provide both standalone and networked direct digital control of terminal units.

2. The actuator or controller shall be BACnet Testing Labs (BTL) listed/certified and carry the BTL Label.
3. The actuator or controller shall tested and certified as a BACnet Application Specific Controller (B-ASC).
4. A BACnet Protocol Implementation Conformance Statement shall be provided for the actuator or controller.
5. The actuator or controller shall communicates over the Field Controller Bus (FC Bus) using BACnet Standard protocol SSPC-135, Clause 9.
6. The actuator or controllers shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.
7. The actuator/controller shall be a configurable digital controller. All components shall be connected and mounted as a single assembly that can be removed as one piece. With ball valve linkage for use on the Johnson Controls VG-1000 1/2 inch to 1 inch valves.
8. The actuator or controller shall be assembled in a plenum-rated plastic housing with flammability rated to UL95-5VB or the controller is designed and suitable for use in other environmental air spaced (plenums) in accordance with Section 300.252© of the National Electrical Code.
9. Each controller shall continuously and adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. This shall reduce commissioning costs and eliminated the maintenance costs of manually re-tuning loops to compensate for load changes.
10. The controller shall provide the ability to download and upload configuration files, both locally and through the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
11. Control set point changes initiated over the network shall be written to the actuator or the controller's non-volatile memory to prevent the loss of set point changes and to prove consistent operation in the event of a communication failure.
12. The controller firmware shall be flash-upgradeable remotely through the communications bus to minimize the cost of feature enhancements.
13. Inputs:
    a. Analog inputs with user defined ranges shall monitor the following analog signals, with only the equipment in the terminal controller cabinet:
        i. 0 VDC to10 VDC Sensors
        ii. 1000 ohm RTDs
        iii. NTC Thermistors
    b. Binary inputs shall monitor dry contact closures. Filtering shall eliminate false signals resulting from input 'bouncing'.
    c. The inputs shall be isolated from power, communications, and output circuits for noise immunity.
    d. Provide side loop application for humidity control.
14. Outputs:
    a. Analog output shall provide a 0 VDC to 10 VDC control output.
    b. Binary outputs shall provide a SPST Triac output rated for 500 mA at 24 VAC.
    c. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.
15. The actuator or controller shall be configured with a software tool that provides a question and answer format for developing and downloading applications.
16. Sensor support:
    a. The actuator or controller shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.

b. The actuator or controller shall support an LCD display room sensor.

c. The actuator or controllers shall support standard room sensors as defined by analog input requirements.

d. The actuator or controllers shall support humidity sensors defined by the AI side loop.

D. Ball Valves, 2 in. to ½ .in through 4 in. Flanged

1. Ball valves shall have forged brass bodies with ASME Class 150 ductile iron flanges.
2. Valves shall be manufactured from 300 series stainless steel balls and the flanges shall rotate independently until tightened down which is an advantage during installation.
3. Valves shall have 300 series steel stems with a blow-out proof stem design.
4. Stem seals shall have double EPDM O-rings.
5. Valves have graphite reinforced PTFE seats with EPDM O-ring backing.
6. Flow characterization disk shall be manufactured from Amodel AS-1145HS Polypthalamide Resin and rated for 50 psid maximum differential pressure.
7. Flow characteristics shall be of equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
8. Valves shall be rated for service with hot water, chilled water and 50% glycol solutions and are rated for use with 25 psig (kPa) saturated steam.
9. Two-way valves shall be rated for 100 psid close off pressure and three-way valves shall be rated for maximum of 50 psid close off pressure.
10. Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
11. Valves shall be maintenance free.
12. Valves shall be provided with a 5 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
13. Valves shall be CE marked as Johnson Controls declares these valves are in compliance with essential requirements and other relevant provisions of the Pressure Equipment Directive (PED). APAC actuators shall be excluded from this regulatory information.
14. Valves shall be Johnson Controls VG1000 Series ball valves or approved equal.

E. Six-Way Control Ball Valves, ½ in. and ¾ in.

1. Six-way valves shall have forged brass bodies which comply with PN16 (300 psi) static pressure rating.
2. Valves shall have chrome plated brass balls.
3. Valves shall have nickel plated brass stems which include a blow-out proof stem.
4. Valves shall have graphite reinforced PTFE seats with EPDM O-ring backing.
5. Stem seals shall be double EPDM O-rings. All seals shall combine to provide a completely leak-free sealing system. The packing shall be laboratory tested and proven leak-free after 100,000 cycles in iron-oxide contaminated water test of a minimum 900ppm.
6. Valves shall be available in female NPT, sweat connection and British Standard Pipe Parallel (BSPP).
7. Valves shall be capable of 3.8Cv (3.3Kv) for ½ in. series and 7.4Cv (6.3Kv) for ¾ in. series.
8. Flow characterization disks shall be manufactured from Amodel AS-1145HS Polypthalamide Resin and rated for 50 psid maximum differential pressure and shall be inserted against the casting of the six-way valve.
9. Flow characteristics shall be of equal percentage on the control port. Bypass port on three-way six-way valves shall have linear flow characteristics.

10. All ball valves with internal pipe thread end connections shall be rated to 580 psi maximum static pressure at 230°F (95°C) fluid temperature.
11. Six-way valves with sweat end connections or press end connection shall be rated to 300 psig (kPa) maximum static pressure at 203°F (95°F) fluid temperature.
12. All six-way valves shall be rated for service with hot water, chilled water and 50% glycol solutions. Six-way valves shall be field supplied with Cv (Kv) control flow disks. This provides the right flow rate for a wide range of applications.
13. Six-way valve bodies shall be designed to regulate media flow which utilizes 270° of rotation with a true close-off feature. It is internal to the valve and isolates source 1 of the circuit from source 2 of the circuit. This shall provide the most efficient way of transition between both hot and chilled water in response to the demand of a controller in HVAC systems.
14. Valves shall be rated for 50 psid close off pressure.
15. Six-way valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
16. Six-way valves shall be maintenance free.
17. Six-way valves shall be provided with a 5 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
18. Valves shall be Johnson Controls VG1600 Series ball valves or approved equal.

F. Six-Way Valves with 270° rotary proportional Non-Spring Return Actuator VA9905-KGA-2

1. The coupling between the valve and actuator shall be designed as a convenient mounting system in order to ensure quick installation reducing the risk of installation errors.
2. The actuator shall be configured for multi-input control using either 0V to 10V or 2V to 10V or 0(4)mA to 20mA with field furnished 500 ohm ¼ W resistor and shall be configurable, programmed or work with conventional equipment controllers and thermostats. This is important for improved control and precision.
3. Dual voltage control, thermostat control, and single analog control.
4. The actuator shall utilize a microprocessor-controller brushless DC motor which provides constant runtime independent of torque and increases the lifecycle by reducing water.
5. The actuator shall not produce audible noise greater than 35 dBA at 1 m (39 to 13/32 in.).
6. The actuator shall utilize mode configuration switch which permits calibration of input signal range selection.
7. Installation and wiring shall be simplified by the integral cables with colored and numbered conductors.
8. The 270° six-way control valve shall be furnished with an internal pressure relief system which is designed to prevent any damage in the terminal unit circuit. The valve and actuator shall work as follows:
    a. When the valve is in close position, for both cooling and heating operating modes, the trapped fluid may vary its pressure due to changes in ambient temperature.
    b. The pressure compensation system relieves such pressure changes.
    c. The actuator has the capability to be wired directly to a building management controller by analog wiring or directly wired to a 24 VAC thermostat.
    d. In order to connect the terminal unit circuit with either the sequence 1 or 2 circuit (expansion vessel), the design of the upper valve means there is no gasket required, while the lower valve provides a true close off.
    e. When the valve is in closed position the water flows inside the upper ball, entering the inlet of the terminal unit because there is no gasket for prevention.
9. The actuator shall utilize mode configuration switch which can permit calibration of input signal range selection.

10. The actuator shall have the option of an integral ½ in. (13mm) threaded conduit connector's option for improved installation and field wiring.
11. The actuator shall include a position indicator handle and manual override which allows intuitive indication of valve position and manual shut off.
12. The actuator shall have a small footprint making application is smaller spaces easier.
13. The actuator shall pass laboratory test of 100,000 cycles and 2.5 million repositions to ensure reliability over time.
14. The valves shall carry a 5 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
15. The actuator shall be NEMA/IP54 Enclosure standards which enhances the range of application environments.
16. The NSR Actuators shall be offered in a plenum-rated model which enables use in other environmental air spaces(plenums) in accordance with 300.22 © of the National Electric Code.
17. The valves and actuator shall comply with the Underwriters Laboratories Inc. © (UL), CE Mark, and RCM Compliance which provide internationally recognized regulatory agency approvals. APAC actuators and valves shall be excluded from this regulatory information.
18. The actuator shall be manufactured under International Standards Organization (ISO) 9001 Quality Control Standards to ensure quality.
19. The actuators shall be Johnson Controls 9905 actuators or approved equal.

G. Butterfly Valves, 2 through 20 in. resilient seat ASME Class 125/150 Flanged

1. Butterfly valves shall have cast iron bodies meetings ASTM A126 Class B requirements, meet ASME class 125/150 flange requirements and shall be fully lugged.
2. Valves seats shall be EPDM.
3. Valves disks shall be ductile iron with Nylon 11 coating.
4. Valves stems shall be stainless steel.
5. Flow characteristics shall be of equal percentage up to 70 degrees of disk rotation.
6. Valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
7. Valves shall be maintenance free.
8. Valves shall be provided with a 3 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
9. Valves shall be UL-recognized and CSA-certified. Valves sold in the APAC region shall be excluded from this regulatory information.
10. Valves shall be Johnson Controls VF series butterfly valves or approved equal.

H. Butterfly Valves, High Performance 2-1/2 through 16 in.

1. Butterfly valve shall have bodies manufactured from carbon steel, ASTM A216 GR WCB/A516 GR 70 and shall be fully lugged per ASME Class 150 or ASME Class 300.
2. Valve seat assemblies shall be RPTFE (reinforced polytetrafluorethylene) and the seat retainer shall be carbon steel, ASTM A516 GR 70.
3. Valve disks shall be stainless steel, ASTM A 351 GR CF8M.
4. Valve stems shall be 17-4 PH stainless steel, ASTM A564-Type 630.
5. Stem seals shall be one carbon fiber ring and three TFE rings.
6. Flow characteristics shall be equal percentage up to 70° of disk rotation.
7. Valves shall be rated for service with hot water, chilled water, 50% glycol solutions and 50 psig (kPa) saturated steam in modulating service or 150 psig (kPa) saturated steam in two position service.

8. Valves shall meet the performance requirements of the ASMA Class 150 and Class 300.
9. Valves shall be maintenance free.
10. Valves shall be provided with a 3 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
11. Valves shall be UL–recognized or CSA-certified. APAC valves shall be excluded from this regulatory information.
12. Valves shall be Johnson Controls VF Series Butterfly Valves or approved equal.

I. Globe Valves, Brass, 1/2 through 2 in.

1. Globe valve stems shall be manufactured from 300 series stainless steel.
2. Valves with brass plugs and seats shall have stem seals with self-adjusting Ethylene Propylene Rubber (EPR) Ring Pack U-Cups.
3. Valves with stainless steel plugs and seats shall have valve stem seals with spring loaded PTFE and Elastomer V-Rings.
4. Flow characteristics shall be of equal percentage for two-way valves and linear for three-way valves.
5. Valves shall meet the pressure and temperature requirements of ANSI B16.15, Class 250.
6. Valves with brass trim shall have a maximum leakage specification of 0.01% of maximum flow per ANSI/FCI 70-2, Class 4.
7. Valves with stainless steel trims shall have a maximum leakage of 0.05% of maximum flow.
8. Valves shall be serviceable without being removed from the pipe.
9. Valves shall be provided with a 3 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
10. Valve bodies shall be manufactured from a RoHS compliant brass.
11. Valves electric actuators shall be UL-recognized or CSA-certified. APAC valves shall be excluded from this regulatory information.
12. Globe valves shall be Johnson Controls VG7000 Series Globe Valves or an approved equal.

J. Globe Valves, Cast Iron, 2-1/2 through 6 in.

1. Globe valve bodies shall be manufactured from cast iron.
2. Valve stems shall be manufactured from 316 series stainless steel.
3. Valves shall have stem seals with Ethylene Propylene Terpolymer (EPT) Ring Pack U-Cups.
4. Flow characteristics shall be equal modified linear.
5. Valves shall meet the pressure and temperature requirements of ANSI B16.15, Class 125.
6. Valves shall have a maximum leakage specification of 0.01% of maximum flow per ANSI/FCI 70-2, Class 3.
7. Valves shall be serviceable without being removed from the pipe.
8. Valves shall be provided with a 3 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
9. Valve electric actuators shall be UL-recognized or CSA-certified. APAC valves shall be excluded from this regulatory information.

K. Valves Electric Zone Valves, 1/2 through 1-1/4 in.

1. Electric zone valves shall have bodies manufactured from forged brass.
2. Valve stems shall be manufactured from hard chrome plated brass.
3. Modulating valves flow characteristics shall be of equal percentage.

4. Valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
5. Two position valves shall have models available rated for use with 15 psig saturated steam.
6. Valves shall be replaceable without being removed from the pipe.
7. Valves are provided with a 2 year warranty. Valves sold in the APAC region comply shall with an 18 month warranty policy.
8. Valves shall be UL, cUL listed or CSA certified. APAC valves shall be excluded from this regulatory information.
9. Valves shall be Johnson Controls J Series electric zone valves or an approved equal.

Pressure-Independent Valves

A. Pressure-Independent Ball Valves NPS 2 in. (DN 50) and smaller

1. Pressure-Independent Ball Valves shall have bodies manufactured from Dezincification resistant (DZR) forged brass, or cast iron.
2. Valves balls shall be manufactured from chrome plated-brass.
3. Valve ball seats shall be manufactured from PTFE.
4. Valves stem seal shall be PTFE packing ring stem seals with EPDM.
5. Valves stem and stem extensions shall be manufactured from brass with a blowout-proof design.
6. Pressure-independent ball valves shall have a pressure rating of 360 psig (2482 kPa) for NPS 1/2 to 1-1/4 (DN 15 to 32) and 230 psig (1585 kPa) for NPS 1-1/2 to NPS 2 (DN 38 to DN 50).
7. Valves shall have a close-off pressure of 200 psig (1379 kPa).
8. Valves shall have a fluid temperature limit of 14°F to 248 °F (-10°C to 120 °C), Not Rated for Steam Service.
9. The maximum actuator fluid temperature limit shall be 14°F to 212°F (-10°C to 100°C) which is not the rate for steam service.
10. Valves shall have an accuracy of +/-5% up to 15psid.
11. Valves flow characteristics shall be of equal percentage with a characterized profile laser cut which is directly into the ball.
12. Valves shall have a maximum leakage in accordance with the ANSI Class IV IEC 60534-4, Class IV Leakage.
13. Valves shall have an integral pressure regulator to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 psig to 58 psig (34 kPa to 400 kPa).
14. Valves shall have a pressure regulator which is removable and replaceable from the valve body NPS ½ .in to 1 .in to 1/4 .in (DN 15 to DN 32).
15. Valves shall have a threaded NPT connections.
16. Two pressure testing (P/T) ports shall be incorporated into the valve body for differential pressure verification.
17. Valves and actuators shall be supplied as an assembly.
18. Valves and actuators shall be provided with a 5 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
19. Pressure-Independent Ball Valves shall be Johnson Controls VP140 Series pressure independent valves or an approved equal.

B. Pressure-Independent Globe Valves NPS ½ in. to ¾ .in (DN 15-20)

1. Pressure-Independent Globe Valves bodies shall be manufactured from DZR forged brass.
2. Valves shall have a pressure rating of 360 psig (2482 kPa).

3. Valves shall have a close-off pressure of 100 psig (700 kPa).
4. Valves fluid temperature limit shall be 14°F to 248°F (-10°C to 120°C) which is not rated for steam service.
5. Valves accuracy shall be +/-5% up to 15 psid.
6. Valves flow characteristic shall be inherently linear and capable of equi- percentage with actuator.
7. Valves shall have a maximum leakage in accordance with ANSI Class IV IEC 60534-4, Class IV Leakage.
8. Valves shall have an integral pressure regulator to regulate pressure to maintain a constant pressure differential while operating within a pressure differential range of 5 psig to 87 psig (34 kPa to 600 kPa). Pressure regulator shall be serviceable/ replaceable without special tools.
9. Valves dirt free design shall allow the valve to pass strife contaminated water tests of 100,000 cycles at 900ppm iron oxide.
10. Valves shall have a threaded NPT connections.
11. Two P/T ports shall be incorporated into the valve body for differential pressure verification.
12. Valves pre-set function shall be adjustable for max flow without special tools.
13. Valves and actuators shall be supplied as an assembly, the single actuator shall be capable of:
    - Auto calibration
    - Linear and equi-percentage control curve
    - VDC or mA control signal, with selection of control signal to be either 0 VDC to 10 VDC, 2 VDC to 10 VDC, 0 VDC to 5 VDC, 5 VDC to 10 VDC, 0 mA to 20 mA, 4 mA to 20 mA
    - LED feedback indication to indicate moving to position, end of stroke confirmation position reached, cycling and loss of signal
14. Pressure-independent globe valves and actuators shall be provided with a 5 year warranty.
15. All valves shall be Johnson Controls VP140 Series pressure independent valves or an approved equal.

C. Pressure-Independent Ball Valves NPS ½ in. through 1 in. to 1/4 .in with integrated controller

1. Pressure-Independent Ball Valves shall have bodies manufactured from DZR forged brass, or cast iron.
2. Valve Balls shall be chrome-plated brass.
3. Valve stems and stem extensions shall be brass, blowout-proof design.
4. Valve ball seats shall be PTFE.
5. Valves stem seal shall be PTFE packing ring stem seals with EPDM.
6. Valves shall have a threaded NPT connections.
7. Valves shall have a pressure rating of 360 psig (2482 kPa) for NPS ½ in. through 1 in. to ¼ in. (DN 15 to 32).
8. Valves close off pressure shall be 200 psig (1370 kPa).
9. Valves fluid temperature limits shall be 14°F to 248°F (-10°C to 120°C) which is not rated for steam service.
10. Valves maximum actuator fluid temperature limits shall be 14°F to 212°F (-10°C to 100°C) which is not rated for steam service.
11. Valves accuracy shall be +/- 5% up to 15 psid.
12. Valves flow characteristic shall be of equal percentage with characterized profile laser cut directly into the ball.
13. Valves maximum leakage shall be in accordance with the ANSI Class IV IEC 60534-4, American National Standards Institute (ANSI) Class IV Leakage.

14. Valves Integral pressure regulator shall be designed to regulate pressure and to maintain a constant pressure differential while operating within a pressure differential range of 5 psig to 58 psig (34 kPa to 400 kPa).
15. Valves pressure regulators shall be removable or replaceable from the valve body from NPS ½ in. through 1 in. to ¼ in. (DN 15 to DN 32).
16. Two P/T ports shall be incorporated into the valve bodies for differential pressure verification.
17. Valves and actuators shall be provided with a 5 year warranty. Valves sold in the APAC region shall comply with an 18 month warranty policy.
18. All valves shall be Johnson Controls VP140 Series pressure independent valves or an approved equal.

D. Pressure-Independent Ball Valves NPS ½ in. through 1 in. to 1/4 in. with integrated controller

1. The specifications apply to Pressure-Independent Ball valves ½ in. through 1 in. to ¼ in. with integrated controller or actuators.
2. The actuator or controller shall provide both standalone and networked direct digital control of terminal units.
3. The actuator or controller shall be BACnet Testing Labs (BTL) listed/certified and carry the BTL Label.
4. The actuator or controller shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
5. A BACnet Protocol Implementation Conformance Statement shall be provided for the actuator or controller.
6. The actuator or controller shall communicate over the Field Controller Bus (FC Bus) using BACnet Standard protocol SSPC-135, Clause 9.
7. The actuator or controllers shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.
8. The actuator or controller shall be a configurable digital controller. Connecting and mounting all the components as a single assembly, enabling the component to be removed as one piece. With ball valve linkage for use on the Johnson Control VP140 ½ in. through 1.in to ¼ in. valves.
9. The actuator or controller shall be assembled in a plenum-rated plastic housing with flammability rated to UL95-5VB or the controller is designed and suitable for use in other environmental air spaced (plenums) in accordance with Section 300.252© of the National Electrical Code.
10. All controllers shall continuously and adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. This shall reduce commissioning costs and eliminated the maintenance costs of manually re-tuning loops to compensate for load changes.
11. The controller shall provide the ability to download and upload configuration files, both locally and through the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
12. Control set point changes initiated over the network shall be written to the actuator or the controller's non-volatile memory to prevent the loss of set point changes and to prove consistent operation in the event of a communication failure.
13. The controller firmware shall be flash-upgradeable remotely through the communications bus to minimize the cost of feature enhancements.
14. Inputs:
    a. Analog inputs with user defined ranges shall monitor the following analog signals, with only the equipment in the terminal controller cabinet:
        i. 0 VDC to 10 VDC Sensors
        ii. 1000 ohm RTDs
        iii. NTC Thermistors

b. Binary inputs shall monitor dry contact closures. Filtering eliminates false signals resulting from input 'bouncing'.

c. The inputs shall be isolated from power, communications, and output circuits for noise immunity.

d. Humidity control shall be provided by side loop applications.

15. Outputs:

a. Analog output shall provide a 0 VDC to 10 VDC control output.

b. Binary outputs shall provide a SPST Triac output rated for 500 mA at 24 VAC.

c. The inputs shall be isolated from power, communications, and output circuits for noise immunity.

16. The actuator or controller shall be configured with a software tool which provides a question and answers format for developing and downloading applications.

17. Sensor support:

a. The actuator or controller shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.

b. The actuator or controllers shall support an LCD display room sensor.

c. The actuator or controllers shall support standard room sensors as defined by analog input requirements.

d. The actuator or controllers shall support humidity sensors defined by the AI side loop.

E. Piping packages

1. Piping packages shall be supplied with control valve and actuator assembly packs.

2. Piping packages assemblies shall be factory leak tested at 100 psi for 24 hours.

3. Piping packages shall include pressure gages.

4. Piping packages shall be pressurized at 40 psi with pressure gages reflecting internal pressure of assembly.

23 09 13.43 Control Dampers

A. The BMS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor or as specifically indicated on the drawings.

B. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.

C. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

D. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" WC static pressure when tested in accordance with AMCA Std. 500.

Note: Download Control Damper Guide Specs as required and add content.

E. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" WC, but no more than 4000 FPM or 6" WC.

1. Acceptable manufacturers are Johnson Controls VD-1250, VD1630, or VD-1330, Ruskin CD50 or CD60, and Vent Products 5650.

F. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below.

1. Acceptable manufacturers: Johnson Controls VD-1620, VD-1320, Ruskin CD36, and Vent Products 5800.

G. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

23 09 23 Direct-Digital Control System for HVAC/Building Management System

Part 1 – General

Related Documents

1. All work of this Division shall be coordinated and provided by the single BMS Contractor.
2. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the applicable sections for details.
3. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.
4. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

Definitions

1. Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.
2. Binary: A two-state system where an “on” condition is represented by one discrete signal level and an “Off” condition is represented by a second discrete signal level.
3. BMS: The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BMS Contractor and to be interfaced to the associated work of other related trades.
4. BMS Contractor: The single Contractor to provide the work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BMS work.
5. Control Sequence: A BMS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.
6. Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BMS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.
7. BMS Network: The total digital on-line real-time interconnected configuration of BMS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.
8. Node: A digitally programmable entity existing on the BMS network.
9. BMS Integration: The complete functional and operational interconnection and interfacing of all BMS work elements and nodes in compliance with all applicable codes, standards and ordinances to provide a single coherent BMS as required by this Division.
10. Provide: The term “Provide” and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.
11. PC: Personal Computer from a recognized major manufacturer or a virtual equivalent provided by, or with the consent of the owner.

12. Furnish: The term “Furnish” and its derivatives when used in this Division shall mean supply at the BMS Contractor’s expense to the designated third party trade contractor for installation. BMS Contractor shall connect furnished items to the BMS, calibrate, test, commission, warrant and document.
13. Wiring: The term “Wiring” and its derivatives when used in this Division shall mean provide the BMS wiring and terminations.
14. Install: The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.
15. Protocol: The term “protocol” and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BMS network nodes.
16. Software: The term “software” and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BMS industry for real-time, on-line, integrated BMS configurations.
17. The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.
18. Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.
19. The following abbreviations and acronyms may be used in describing the work of this Division:

AHJ	Authority Having Jurisdiction
AI	Analog Input
AO	Analog Output
AWG	American Wire Gauge
BTL	BACnet® Testing Laboratories
CPU	Central Processing Unit
DDC	Direct Digital Control
DI	Digital Input
DO	Digital Output
EEPROM	Electronically Erasable Programmable Read Only Memory
EMI	Electromagnetic Interference
HD	High Definition
HOA	Hand-Off-Auto
I/O	Input/Output
IT	Information Technology
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCC	Motor Control Center
NC	Normally Closed
NO	Normally Open
OAT	Outdoor Air Temperature
OEM	Original Equipment Manufacturer (Private label)

OWS	Operator Workstation
PC	Personal Computer
ppm	parts per million
RAM	Random Access Memory
RF	Radio Frequency
RFI	Radio Frequency Interference
RH	Relative Humidity
ROM	Read Only Memory
RTD	Resistance Temperature Device
TCP/IP	Transmission Control Protocol/Internet Protocol
UPS	Uninterruptible Power Supply
VAC	Volts, Alternating Current
VAV	Variable Air Volume
VDC	Volts, Direct Current
VPN	Virtual Private Network
VSD	Variable Speed Drive
WAN	Wide Area Network

BMS System Description

1. The BMS shall be a complete system designed for use with the enterprise IT systems. This functionality shall extend into the equipment rooms. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.
2. Any and all components of the BMS that are connected via field bus or IP network, including the network controllers, equipment controllers, application specific controllers, server and user interface software, system and controller programming tools and software applications shall be designed, engineered, and tested to work together as a complete building management system, and shall be manufactured by the same BMS manufacturer.
3. BMS system architecture shall support integration of third party devices using industry accepted protocols such as BACnet, LonWorks, and MODBUS.
4. All points of user interface shall be on standard computing devices that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these devices will be a standard Web Browser.

   Note: Item 4 is only applicable on systems with extensive data storage or simultaneous user access requirements
5. Where necessary and as dictated elsewhere in these Specifications, Servers shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions.
6. The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.
7. The BMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services,

permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.

8. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:
    a. Operator information, alarm management and control functions
    b. Information management including monitoring, transmission, archiving, retrieval, and reporting functions
    c. Diagnostic monitoring and reporting of BMS functions
    d. Energy management
    e. Standard applications for terminal HVAC systems
    f. Enterprise-wide information and control access
    g. Offsite monitoring and management access

    Note: Include/edit items h as required for the specific project

    h. [Indoor Air Quality monitoring and control]

Quality Assurance

1. General
    a. The contractor shall be a controls contractor who meets one of the following criteria:
        i. The BMS Contractor shall be a recognized national manufacturer, installer, and service provider of BMS.
        ii. Purchases through an authorized BMS distributor of the manufacturer and has been properly trained as an "Authorized Systems" contractor or installer through a qualified program supported and endorsed by the BMS manufacturer. Proof of such shall be submitted prior to the award of any contract or notice to proceed.
    b. BMS Contractors whether having a direct or indirect authorized relationship with the BMS manufacturer shall provide documentation that this relationship is current and in good standing with the BMS manufacturer prior to any contracts being awarded. The BMS Contractor shall also provide the name and contact information of the manufacturer's individual responsible for managing the distribution of their BMS products, for the owner and/or engineer's benefit.
    c. In order to protect the rights of the owner for future service, repairs, &/or additional work, the BMS Contractor shall submit a letter from the BMS manufacturer stating that they are not the "exclusive" representative of this manufacturer. The owner does not intend to be "locked in" to one representative. In order to provide the owner with the choice of who they do business with for work and/or services on this system after the scope of work detailed in this specification has been completed, any BMS manufacturer that provides "exclusive" geographic agreements with only one (1) BMS Contractor or rep in this area, shall not be an acceptable.
    d. The owner requires that there is at least three (3) BMS Contractors servicing this geography that meet the above criteria for the BMS Manufacturer in order for the manufacturer to be accepted.
    e. The BMS Contractor shall have a facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis. The BMS Contractor shall have at this facility factory trained, directly employed and full-time technical staff, spare parts inventory, and all necessary test and diagnostic equipment.
    f. As evidence and assurance of the BMS Contractor's ability to support the owner's system with service and parts, the BMS Contractor must have been in the BMS business for at least the last five (5) years and have successfully completed at least 3 projects of comparable value of this contract in the preceding five years.

g. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.

2. Workplace Safety and Hazardous Materials

a. Provide a safety program in compliance with the Contract Documents.

b. The BMS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.

c. The Contractor and its employees and subtrades shall comply with federal, state and local safety regulations.

d. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA rules that have jurisdiction for at least each topic listed in the Safety Certification Manual.

e. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.

f. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.

g. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractor’s company is in full compliance with the Project safety requirements.

h. The Contractor’s safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the AHJ at the Project site.

i. The Contractor’s employees and subcontractor’s staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

3. Quality Management Program

a. Designate a competent and experienced employee to provide BMS Project Management. The designated Project Owner shall be empowered to make technical, scheduling and related decisions on behalf of the BMS Contractor. At minimum, the Project Owner shall:

- Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
- Manage the financial aspects of the BMS Contract.
- Coordinate as necessary with other trades.
- Be responsible for the work and actions of the BMS workforce on site.

References

1. All work shall conform to the following Codes and Standards, as applicable:

a. National Fire Protection Association (NFPA) Standards

b. National Electric Code (NEC) and applicable local Electric Code

c. UL listing and labels

d. UL 864 10th Edition UUKL Smoke Control (for USA and Canada)

e. UL 268 Smoke Detectors

f. UL 916 Energy Management

g. NFPA 70 – National Electrical Code

h. NFPA 90A – Standard For The Installation Of Air Conditioning And Ventilating Systems

i. NFPA 92A and 92B Smoke Purge/Control Equipment

j. Factory Mutual (FM)

k. American National Standards Institute (ANSI)
l. National Electric Manufacturer's Association (NEMA)
m. American Society of Mechanical Engineers (ASME)

Note: add ASHRAE 62 IAQ as applicable below.

n. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
o. Air Movement and Control Association (AMCA)
p. Institute of Electrical and Electronic Engineers (IEEE)
q. American Standard Code for Information Interchange (ASCII)
r. Electronics Industries Association (EIA)
s. Occupational Safety and Health Administration (OSHA)
t. American Society for Testing and Materials (ASTM)
u. Federal Communications Commission (FCC) including Part 15, RF Devices
v. Americans Disability Act (ADA)
w. ANSI/EIA 909.1-A-1999 (LonWorks®)
x. ANSI/ASHRAE Standard 195 (BACnet)

Note: add ASHRAE 62 IAQ as applicable

2. In the case of conflicts or discrepancies, the more stringent regulation shall apply.
3. All work shall meet the approval of the Authorities Having Jurisdiction at the project site.

Work By Others

1. The demarcation of work and responsibilities between the BMS Contractor and other related trades shall be as outlined in the BMS RESPONSIBILITY MATRIX.

Note: Include responsibility matrix as required for project coordination and common practice of the specifier.

BMS Responsibility Matrix

Work	Furnish	Install	Low Volt. Wiring/Tube	Line Power
BMS low voltage and communication wiring *[1] (note 1)	BMS	BMS	BMS	N/A
VAV box controller (note 2)	BMS	23*[2]	BMS	26
BMS conduits and raceway	BMS	BMS	BMS	BMS
Automatic dampers (non-factory)	BMS	23	N/A	N/A
Automatic valves	BMS	23	BMS	N/A
VAV boxes	23	23	N/A	N/A
Pipe insertion devices and taps including thermowells, flow and pressure stations.	BMS	23	BMS	BMS
BMS Current Switches.	BMS	BMS	BMS	N/A
BMS Control Relays	BMS	BMS	BMS	N/A
Power distribution system monitoring interfaces	26	26	BMS	26
Concrete and/or inertia equipment pads and seismic bracing	23	23	N/A	N/A

Work	Furnish	Install	Low Volt. Wiring/Tube	Line Power
BMS interface with Chiller controls	BMS	BMS	BMS	BMS
Chiller controls interface with BMS	23	23	BMS	26
Elect. baseboard heating control (note 3)	23	26*3	N/A*3	26
ADD OTHER THIRD PARTY EQUIPMENT HERE	N/A	N/A	N/A	N/A
All BMS Nodes, equipment, housings, enclosures and panels.	BMS	BMS	BMS	BMS
Smoke Detectors (note 4)	26	26	26/BMS *4	26
Fire/Smoke Dampers (note 5)	23	23	BMS*5	26
Fire Dampers	23	23	N/A	N/A
Chiller Flow Switches	23	23	BMS	N/A
Boiler wiring	23	23	23	23
Water treatment system	23	23	23	26
VSDs	BMS	26	BMS	26
Refrigerant monitors	BMS	BMS	BMS	26
Computer Room A/C Unit field-mounted controls	23	23	BMS	26
Fire Alarm shutdown relay interlock wiring	26	26	26	26
Fire Alarm smoke control relay interlock wiring	26	26	BMS	26
Fireman's Smoke Control Override Panel	26	26	26	26
Fan Coil Unit controls	BMS	BMS	BMS	26
Cabinet/Unit Heater controls (note 6)	BMS/23*6	26/BMS*6	BMS	26
Packaged RTU space mounted controls	23	BMS	BMS	26
Packaged RTU factory-mounted controls	23	23	BMS	26
Packaged RTU field-mounted controls	BMS	BMS	BMS	26
Cooling Tower Vibration Switches	23	23	26	26
Cooling Tower Level Control Devices	23	23	26	26
Cooling Tower makeup water control devices	23	23	26	26
Starters, HOA switches	26	26	N/A	26
Control damper actuators	BMS	BMS	BMS	26

Footnotes:

*1. BMS low voltage and communications wiring: BMS Ethernet communications cable and IP infrastructure furnish and install by BMS Contractor or Division 26 Electrical Contractor as per options in Row #1 of the BMS Responsibility Matrix above.

*2. VAV box controller factory installation would normally be by Division 23 Mechanical who furnishes the VAV boxes; could be by BMS for field installation of special controllers, see Row #2 of the BMS Responsibility Matrix above.

*3. Electric Baseboard Heating Controls – for line voltage stand-alone controls: furnished by Division 23 Mechanical Contractor who furnishes the baseboard units; line voltage controls installed and connected by Division 26 Electrical Contractor. Alternately, controls may be furnished and installed by BMS Contractors for projects requiring Baseboard Heating controls to be integrated into the BMS. Refer to Section 230993 SEQUENCE OF OPERATIONS.

*4. Smoke Detector also wired to shut down AHU/HVAC by BMS Contractor; Division 26 for projects NYC. Duct smoke detectors and fire alarm control modules shall be provided by others. Provide wiring, conduit, and necessary interface with fire alarm system to perform specified sequence of operation

*5. Fire/Smoke Dampers: BMS Contractor to provide and ensure OPEN/CLOSE control of Fire/Smoke dampers as coordinated between BMS HVAC systems sequences, controls and overrides, and the Fire Alarm system control status priorities and overrides. Coordinate with Division 26 to provide duct detectors or fire alarm control modules for air handling unit and exhaust system shutdown and smoke control inputs to the DDC system. In most cases fire alarm control modules will be the most effective and flexible way of achieving this interface. Ensure that the logic matrix for the fire alarm devices to trigger a HVAC response is clearly specified.

*6. Cabinet/Unit Heater Controls – for line voltage stand-alone controls: furnished by Division 23 Mechanical Contractor who furnishes the Cabinet/Unit Heaters; line voltage stand-alone controls installed and connected by Division 26 Electrical Contractor. Even for stand-alone controls, it is common for the line voltage TStat and associated interlock wiring to be installed by the BAS. The power to the UH/CUH is performed by the Division 26 contractor. Alternately, controls may be furnished and installed by BMS Contractors for projects requiring Cabinet/Unit Heater controls to be integrated into BMS. Refer to Section 230993 SEQUENCE OF OPERATIONS.

Submittals

1. Shop Drawings, Product Data, and Samples
   a. The BMS contractor shall submit a list of all shop drawings with submittals dates within 30 days of contract award.
   b. Submittals shall be in defined packages. Each package shall be complete, shall only reference itself, and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.
   c. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BMS work.
   d. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.
   e. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
   f. The BMS Contractor shall correct any errors or omissions noted in the first review.
   g. At a minimum, submit the following:
      - BMS network architecture diagrams including all nodes and interconnections
      - Systems schematics, sequences, and flow diagrams
      - Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address
      - Samples of Graphic Display screen types and associated menus
      - Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features
      - Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type
      - Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
      - Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type
      - Details of all BMS interfaces and connections to the work of other trades
      - Product data sheets or marked catalog pages including part number, photo and description for all products including software
2. Existing Systems Inventory
   a. Where applicable, provide a complete and current BMS site inventory for all existing field and supervisory controllers to be integrated into the new BMS including manufacturer, model number, firmware version, available updates, battery condition, integrations, controlled equipment, and point counts.
   b. Site inventory shall be provided on a separate, new USB compatible flash drive.

Record Documentation

1. Operation and Maintenance Manuals.

Note: Item a. should be reviewed and edited as required. Visio or AutoCAD drawings are generally not provided unless specifically requested.

a. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media or USB Flash Drive, and include the following for the BMS provided:

- Table of contents
- As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
- Manufacturer's product data sheets or catalog pages for all products including software
- System Operator's manuals
- Archive copy of all site-specific databases and sequences
- BMS network diagrams
- Interfaces to all third party products and work by other trades

Note: Item b. is optional, edit as required

b. The Operation and Maintenance Manual shall be self-contained, and include all necessary software required to access the product data sheets. Include a logically organized table of contents. Viewer software shall provide the ability to display, zoom, print, and search all documents.

2. On-Line documentation: After completion of all tests and adjustments the contractor shall provide a copy of all as-built information and product data to be installed on a customer designated computer workstation or server.

Warranty

1. Standard Material and Labor Warranty:

a. Provide a one-year labor and material warranty on the BMS.

b. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Contractor at the cost of the BMS Contractor.

c. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BMS Contractor's normal business hours.

d. Maintenance of computer Software Programs: The BMS Contractor shall maintain all software during the standard first year warranty period. In addition, all factory or sub-vendor upgrades to software during the first year warranty period shall be added to the systems, when they become available, at no additional cost. In addition to first year standard warranty, software provided by BMS Contractor shall come with a 5 Year Software Maintenance license. All supervisory controllers and BAS Servers are included in this coverage. Labor to implement upgrades in years two through five are not included in standard warranty.

e. The Owner shall grant to BMS Contractor reasonable access to the BMS during the warranty period. Remote access to the BMS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

Part 2 – Products

General Description

1. The BMS shall be a complete system designed for scalable implementation from small stand-alone use to large, networked systems. This functionality shall extend into the equipment rooms. Devices residing on the enterprise IT network shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. The contractor shall be responsible for coordination with the owner's IT staff to ensure that the BAS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.

2. The BMS shall consist of the following:

a. Supervisory controller(s), for managing networks of equipment controllers and providing supervisory control services

b. Programmable equipment controllers, for directly operating and controlling mechanical equipment.

c. Field bus network, for exchanging data between equipment controllers and between equipment controllers and supervisory controllers

d. Automation network, for exchanging data between supervisory controllers, distributed user interface(s), and BMS server.

e. Distributed user interface(s), for providing operational access to the BMS

f. BMS server (optional), for managing networks of supervisory controllers, equipment controllers and providing additional supervisory control services.

g. Local Display Device(s)

h. Application software, for defining the sequence of operation of the BMS.

i. Other components required for a complete and working BMS

3. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

a. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

b. The System shall maintain all settings and overrides through a system reboot.

5. The System shall comply with the following International Code Council (ICC) Codes:

a. Building Officials and code Administrators International (BOMA) model code

b. International Conference of Building Officials (ICBO) model code

c. Southern Building Code Congress International (SBCCI) regulations

6. Acceptable Manufacturers

a. Johnson Controls, Facility Explorer

Supervisory Network Controller

1. General

a. The Supervisory Network Controller shall be a fully user-programmable, supervisory controller. The Supervisory Network Controller shall monitor the network of equipment controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other supervisory controllers.

b. The Supervisory Network Controller shall also be a fully user-programmable, equipment controller that includes a minimum of 28 I/O points.

c. Automation Network – The Supervisory Network Controller shall reside on the automation network and shall support a subnet system controller.

d. User Interface – Each Supervisory Network Controller shall have the ability to deliver a web-based User Interface using the Site Management Portal functionality previously described. All computers connected physically or virtually to the automation network shall have access to the web-based user interface.

i. The web-based user interface software shall be embedded in the Supervisory Network Controller Systems that require a local copy of the system database on the user's device are not acceptable.

ii. The Supervisory Network Controller shall support a minimum of two (2) concurrent users.

iii. The web-based user interface shall have the capability to access all system data through a single Supervisory Network Controller.

iv. Remote users connected to the network through a Virtual Private Network (VPN) shall also have total system access through one Supervisory Network Controller.

v. Systems that require the user to address more than one Supervisory Network Controller to access all system information are not acceptable.

vi. The Supervisory Network Controller shall have the capability of serving web-based user interface graphics. The graphics capability shall be embedded in the Supervisory Network Controller

vii. Systems that only support user interface graphics from a central database or require the graphics to reside on the user's device are not acceptable.

viii. The web-based user interface shall support the following functions using a supported web browser:

- Configuration
- Commissioning
- Data Archiving
- Monitoring
- Commanding
- System Diagnostics

ix. Systems that require workstation software or modified web browsers are not acceptable.

e. Processor – The Supervisory Network Controller shall be microprocessor-based with a minimum word size of 32 bits. The Supervisory Network Controller shall be a multi-tasking, multi-user, and real-time digital control process. Standard operating systems shall be employed. Supervisory Network Controller size and capability shall be sufficient to fully meet the requirements of this Specification.

f. Memory – Each Supervisory Network Controller shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

g. Secure Boot – The Supervisory Network Controller shall prevent malicious or unauthorized software applications from loading during the system startup process.

h. User Authentication – The Supervisory Network Controller shall support local user authentication.

i. Password Security – Access to the Supervisory Network Controller embedded user interface shall require a password of 8 to 50 characters including a minimum of one lower case letter, one upper case letter, one number, and one special character. An alarm shall be generated after three unsuccessful attempts within 15 minutes and the user shall be denied access until permission is renewed by a system administrator.

j. Network Security – Communication between the Supervisory Network Controller and other system networked devices shall be encrypted and support HTTPS with Transport Level Security (TLS) Version 1.2. Self-signed certificates are to be provided with the option of configuring trusted certificates.

k. Hardware Real Time Clock – The Supervisory Network Controller shall include an integrated, hardware-based, real-time clock, with a supercapacitor to maintain time for a minimum of 72 hours during a power loss. Controllers using a battery to maintain time during a power loss shall not be acceptable.

l. Diagnostics – The Supervisory Network Controller shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Supervisory Network Controller shall provide both local and remote annunciation of any detected component failures or repeated failures to establish communication.

m. Power Failure – In the event of the loss of normal power, the Supervisory Network Controller shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

   i. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.

   ii. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

n. Certification – The Supervisory Network Controller shall meet and be listed to the UL 916 Standard for Energy Management Equipment and be FCC Compliant to CFR47, Part 15, Subpart B, Class A.

o. Device Integration – The Supervisory Network Controller shall support integrating and supervising networked devices using the following communication protocols on the device/controller network:

   i. The Supervisory Network Controller shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135 on the controller network.

      - The Supervisory Network Controller shall support Remote Field Bus integration via a BACnet IP to MS/TP router.
      - The Supervisory Network Controller shall be tested and BTL listed/certified as a BACnet Building Controller (B-BC).
      - A BACnet Protocol Implementation Conformance Statement shall be provided for the Supervisory Network Controller.
      - The Protocol Implementation Conformance Statement shall be submitted 10 days prior to bidding.

p. The Supervisory Network Controller shall employ a finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

q. The Supervisory Network Controller shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only, shall not be acceptable.

r. The Supervisory Network Controller shall support the following types of inputs and outputs:

   i. Universal Inputs – shall be configured to monitor any of the following:

      - Analog Input, Voltage Mode
      - Analog Input, Current Mode
      - Analog Input, Resistive Mode
      - Binary Input, Dry Contact Maintained Mode
      - Binary Input, Pulse Counter Mode

   ii. Binary Inputs – shall be configured to monitor either of the following:

      - Dry Contact Maintained Mode
      - Pulse Counter Mode

   iii. Analog Outputs – shall be configured to output either of the following:

      - Analog Output, Voltage Mode
      - Analog Output, Current Mode

   iv. Binary Outputs – shall output the following:

      - 24 VAC Triac

   v. Configurable Outputs – shall be configured to output either of the following:

- Analog Output, Voltage Mode
- Binary Output, 24 VAC Triac Mode

s. The Supervisory Network Controller shall have the ability to monitor and control a network of sensors and actuators over a Sensor Actuator (SA) Bus.

i. The SA Bus shall be a MS/TP Bus supporting BACnet Standard protocol SSPC-135.

ii. The SA Bus shall support a minimum of 9 devices.

iii. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the Network Control Engine and the furthest connected device.

t. The Supervisory Network Controller shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the Field Bus or the SA Bus.

u. The Supervisory Network Controller shall support, but not be limited to, the following applications:

Note: Item u.i. specifies an optional software feature, Central Plant Optimization 10, Remove reference from the spec if not used on the project and replace with “Cooling central plant applications”

i. Chilled water/central plant optimization applications including but not limited to:

- Selection and sequencing of up to eight chillers of different sizes.
- Selection and sequencing of up to eight (each) primary and secondary chilled water pumps of varying pumping capacities.
- Selection and sequencing of up to eight condenser water pumps.
- Selection and sequencing of cooling towers and bypass valve, including single speed, multi-speed, and Vernier control.
- Selection and sequencing of up to four heat exchangers, of different capacities.
- A proven and documented central cooling plant optimization program that incorporates custom equipment efficiency profiles, without rewriting software code, in order to meet the building load using the least amount of energy as calculated.
- The use of advanced control algorithms that apply equipment specific parameters, including operational limits and efficiency profiles, in order to determine equipment start and runtime preferences.
- Identification of the most efficient equipment combination and automatic control of state and speed of all necessary equipment to balance runtime, optimize timing and sequencing and ensure the efficiency and stability of the central cooling plant.
- Control definition for the chiller plant in a single Equipment Controller or Network Control Engine, as supported by available memory and point I/O, or capable of being split across multiple Equipment Controllers or Network Control Engines.

ii. Central heating plant applications.

iii. Lighting and electrical distribution.

iv. Built-up air handling units for special applications.

v. Power generation and energy monitoring equipment.

vi. Interfaces to security and fire detection systems.

v. The Supervisory Network Controller shall provide removable, labeled, screw terminal blocks for 24 VAC power, communication bus and I/O point field wiring.

w. The Supervisory Network Controller shall include the following multi-color, flashing LEDs to indicate important operating conditions and status:

i. Heartbeat – to indicate each of the following states: operational (normal), powered but not operational, starting up, shutting down, or no power applied

ii. Fault – to indicate if fault conditions have been detected

iii. SA Bus – to indicate if communication is occurring on the SA Bus

iv. FC BUS-1 – to indicate if communication is occurring on FC Bus port 1

v. Ethernet Activity - to indicate if Ethernet Traffic is occurring or not occurring

vi. USB-1|2 – to indicate if a supported device is connected, no device is connected, or an unsupported device is connected on USB port 1 or 2

vii. FC EOL - to indicate if the end-of-line termination switch is on or off

x. Communications Ports – The Supervisory Network Controller shall provide the following ports for connecting networkable devices:

i. Two (2) USB ports

ii. One (1) RS-485 port

iii. Two (2) Ethernet ports

Note: Items below specify an integrated display/keypad. Remove from spec if not used on project.

y. The Supervisory Network Controller shall support an integrated user interface featuring a display and keypad.

i. The integrated user interface shall allow viewing and monitoring points, alarms, and trends.

ii. The integrated user interface shall allow viewing and changing setpoints, modes of operation, and parameters.

iii. The integrated user interface shall provide password protection with user-adjustable password timeout.

iv. The information presented by the integrated user interface shall be organized into folders for easy navigation.

v. The integrated user interface shall support textual descriptions in English for each point.

vi. The display shall be, at minimum, a 2.4-inch, color display with 320x240 resolution.

vii. The display shall support adjustable contrast and brightness.

viii. The keypad shall include no more than seven (7) keys.

2. Supervisory Network Controller – Standard

a. Provide Johnson Controls SNCxxxxx-04x or approved equal as indicated on plans.

3. Supervisory Network Controller – Large

a. Provide Johnson Controls SNCxxxxx-0x or approved equal as indicated on plans.

Supervisory Controller(s)

1. Supervisory controller(s) shall provide network management services between itself and the equipment controllers which are connected to its communications trunks, between itself and other supervisory controllers, and between itself and any user interface clients that are part of the BMS.

2. Supervisory controller(s) shall be enabled to support and shall be licensed with the BACnet open protocol drivers (client and server) by default.

3. Supervisory controller(s) shall perform control and operating strategies for the system based on information from any equipment controller connected to the BMS, including but not limited to the following:

a. Scheduling, including calendar functions

b. Historical data collection, management, and visualization

c. Alarm initiation, routing, and notification

d. Time synchronization

e. Managing the exchange of data between itself and equipment controllers

f. Closed loop control and interlocking

4. Supervisory controllers shall be capable of peer-to-peer communications with other supervisory controllers and with any user interface client connected to the BMS, whether the user interface client is directly connected, connected via cellular modem or connected via the Intranet or Internet.

5. The communication protocols utilized for peer-to-peer communications between supervisory controllers shall be Niagara 4 Fox, BACnet TCP/IP or SNMP. Use of a different communication protocol for peer-to-peer communications between supervisory controllers is not allowed.

6. The supervisory controller(s) shall employ a device count capacity license model that supports expansion capabilities.

7. The supervisory controller(s) shall provide the following hardware features as a minimum:

a. Two 10/100 Mbps Ethernet ports.

b. Two isolated RS-485 ports with biasing switches.

c. 1 GB RAM

d. 4 GB Flash Total Storage / 2 GB user storage

e. Wi-Fi (Client or WAP)

f. USB flash drive

g. High speed field bus expansion

h. -20-60 degrees C ambient operating temperature

i. Integrated 24 VAC/DC global power supply

j. MicroSD memory card employing Encrypted Safe Boot Technology

8. The supervisory controller(s) shall include an embedded web server to support standard web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

9. The supervisory controller(s) shall provide alarm generation, storage, routing, management and analysis to data sourced from equipment controllers, network thermostats, and direct field inputs, including the following capabilities:

a. Alarming capability shall support being added to any data point in the supervisory controller's database.

b. User-defined criteria shall be used to define when the point meets an alarm condition (is in an alarmed state), including, but not limited to the following:

i. For numeric-type data points: when the data point's value falls outside a user-defined range.

ii. For Boolean or enumerated type data points: when the data point's state matches a user defined alarm state.

iii. For string-type data points, when the data point's string text includes or excludes a user-defined string text.

iv. For commanded points, when the data point's actual value does not match its commanded value after an appropriate (user-defined) time delay.

c. Alarm generation shall be selectable for annunciation type and acknowledgement requirements, including but not limited to:
    i. To alarm.
    ii. Return to normal.
    iii. To default.
d. Each alarm record shall include at a minimum, the following information:
    i. Name of source data point
    ii. Time and date of alarm occurrence
    iii. Acknowledge time, date, and user who issued acknowledgement
e. Routing of alarms shall be user-defined, and may include one or more of the following destinations:
    i. A dynamically-updated alarm console on the distributed user interface screen.
    ii. A bound, animated symbol on the distributed user interface screen.
    iii. Email
    iv. Pagers, using paging services that initiate a page-on receipt of email message.
    v. SMS text message
    vi. Line printer
    vii. Another supervisory controller or a BMS Server for alarm centralization and/or archival
f. Alarms that have gone unacknowledged by the specified contact for a specified time shall re-routed to the next specified contact.
g. Alarms shall support customized text instructions to be assigned to them, so that any time an alarm is generated, the instructions are included and presented along with the alarm notification to guide the operator on how to recover from the alarm condition.
h. Authorized operators shall be allowed (and optionally required) to add a note to one or more alarm records simultaneously to provide historical context for the event that trigged the alarm.
i. Authorized operators shall be allowed to acknowledge alarms using the alarm console on the user interface.
j. Authorized operators shall be allowed to silence the audible alarm sound on the alarm console.
k. Authorized operators shall be allowed to delete alarm records from the alarm database but only after the alarms have been acknowledged and the source data point is in a normal (no longer in alarm) state.

10. The supervisory controller(s) shall support the following security functions to prevent unauthorized access:
    a. The supervisory controller(s) shall use module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
    b. The supervisory controller(s) shall use Role-Based Access Control (RBAC) for managing user roles and permissions.
    c. The supervisory controller(s) shall require strong user passwords.
    d. All data in motion and sensitive data at rest in the supervisory controller(s) shall be encrypted.
    e. The supervisory controller(s) shall support LDAP and Kerberos integration of access management.

11. The supervisory controller(s) shall support tagging to utilize Search, Hierarchy, and User Permission functionality.
12. The supervisory controller(s) shall provide scheduling capabilities being added to any writable data point in the supervisory controller's database, sourced from any equipment controllers, network thermostats, and direct field inputs, including the following capabilities:
    a. The supervisory controller(s) shall support scheduling on a weekly and special event basis.
    b. Authorized operators shall be allowed to view and adjust the exact start/stop time and dates for the weekly schedule and special events from the user interface.
    c. The supervisory controller(s) shall support sharing schedule configurations with other supervisory controller(s), with the BMS server, and with scheduling-enabled BACnet devices.
13. The supervisory controller(s) shall support data logging capabilities being added to any data point in the supervisory controller's database, sourced from any equipment controllers, network thermostats, and direct field inputs, including the following capabilities:
    a. Data logs shall be organized into ordered collections of timestamped records, herein called histories.
    b. Each history record shall include at a minimum, the following information:
        i. History name
        ii. Data point value
        iii. Time and date when data point was logged
    c. User-defined criteria shall be used to define when the data point is logged, including, but not limited to the following:
        i. When the data point's value, state, or string changes by a user-defined amount.
        ii. At a regular, repeating, user-defined time intervals.
    d. The supervisory controller shall support user-specified local storage capacity for the history records. The data logging behavior upon reaching the specified capacity shall be user-selectable from the following options:
        i. Stop: terminate recording.
        ii. Roll: overwrite older records with newer ones.
    e. Histories shall support being viewed by operators in a table or chart format on the user interface.
    f. The supervisory controller shall support the automatic exporting of one or more histories to the BMS server for long term archival.
14. The supervisory controller's configuration software shall be embedded into the supervisory controller, enabling an authorized user to access the configuration software using a web browser.

Note: Adjust item 15 below as required to match project requirements.

15. The supervisory controller shall be provided with a 5 year software maintenance license. Labor to implement not included.

DDC Equipment Controllers

Note: For this following section, multiple Facility Explorer equipment controller types are listed. Keep references to those that are appropriate for the intended project and remove references to those that are not.

1. General Purpose Equipment Controller (CGM and CGE controllers)

a. The General Purpose Equipment Controller shall be a fully programmable, digital controller. The CGM Controller communicates via the BACnet MS/TP protocol. The CGE controller communicates via the BACnet/IP protocol.

    i. The CGM/CGE shall support BACnet Standard ANSI/ASHRAE 135.

        - The CGM/CGE shall be BTL listed/certified.
        - The CGM/CGE shall be tested and certified as a BACnet Advanced Application Controller (B-AAC).
        - A BACnet Protocol Implementation Conformance Statement shall be provided for the CGM/CGE.
        - The Conformance Statement shall be submitted 10 days prior to bidding.

b. The CGM/CGE shall employ finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

c. CGM/CGE controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.

d. The CGM/CGE shall be assembled in a plastic housing with protection class IP20 (IEC529) and flammability rated to UL94-5VB.

e. The CGM/CGE shall include an integral real-time clock and support time-based tasks which enables these equipment controllers to monitor and control:

    i. Schedules

    ii. Calendars

    iii. Alarms

    iv. Trends

f. The CGM/CGE can continue time-based monitoring when offline for extended periods of time from a network.

g. The CGM/CGE can operate as a stand-alone controller in applications that do not require a networked supervisory device or for network applications where it is preferred to have the scheduling, alarming, and/or trending performed locally in the equipment controllers.

h. The CGM shall include troubleshooting LEDs to indicate the following conditions:

    i. Power—to indicate if the controller is powered or not powered

    ii. Fault – to indicate if the controller is in its default state, has no faults, has a device fault, is in startup or download mode, or has an SA Bus communication issue

    iii. SA Bus – to indicate if SA Bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

    iv. FC Bus – to indicate if FC Bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

    v. EOL – to indicate if the end-of-line termination switch is on or off

i. The CGE shall include troubleshooting LEDs to indicate the following conditions:

    i. Power—to indicate if the controller is powered or not powered

    ii. Fault– to indicate if the controller is in its default state, has no faults, has a device fault, is in startup or download mode, or has an SA Bus communication issue

    iii. SA Bus - to indicate if SA Bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

    iv. ETH-1 - to indicate if the controller is connected and communicating, or is not connected

v. ETH-2- to indicate if the controller is connected and communicating, or is not connected

j. The CGM/CGE shall have the ability to transfer and apply firmware files to all SA Bus devices (XPM, PCX, and NS8000) connected to it.

k. The CGM/CGE shall include pluggable screw terminal blocks for all I/O, SA Bus communication, and power wiring connections. The CGM shall also include a pluggable screw terminal block for FC bus communication.

l. The CGM/CGE shall accommodate the direct wiring of analog and binary I/O field points with the following resolution.

i. Inputs – 24-bit analog-to-digital converter

ii. Outputs – +/- 200 mV accuracy in 0-10 VDC applications

m. The CGM/CGE shall support the following types of inputs and outputs supplied in the amounts required for the specified applications:

i. Universal Inputs – shall be configurable to monitor any of the following:

- 0-10 VDC analog input
- 4-20 mA analog input
- 0-600k ohms analog input
- Dry contact binary input

ii. Binary Inputs – shall be configurable to monitor either of the following:

- Dry Contact Maintained Mode
- Pulse Counter Mode

iii. Analog Outputs – shall be configurable to output either of the following:

- 0-10 VDC analog output
- 4-20 mA analog output

iv. Binary Outputs – shall output the following:

- 24 VAC Triac

v. Configurable Outputs – shall be capable of the following:

- 0-10 VDC analog output
- 24 VAC Triac binary output

n. The CGM shall have the ability to reside on a Field Controller Bus (FC Bus).

i. The FC Bus shall be a MS/TP Bus supporting BACnet Standard protocol SSPC-135.

ii. The FC Bus shall support communications between the CGMs and the supervisory controller.

iii. The FC Bus shall also support peer-to-peer communications between non-supervisory devices, allowing these devices to communicate system data with each other directly, bypassing the supervisory controllers on the bus.

iv. The FC Bus shall support a minimum of 100 equipment controllers and/or expansion modules in any combination.

v. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the CGM and the furthest connected device.

o. The CGE shall have the ability to reside on the Automation Network with the following capabilities

i. The CGE shall communicate with Open Data Servers (BACnet listed OWS) and Network Engines.

ii. The CGE shall support BACnet IPv4

iii. The CGE shall support Peer to Peer communications with other controllers on the automation network.

p. The CGM shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.

q. The CGE shall include three (3) decimal rotary dial switches for setting the controller number.

r. The CGM/CGE shall have the ability to monitor and control a network of sensors and actuators over a SA Bus.

i. The SA Bus shall be a MS/TP Bus supporting BACnet Standard Protocol SSPC-135.

ii. The SA Bus shall support a minimum of 10 devices per trunk.

iii. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the CGM/CGE and the furthest connected device.

s. The CGM shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over a MS/TP Bus.

t. The CGM/CGE shall support, but not be limited to, the following applications.

Note: Item q.i. specifies an optional software feature, Central Plant Optimization 10, Remove reference from the spec if not used on the project and replace with “Cooling central plant applications”

i. Chilled water/central plant optimization applications including but not limited to:

- Selection and sequencing of up to eight chillers of different sizes.
- Selection and sequencing of up to eight (each) primary and secondary chilled water pumps of varying pumping capacities.
- Selection and sequencing of up to eight condenser water pumps.
- Selection and sequencing of cooling towers and bypass valve, including single speed, multi-speed, and Vernier control.
- Selection and sequencing of up to four heat exchangers, of different capacities.
- A proven and documented central cooling plant optimization program that incorporates custom equipment efficiency profiles, without rewriting software code, in order to meet the building load using the least amount of energy as calculated.
- The use of advanced control algorithms that apply equipment specific parameters, including operational limits and efficiency profiles, in order to determine equipment start and runtime preferences.
- Identification of the most efficient equipment combination and automatic control of state and speed of all necessary equipment to balance runtime, optimize timing and sequencing and ensure the efficiency and stability of the central cooling plant.
- Control definition for the chiller plant in a single CGM, CGEs, PCA, or supervisory controller, as supported by available memory and point I/O, or capable of being split across multiple CGMs, CGEs, PCAs, or supervisory controllers.

ii. Heating central plant applications.

iii. Built-up air handling units for special applications.

iv. Terminal & package units.

v. Special programs as required for systems control.

Note: Item r. specifies a Local Controller Display. Remove from spec if not used on the project.

u. The CGM/CGE shall support a Local Controller Display as a remote device communicating over the SA Bus.

i. The Display shall use a BACnet Standard SSPC-135 MS/TP protocol.

ii. The Display shall allow the user to view monitored points without logging into the system.

iii. The Display shall allow the user to view and change setpoints, modes of operation, and parameters.

iv. The Display shall provide password protection with user adjustable password timeout.

v. The Display shall be menu driven with separate paths for:

- Input/Output
- Parameter/Setpoint
- Overrides

vi. The Display shall use easy-to-read English text messages.

vii. The Display shall allow the user to select the points to be shown and in what order.

viii. The Display shall support a back lit LCD with adjustable contrast and brightens and automatic backlight brightening during user interaction.

ix. The display shall be a minimum of 4 lines and a minimum of 20 characters per line.

x. The Display shall have a keypad with no more than 7 keys.

xi. The Display shall be panel mountable.

v. Provide Johnson Controls CGM/CGE or approved equal as shown on plans.

w. Equipment Controllers shall be programmed using the ASHRAE Guideline 36: High-Performance Sequences of Operation for HVAC Systems

2. VAV Box Controller (CVM and CVE controllers)

a. The VAV Box Controller shall provide both standalone and networked DDC of pressure-independent, VAV terminal units.

b. The VAV Box controller shall be a fully programmable, digital controller that communicates via BACnet MS/TP protocol.

i. The CVM/CVE shall support BACnet Standard ANSI/ASHRAE 135.

- The CVM/CVE shall be BTL listed/certified.
- The CVM/CVE shall be tested and certified as a BACnet Advanced Application Controller (B-AAC).
- A BACnet Protocol Implementation Conformance Statement shall be provided for the CVM/CVE.
- The Conformance Statement shall be submitted 10 days prior to bidding.

c. The CVM/CVE shall support 14 pre-built single duct VAV box control applications to allow the controller to be made fully operational without the need to create a custom program.

d. The CVM/CVE shall employ finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

e. CVM/CVE controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.

f. The CVM/CVE shall be assembled in a plenum-rated plastic housing with protection class IP20 (IEC529) and flammability rated to UL94-5VB.

g. The CVM/CVE shall include an integral real-time clock and support time-based tasks which enables these equipment controllers to monitor and control:

i. Schedules

ii. Calendars

iii. Alarms

iv. Trends

h. The CVM/CVE can continue time-based monitoring when offline for extended periods of time from a network.

i. The CVM/CVE shall include an integral differential pressure transducer and damper actuator. An additional configuration option shall be available that also includes an integral potentiometer for actual damper position feedback. All components shall be connected and mounted as a single assembly, removable as one piece.

j. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 60 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.

k. The CVM/CVE shall determine airflow by a state-of-the-art, digital, non-flow pressure sensor that supports automatic correction for polarity on high- and low-pressure DP tube connections to eliminate high- and low-pressure connection mistakes.

l. The CVM/CVE shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.

m. The CVM/CVE can operate as a stand-alone controller in applications that do not require a networked supervisory device or for network applications where it is preferred to have the scheduling, alarming, and/or trending performed locally in the equipment controllers.

n. The CVM shall include troubleshooting LEDs to indicate the following conditions:

i. Power—to indicate if the controller is powered or not powered

ii. Fault – to indicate if the controller is in its default state, has no faults, has a device fault, is in startup or download mode, or has an SA Bus communication issue

iii. SA Bus – to indicate if SA Bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

iv. FC Bus – to indicate if FC Bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

v. EOL – to indicate if the end-of-line termination switch is on or off

o. The CVM shall include troubleshooting LEDs to indicate the following conditions:

i. Power—to indicate if the controller is powered or not powered

ii. Fault - to indicate if the controller is in its default state, has no faults, has a device fault, is in startup or download mode, or has an SA Bus communication issue

iii. SA Bus– to indicate if SA Bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

iv. ETH-1 - to indicate if the controller is connected and communicating, or is not connected

v. ETH-2 - to indicate if the controller is connected and communicating, or is not connected

p. The CVM/CVE shall have the ability to transfer and apply firmware files to all SA Bus devices (XPM, PCX, and NS8000) connected to it.

q. The CVM/CVE shall include pluggable screw terminal blocks for all I/O, FC and SA Bus communication, and power wiring connections.

r. The CVM/CVE shall accommodate the direct wiring of analog and binary I/O field points with the following resolution.

i. Inputs – 24-bit analog-to-digital converter

ii. Outputs – +/- 200 mV accuracy in 0-10 VDC applications

s. The CVM/CVE shall support the following types of inputs and outputs supplied in the amounts required for the specified applications:

i. Universal Inputs – shall be configurable to monitor any of the following:

- 0-10 VDC analog input
- 4-20 mA analog input
- 0-600k ohms analog input
- Dry contact binary input

ii. Binary Outputs – shall output the following:

- 24 VAC Triac binary outputs

iii. Configurable Outputs – shall be configurable of outputting the following:

- 0-10 VDC analog output
- 24 VAC Triac binary output

t. The CVM shall have the ability to reside on a Field Controller Bus (FC Bus).

i. The FC Bus shall be a MS/TP Bus supporting BACnet Standard protocol SSPC-135.

ii. The FC Bus shall support communications between the CVMs and the supervisory controller.

iii. The FC Bus shall also support peer-to-peer communications between non-supervisory devices, allowing these devices to communicate system data with each other directly, bypassing the supervisory network engine on the bus.

iv. The FC Bus shall support a minimum of 100 equipment controllers and/or expansion modules in any combination.

v. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the CVM and the furthest connected device.

u. The CVE shall have the ability to reside on the Automation Network with the following capabilities

i. The CVE shall communicate with Open Data Servers (BACnet listed OWS) and Network Engines.

ii. The CVE shall support BACnet IPv4

iii. The CVE shall support Peer to Peer communications with other controllers on the automation network

v. The CVM shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.

w. The CVE shall include three (3) decimal rotary dial switches for setting the controller number.

x. The CVM/CVE shall have the ability to monitor and control a network of sensors and actuators over a SA Bus.

i. The SA Bus shall be a MS/TP Bus supporting BACnet Standard Protocol SSPC-135.

ii. The SA Bus shall support a minimum of 10 devices per trunk.

iii. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the CVM/CVE and the furthest connected device.

y. The CVM shall have the capability to execute VAV box control sequences involving direct wired I/O points as well as input and output devices communicating over a MS/TP Bus.

z. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.

aa. Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.

bb. The controller shall provide the ability to download and upload VAV box control application configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group.

cc. Control setpoint changes initiated over the network shall be written to the controller's non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.

dd. The CVM/CVE controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.

ee. The CVM/CVE controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.

ff. The CVM/CVE controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.

gg. The CVM/CVE controller shall have on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The CVM/CVE shall calculate Exponentially Weighted Moving Averages (EWMA) for each of the following metrics, which shall be available to the end user for efficient management of the VAV terminals.

i. Absolute temperature loop error

ii. Signed temperature loop error

iii. Absolute airflow loop error

iv. Signed airflow loop error

v. Average damper actuator duty cycle

hh. The controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:

i. Unreliable space temperature sensor

ii. Unreliable differential pressure sensor

iii. Starved box

iv. Actuator stall

v. Insufficient cooling

vi. Insufficient heating

ii. The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The CVM/CVE would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.

jj. The CVM/CVE controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality) and shall be capable of resetting the box minimum airflow based on the percent of outdoor air in the primary air stream.

kk. The CVM/CVE controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

ll. Provide Johnson Controls CVM/CVE or approved equal as shown on plans.

mm. Equipment Controllers shall be programmed using the ASHRAE Guideline 36: High-Performance Sequences of Operation for HVAC Systems

3. XPM expansion I/O module (XPM)

a. The XPM provides additional input and output interfaces for use in digital controllers.

b. The XPM shall communicate with controllers over the FC Bus or the SA Bus.

c. The XPM shall support BACnet Standard ANSI/ASHRAE 135.

   i. The XPM shall be BTL listed/certified and carry the BTL Label.

   ii. The XPM shall be tested and certified as a BACnet Smart Actuator (B-SA).

   iii. A BACnet Protocol Implementation Conformance Statement shall be provided for the XPM.

   iv. The Conformance Statement shall be submitted 10 days prior to bidding.

d. The XPM shall include pluggable screw terminal blocks for all I/O, SA/FC bus communication, and power wiring connections.

e. The XPM shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.

f. The XPM shall accommodate the direct wiring of analog and binary I/O field points with the following resolution:

   i. Inputs – 24-bit analog-to-digital converter

   ii. Outputs – +/- 200 mV accuracy in 0-10 VDC applications

g. The XPM shall support the following types of inputs and outputs:

   i. Universal Inputs – shall be configured to monitor any of the following:

      - 0-10 VDC analog input
      - 4-20 mA analog input
      - 0-600k ohms analog input
      - Dry contact binary input

   ii. Binary Inputs – shall be configured to monitor either of the following:

      - Dry Contact Maintained Mode
      - Pulse Counter Mode

   iii. Analog Outputs – shall be configured to output either of the following:

      - 0-10 VDC analog output
      - 4-20 mA analog output

   iv. Binary Outputs – shall output the following:

      - 24 VAC Triac

   v. Configurable Outputs – shall be capable of the following:

      - 0-10 VDC analog output
      - 24 VAC Triac binary output

h. The XPM shall include troubleshooting LEDs to indicate the following conditions:

   i. Power – to indicate if the device is powered or not powered

   ii. Fault – to indicate if the device is in its default state, has no faults, has a device fault, is in startup or download mode, or has an SA Bus communication issue

   iii. SA/FC Bus – to indicate if bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

   iv. EOL – to indicate if the end of line termination is on or off.

i. Provide Johnson Controls XPM or approved equal as shown on plans.

Programmable equipment controllers

1. Programmable equipment controllers shall include direct wired input interfaces for monitoring analog and binary signals from field devices.
2. Programmable equipment controllers shall include direct wired output interfaces for controlling field equipment.
3. Programmable equipment controllers shall include a BACnet MS/TP or optionally N2Open field bus network interface.
    a. Programmable equipment controllers shall be BACnet Testing Labs (BTL) listed.
    b. Programmable equipment controllers shall be tested and certified as a BACnet Application Specific Controller (B-ASC) or as BACnet Advanced Application Controller (B-AAC).
    c. A BACnet Protocol Implementation Conformance Statement shall be provided for the programmable equipment controllers 10 days prior to bidding.
4. Programmable equipment controllers shall include an expansion sensor and actuator bus (SA Bus) network interface, for interfacing up to 9 of the following types of devices:
    a. Expansion input/output modules (FX-PCX, F4-XPM)
    b. Network sensors (NS-xxx), of the following types and characteristics:
        i. Network room temperature and humidity sensor(s)
            - The network room temperature and humidity sensors shall be suitable for mounting in an occupied space.
            - The network room temperature and humidity sensor(s) shall be available in either surface mount or wall mount packaging.
            - The network room temperature and humidity sensor(s) shall include either screw terminals or 6-pin RJ-style modular jack for SA Bus wiring connections.
            - The network room temperature and humidity sensor(s) shall have the ability to monitor the following variables as required by the system's sequence of operations:
                (i) Zone temperature
                (ii) Zone humidity
                (iii) Zone setpoint
            - The network room temperature and humidity sensor(s) shall include the following operator controls:
                (i) A backlit Liquid Crystal Display (LCD) to indicate the temperature, humidity and setpoint
                (ii) An LED to indicate the status of the Override feature
                (iii) A button to toggle the temperature display between Fahrenheit and Celsius
                (iv) A button to program the display for temperature or humidity
                (v) A button to initiate a timed override command
                (vi) A dial to change the setpoint or warmer/cooler adjustment.
        ii. Network room CO_2 sensor(s):
            - The network room CO_2 sensor(s) shall be suitable for mounting in an occupied space

- The network room CO_2 sensor(s) shall be available in either surface mount or wall mount packaging.
- The network room CO_2 sensor(s) shall include either screw terminals or 6-pin RJ-style modular jack for SA Bus wiring connections.
- The network room CO_2 sensor(s) measurement range shall be 0-2,000 ppm.

iii. Network discharge air temperature sensor(s):

- The network discharge air temperature sensor(s) shall be suitable for mounting in supply or discharge air duct.
- The network discharge air temperature sensor(s) shall include a 4 inch or 8 inch duct insertion probe.
- The network discharge air temperature sensor(s) shall include 10 foot pigtail type wiring lead.

c. Variable speed drive(s)

d. Local display/keypad (FX-DIS17) with the following characteristics:

i. The local display/keypad shall allow the user to view monitored points without logging into the system.

ii. The local display/keypad shall allow the user to view and change setpoints, modes of operation, and parameters.

iii. The local display/keypad shall provide password protection with user adjustable password timeout.

iv. The local display/keypad shall be menu driven with separate paths for:

- Input/Output
- Parameter/Setpoint
- Overrides

v. The local display/keypad shall use easy-to-read English text messages.

vi. The local display/keypad shall allow the user to select the points to be shown and in what order.

vii. The local display/keypad shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.

viii. The local display/keypad shall be a minimum of 4 lines and a minimum of 20 characters per line

ix. The local display/keypad shall have a keypad with no more than 6 keys.

x. The local display/keypad shall be panel mountable.

e. Air balancing tool

f. One-to-one wireless room sensor receiver (FX-WRZ7860), with the following capabilities:

i. The one-to-one wireless room sensor receiver shall receive wireless radio frequency (RF) signals containing temperature, humidity and occupancy data from multiple wireless room sensors (WRZ sensors) and communicate this information to programmable equipment controllers via the Sensor Actuator (SA) Bus.

ii. The one-to-one wireless room sensor receiver shall use direct sequence spread spectrum RF technology.

iii. The one-to-one wireless room sensor receiver shall operate on the 2.4 GHZ ISM Band.

iv. The one-to-one wireless room sensor receiver shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.

v. The one-to-one wireless room sensor receiver shall be FCC compliant to CFR Part 15 subpart B Class A.

vi. The one-to-one wireless room sensor receiver shall operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.

vii. The one-to-one wireless room sensor receiver shall be capable of communication with from one to five wireless room sensors up to a distance of 200 Feet.

viii. The one-to-one wireless room sensor receiver shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.

ix. The one-to-one wireless room sensor receiver shall have LED indicators to provide information regarding the following conditions:

- Power
- SA Bus - Receiver Activity/No Activity
- Wireless RF - Transmission from sensors/No Transmission
- Wireless Rapid Transmit Mode - No transmission/ weak signal/Adequate signal/Excellent signal

x. The one-to-one wireless room sensor receiver shall receive room temperature, humidity, and occupied information from the wireless room sensors, which shall include the following capabilities:

- The wireless room sensors shall use direct sequence spread spectrum RF technology.
- The wireless room sensors shall operate on the 2.4 GHZ ISM Band.
- The wireless room sensors shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
- The wireless room sensors shall be FCC compliant to CFR Part 15 subpart B Class A.
- The wireless room sensors shall be available with:
  - (i) Warmer/Cooler Set Point Adjustment
  - (ii) No Set Point Adjustment
  - (iii) Set Point Adjustment Scale - 55 to 85º F.
- The wireless room sensors shall be assembled in NEMA 1 plastic housings.

5. Programmable equipment controllers shall have the capability to execute complex control sequences involving direct wired input/output points as well as input and output devices communicating over the FC Bus or the SA Bus.

6. Programmable equipment controllers shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

7. Programmable equipment controllers shall employ a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately.

Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.

8. Programmable control logic shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
9. Programmable equipment controllers shall be fully programmable and definable using a software tool with the following characteristics:
    a. A simple, check-the-box or selection-type wizard method, with selections for the most popular HVAC equipment and control strategy options.
    b. A graphical, functional logic block editor for creating new or editing existing programming logic.
10. Programmable equipment controllers shall provide the ability to be downloaded and uploaded either locally or using the communications network. Programmable equipment controllers shall support being loaded individually or as a group
11. Control setpoint changes initiated over the network shall be written to programmable equipment controllers' non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.
12. Programmable equipment controllers' firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.
13. Programmable equipment controllers shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB or the controller is designed and suitable for use in other environmental air space (plenums) in accordance with Section 300.252(C) of the National Electrical Code.
14. The programmable equipment controllers shall include troubleshooting LED indicators to identify the following conditions:
    a. Power On
    b. Power Off
    c. Download or Startup in progress, not ready for normal operation
    d. No Faults
    e. Device Fault
    f. Field Controller Bus - Normal Data Transmission
    g. Field Controller Bus - No Data Transmission
    h. Field Controller Bus - No Communication
    i. Sensor-Actuator Bus - Normal Data Transmission
    j. Sensor-Actuator Bus - No Data Transmission
    k. Sensor-Actuator Bus - No Communication
15. Models of programmable equipment controllers dedicated to controlling variable air volume (VAV) boxes (FX-PCV) shall be provided with the following characteristics:
    a. The programmable VAV box controller shall provide both standalone and networked direct digital control of pressure-independent or pressure-dependent variable air volume terminal units, for either single or dual duct applications.
    b. The programmable VAV box controller shall communicate over the Field Controller Bus using BACnet Standard protocol SSPC-135.

c. The programmable VAV box controller shall include an integrated differential pressure transducer and VAV box damper actuator, all connected and housed as a single assembly that can be mounted and removed as one piece. Alternate configurations shall be available as follows:

   i. A configurable digital controller with integral differential pressure transducer but without a damper actuator – for controlling large VAV boxes that require high torque.

   ii. A configurable digital controller with an integral damper actuator but without a differential pressure transducer – for commercial zoning applications or for pressure dependent VAV box applications.

   iii. A configurable digital controller with an integral damper actuator and ball valve linkage but without a differential pressure transducer –for chilled beam applications.

d. The programmable VAV box controller shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB or the controller is designed and suitable for use in other environmental air space (plenums) in accordance with Section 300.252(C) of the National Electrical Code.

e. The integral VAV box damper actuator shall be a 4 Nm, non-spring return, fast-response actuator capable of stroking 90 degrees in 60 seconds for quick damper positioning to expedite commissioning and troubleshooting tasks.

f. The programmable VAV box controller shall measure airflow using an integrated, digital, non-flow pressure sensor providing 14-bit resolution with bidirectional flow operation that supports automatic correction for polarity on high- and low-pressure DP tube connections to eliminate high- and low-pressure connection mistakes.

g. The programmable VAV box controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.

h. The programmable VAV box controller shall include input interface(s) to monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

   i. 0-10 VDC sensors

   ii. 0-2k ohm resistive temperature detector (RTDs)

   iii. 10k Type L and 2.252k type 2 NTC thermistors

i. The programmable VAV box controller shall include input interface(s) to monitor dry contact closures, with filtering to eliminate false signals resulting from input "bouncing”.

j. The programmable VAV box controller input interfaces shall be internally isolated from power, communications, and output circuits, for noise immunity.

k. The programmable VAV box controller shall include output interface(s) with the following characteristics:

   i. 0-10 VDC analog output

   ii. SPST triac output rated for 500mA at 24 VAC.

l. The programmable VAV box controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle, to reduce commissioning costs, and to eliminate the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.

m. The programmable VAV box controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.

n. The programmable VAV box controller shall interface with air balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.

o. The programmable VAV box controller shall have on-board diagnostics, including control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The programmable VAV box controller shall calculate exponentially weighted moving averages (EWMA) for each of the following, and these metrics shall be available to the end user for efficient management of the VAV terminals.

i. Absolute temperature loop error

ii. Signed temperature loop error

iii. Absolute airflow loop error

iv. Signed airflow loop error

v. Average damper actuator duty cycle

p. The programmable VAV box controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall include:

i. Unreliable space temperature sensor

ii. Unreliable differential pressure sensor

iii. Starved box

iv. Actuator stall

v. Insufficient cooling

vi. Insufficient heating

q. The programmable VAV box controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The programmable VAV box controller would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.

r. The programmable VAV box controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality) and shall be capable of resetting the box minimum airflow based on the percent of outdoor air in the primary air stream.

s. The programmable VAV box controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

16. Models of programmable equipment controllers dedicated for general purpose applications (FX-PCG) shall be provided with the following characteristics:

a. The general purpose programmable equipment controllers shall support, but not be limited to, the following applications:

i. Terminal units

ii. Packaged rooftop units and heat pumps

iii. Built-up air handling units

iv. Chilled water/central plants

v. Heating central plants

vi. Special applications as required for systems control

b. The PCG shall be assembled in a plastic housing with flammability rated to UL94-5VB.

c. The general purpose programmable equipment controllers shall include input interface(s) to monitor the following analog signals, without the addition of equipment outside the controller cabinet:

i. 0-10 VDC sensors

ii. 4-20 mA sensors

iii. 0-2k ohm resistive temperature detector (RTDs)

iv. 10k Type L and 2.252k type 2 NTC thermistors

d. The general purpose programmable equipment controllers shall include input interface(s) to monitor the following binary signals:

i. Dry contact closures, with filtering to eliminate false signals resulting from input "bouncing".

ii. Pulse Counter/Accumulator Mode (high speed), 100 Hz

e. The general purpose programmable equipment controllers' input interfaces shall be internally isolated from power, communications, and output circuits, for noise immunity.

f. The general purpose programmable equipment controllers shall include output interface(s) with the following characteristics:

i. 0-10 VDC analog output

ii. 4-20 mA analog output

iii. SPST triac output rated for 500mA at 24 VAC.

g. The general purpose programmable equipment controllers' output interfaces shall be internally isolated from power, communications, and other output circuits for noise immunity.

Note: Item (g) below specifies an integrated display/keypad. Remove from specification if not used on the project.

h. The general purpose programmable equipment controllers shall support an optional, display/keypad integrated into the controller's housing face, with the following characteristics:

i. The integrated display/keypad shall allow the user to view monitored points without logging into the system.

ii. The integrated display/keypad shall allow the user to view and change setpoints, modes of operation, and parameters.

iii. The integrated display/keypad shall provide password protection with user adjustable password timeout.

iv. The integrated display/keypad shall be menu driven with separate paths for:

- Input/Output
- Parameter/Setpoint
- Overrides

v. The integrated display/keypad shall use easy-to-read English text messages.

vi. The integrated display/keypad shall allow the user to select the points to be shown and in what order.

vii. The integrated display/keypad shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.

viii. The integrated display/keypad shall be a minimum of 4 lines and a minimum of 20 characters per line.

ix. The integrated display/keypad shall have a keypad with no more than 6 keys.

17. Models of programmable equipment controllers dedicated for advanced control applications (FX-PCA) shall be provided with the following characteristics:

a. The advanced application equipment controllers shall support, but not be limited to, the following applications:

i. Packaged rooftop units and heat pumps

ii. Built-up air handling units

iii. Chilled water/central plants

iv. Heating central plants

v. Special applications as required for systems control

vi. Chilled water/central plant optimization applications including but not limited to:

- Selection and sequencing of up to eight chillers of different sizes
- Selection and sequencing of up to eight (each) primary and secondary chilled water pumps of varying pumping capacities
- Selection and sequencing of up to eight condenser water pumps
- Selection and sequencing of cooling towers and bypass valve, including single speed, multi-speed, and Vernier control
- Selection and sequencing of up to four heat exchangers, of different capacities
- A proven and documented central cooling plant optimization program that incorporates custom equipment efficiency profiles, without rewriting software code, in order to meet the building load using the least amount of energy as calculated.
- The use of advanced control algorithms that apply equipment specific parameters, including operational limits and efficiency profiles, in order to determine equipment start and runtime preferences
- Identification of the most efficient equipment combination and automatic control of state and speed of all necessary equipment to balance runtime, optimize timing and sequencing and ensure the efficiency and stability of the central cooling plant

vii. Equipment not using a networked supervisory controller or where it is preferred to have the scheduling, alarming, and/or trending performed locally in the equipment controllers.

b. The PCA controllers shall communicate via BACnet MS/TP or BACnet/IP communication protocols, depending on the model.

c. The PCA shall be assembled in a plastic housing with flammability rated to UL94-5VB.

d. The advanced application equipment controllers shall include an integral real-time clock which enables them to locally provide the following time-based application services:

i. Scheduling

ii. Alarming

iii. Trending

e. The advanced application equipment controllers shall continue time-based monitoring when offline from a supervisory controller for extended periods of time.

f. The advanced application equipment controllers shall include input interface(s) to monitor the following analog signals, without the addition of equipment outside the controller cabinet:

i. 0-10 VDC sensors

ii. 4-20 mA sensors

iii. 0-2k ohm resistive temperature detector (RTDs)

iv. 10k Type L and 2.252k type 2 NTC thermistors

g. The advanced application equipment controllers shall include input interface(s) to monitor the following binary signals:

i. Dry contact closures, with filtering to eliminate false signals resulting from input "bouncing".

ii. Pulse Counter/Accumulator Mode (high speed), 100 Hz

h. The advanced application equipment controllers shall be internally isolated from power, communications, and output circuits, for noise immunity.

i. The advanced application equipment controllers shall include output interface(s) with the following characteristics:

i. 0-10 VDC analog output

ii. 4-20 mA analog output

iii. SPST triac output rated for 500mA at 24 VAC.

iv. SPST relay outputs

v. SPDT relay outputs

j. The advanced application equipment controllers' output interfaces shall be internally isolated from power, communications, and other output circuits for noise immunity.

k. The advanced application equipment controllers shall support an optional, display/keypad integrated into the controller's housing face, with the following characteristics:

i. The integrated display/keypad shall allow the user to view monitored points without logging into the system.

ii. The integrated display/keypad shall allow the user to view and change setpoints, modes of operation, and parameters.

iii. The integrated display/keypad shall provide password protection with user adjustable password timeout.

iv. The integrated display/keypad shall be menu driven with separate paths for:

- Input/Output
- Parameter/Setpoint
- Overrides

v. The integrated display/keypad shall use easy-to-read English text messages.

vi. The integrated display/keypad shall allow the user to select the points to be shown and in what order.

vii. The integrated display/keypad shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.

viii. The integrated display/keypad shall be a minimum of 4 lines and a minimum of 20 characters per line.

ix. The integrated display/keypad shall have a keypad with no more than 6 keys.

18. Models of programmable equipment controllers dedicated for chilled beam applications (FX-PCV1656) shall be provided with the following characteristics:

    a. The programmable chilled beam controllers shall include an integrated 4 Nm, non-spring return actuator and ball valve linkage for use with the Johnson Controls VG-1000 1/2 - 1 inch valves.

    b. The programmable chilled beam controllers shall include input interface(s) to monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

        i. 0-10 VDC sensors

        ii. 0-2k ohm resistive temperature detector (RTDs)

        iii. 10k Type L and 2.252k type 2 NTC thermistors

    c. The programmable chilled beam controllers shall include input interface(s) to monitor dry contact closures, with filtering to eliminate false signals resulting from input "bouncing".

    d. The programmable chilled beam controllers input interfaces shall be internally isolated from power, communications, and output circuits, for noise immunity.

    e. The programmable chilled beam controllers shall include output interface(s) with the following characteristics:

        i. 0-10 VDC analog output

        ii. SPST triac output rated for 500mA at 24 VAC.

    f. The programmable chilled beam controllers' output interfaces shall be internally isolated from power, communications, and other output circuits for noise immunity.

    g. The programmable chilled beam controller shall include an integral actuator and ball valve linkage for use with the Johnson Controls VG-1000 1/2 - 1 inch valves.

Field Bus Network

1. The field bus network shall support communications and data exchange between the equipment controller(s) and the supervisory controller(s).
2. The field bus network shall be a MS/TP Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
3. The field bus network cabling shall be 22 AWG, stranded, 3-wire twisted, shielded cable.
4. End of line (EOL) termination shall be used on the two devices located at either end of each field bus network segment.
5. The field bus network shall support a maximum 3 bus segments.
6. A field bus network segment shall support a maximum of 32 devices.
7. Each field bus network segment shall be up to 1,220 m (4,000 ft) in length.
8. Each field bus network shall be up to 3,660 m (12,000 ft) in length.
9. End of line (EOL) termination shall be used on the two devices located at either end of each field bus network segment.

Note: Item 2F below specifies the ZFR Pro Series Wireless Field Bus System. Remove from spec if not used on project.

ZFR Pro Series Wireless Field Bus System

10. The ZFR Pro Series System shall employ ZigBee technology to create a wireless mesh network to provide wireless connectivity for programmable equipment controllers and network room sensors. Wireless devices shall co-exist on the same network with hardwired devices. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.
11. The wireless network coordinator (WNC) shall provide a wireless interface between a supervisory controller's BACnet IP network and supported programmable equipment controllers and network thermostats. Each wireless mesh network shall be provided with a wireless network coordinator for initiation and formation of the network
12. The wireless network coordinator shall use direct sequence spread spectrum RF technology.
13. The wireless network coordinator shall operate on the 2.4 GHZ ISM Band.
14. The wireless network coordinator shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
15. The wireless network coordinator shall be FCC compliant to CFR Part 15 subpart B Class A.
16. The wireless network coordinator shall include a separately mountable radio, housed in either a wall-mount or conduit-mount package.
17. The wireless network coordinator radio shall operate as a bidirectional transceiver with the sensors and routers to confirm and synchronize data transmission.
18. The wireless network coordinator shall be capable of communication with sensors and routers up to a maximum distance of 250 feet (line of sight).
19. The wireless network coordinator shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.
20. The wireless network coordinator shall include diagnostic indicators to provide information required for efficient operation and commissioning.
21. The wireless field bus router(s) shall be used with any model programmable equipment controller to provide a wireless interface to the supervisory controller via the wireless network coordinator, and to associated WRZ wireless room sensors.
22. The wireless field bus router(s) shall support be mounted separately from the programmable equipment controllers, and be housed in either a wall-mount or conduit-mount package.
23. The wireless field bus router(s) shall use direct sequence spread spectrum RF technology.
24. The wireless field bus router(s) shall operate on the 2.4 GHZ ISM Band.
25. The wireless field bus router(s) shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
26. The wireless field bus router(s) shall be FCC compliant to CFR Part 15 subpart B Class A.
27. The wireless field bus router(s) shall operate as a bidirectional transceiver with other mesh network devices to ensure network integrity.
28. The wireless field bus router(s) shall be capable of communication with other mesh network devices.
29. The wireless field bus router(s) shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.
30. The wireless field bus router(s) shall provide LED indication for use in commissioning and troubleshooting that can be disabled.

31. The wireless field bus router(s) shall support the ability to be used alternatively as a wireless repeater should the network design require it.

Network Thermostats (TEC3xxx Series)

1. Network Thermostat – Fan Coil and Zoning
    a. The network thermostat shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters, a pressure dependent VAV System, zoning type systems employing reheat including local hydronic reheat valves, or other similar equipment.
    b. The Networked Thermostat shall communicate over the FC Bus using BACnet Standard protocol SSPC-135 or Johnson Controls N2 protocol.
        i. Communications shall be selectable locally at thermostat through the display.
    c. The TEC shall be BTL listed/certified and carry the BTL Label.
        i. The TEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
        ii. A BACnet Protocol Implementation Conformance Statement shall be provided for the TEC.
        iii. The Conformance Statement shall be submitted 10 days prior to bidding.
    d. The network thermostat shall include a 4.2 inch LED backlit touch screen with the following configurable icons.
        i. Home screen configurable icons include:
            - On/Off icon
            - Fan override icon
            - Zone temperature icon
            - Hold temperature icon
            - Zone humidity (on applicable models) icon
            - Occupancy status (on applicable models) icon
            - Temperature setpoint icon
            - Alarm icon
            - Unit status icon
            - Date/Time icon
            - Fan override icon
        ii. Home screen non-configurable icon includes:
            - Menu icon
    e. The network thermostat shall provide the flexibility to support any one of the following inputs:
        i. Integral indoor air temperature sensor.
        ii. Analog input for remote air temperature sensing that supports the following sensor types.
            - Nickel
            - Platinum
            - A99B PENN
            - 2.25k ohm NTC
            - 10k ohm NTC
            - 10k ohm NTC Type 3

iii. Universal input that supports the following configurations:
- Analog sensor
- Cooling when switch is closed
- Heating when switch is closed

iv. Remote indoor air temperature sensor.

v. Two configurable binary inputs with the following configurations:
- Disabled
- Occupancy
- Override
- Remote PIR
- Dirty filter
- Service
- Fan Lock
- Open door
- Open window

f. The network thermostat shall provide 4 digit passcode security.

g. The network thermostat shall employ nonvolatile EEPROM for all adjustable parameters.

h. The network thermostat shall have a temperature accuracy of ±0.9°F/±0.5°C at 70.0°F/21.0°C typical calibrated.

i. The network thermostat shall have a humidity accuracy of ±5% RH from 20 to 80% RH at 50 to 90°F (10 to 32°C.)

j. The network thermostat shall provide user equipment visibility from a mobile device through the MAP.

k. On/off or floating fan coil and zoning applications:

i. The network thermostat shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters, a pressure dependent VAV System, zoning type systems employing reheat including local hydronic reheat valves, or other similar equipment.

l. The network thermostat shall provide the flexibility to support any one of the following fan outputs:

i. Three speed fan control

ii. Proportional speed fan control configurable from 0 to 10V

m. The network thermostat shall provide the flexibility to support any one of the following valve outputs:

i. Two on/off

ii. Two floating

n. The network thermostat shall provide the flexibility to adjust the following control parameters:
- Adjustable maximum setpoint offset from 0 to 20˚F
- Adjustable fan on delay from 0 to 120 seconds
- Adjustable fan off delay from 0 to 120 seconds
- Adjustable minimum cooling on time from 0 to 360 seconds
- Adjustable minimum cooling off time from 0 to 360 seconds
- Adjustable minimum heating on time from 0 to 360 seconds

- Adjustable minimum heating off time from 0 to 360 seconds
- Adjustable minimum reheat on time from 0 to 360 seconds
- Adjustable minimum reheat off time from 0 to 360 seconds
- Adjustable stroke time from 5 to 300 seconds
- Adjustable supply fan minimum command from 0 to 100%
- Adjustable supply fan Medium command from 0 to 100%
- Adjustable supply fan high command from 0 to 100%
- Adjustable reheat minimum damper position from 0 to 100%

o. Provide Johnson Controls TEC361x or approved equal as indicated on plans.

2. Network Thermostat– RTU/heat pump with economizer

a. The network thermostat shall be capable of controlling the following types of split or packaged units:

i. Cooling only units

ii. Cooling units with gas or electric heat

iii. Heat pumps

iv. Units with economizers

b. The Networked Thermostat shall communicate over the FC Bus using BACnet Standard protocol SSPC-135 or Johnson Controls N2 protocol.

i. Communications shall be selectable locally at thermostat through the display.

c. The TEC shall be BTL listed/certified and carry the BTL Label.

i. The TEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).

ii. A BACnet Protocol Implementation Conformance Statement shall be submitted for the TEC.

iii. The Conformance Statement shall be submitted 10 days prior to bidding.

d. The network thermostat shall include a 4.2 inch LED backlit touch screen with the following configurable icons.

i. Home screen configurable icons include:

- On/Off icon
- Fan override icon
- Zone temperature icon
- Hold temperature icon
- Zone humidity (on applicable models) icon
- Occupancy status (on applicable models) icon
- Temperature setpoint icon
- Alarm icon
- Unit status icon
- Date/Time icon
- Fan override icon

- Home screen non-configurable icon includes:
- Menu icon

e. The network thermostat shall provide the flexibility to support any one of the following inputs:
   i. Integral indoor air temperature sensor.
   ii. Analog input for remote air temperature sensing that supports the following sensor types:
      - Nickel
      - Platinum
      - A99B PENN
      - 2.25k ohm NTC
      - 10k ohm NTC
      - 10k ohm NTC Type 3
   iii. Remote indoor air temperature sensor.
   iv. Analog input for outdoor air temperature sensor.
   v. Analog input for remote temperature monitoring.
   vi. Two configurable binary inputs with the following configurations:
      - Disabled
      - Occupancy
      - Override
      - Remote PIR
      - Dirty filter
      - Service
      - Fan Lock
      - Open door
      - Open window
f. The network thermostat shall provide the flexibility to support any one of the following outputs:
   i. Up to two heating stages
   ii. Up to two cooling stages
g. The network thermostat shall provide 4 digit passcode security.
h. The network thermostat shall provide the flexibility to adjust the following control parameters:
   i. Adjustable compressor minimum on time from 0 to 360 seconds
   ii. Adjustable compressor minimum off time from 0 to 360 seconds
   iii. Adjustable maximum setpoint offset from 0 to 20˚F
   iv. Adjustable heating minimum on time from 0 to 360 seconds
   v. Adjustable heating minimum off time from 0 to 360 seconds
   vi. Adjustable cooling lockout temperature from 0 to 100˚F

vii. Adjustable heating lockout temperature from 0 to 100˚F

viii. Adjustable supplemental minimum on time from 0 to 360 seconds

ix. Adjustable supplemental minimum off time from 0 to 360 seconds

x. Adjustable economizer minimum position from 0 to 100%

xi. Adjustable economizer dry bulb setpoint from 0 to 100˚F

xii. Adjustable compressor low lockout temperature from -20 to 100˚F

xiii. Adjustable compressor high lockout temperature from -20 to 100˚F

i. The network thermostat shall employ nonvolatile electrically EEPROM for all adjustable parameters.

j. The network thermostat shall have a temperature accuracy of ±0.9°F/±0.5°C at 70.0°F/21.0°C typical calibrated.

k. Where required by application and indicated on plans or room schedules provide the network thermostat with an integral Passive Infra-Red (PIR) occupancy sensor model.

l. The network thermostat shall provide user equipment visibility from a mobile device through the MAP.

m. Provide Johnson Controls TEC363x or approved equal as indicated on plans.

3. Standalone Thermostat – Fan Coil and Zoning

a. The standalone thermostat shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters, a pressure dependent VAV system, zoning type systems employing reheat including local hydronic reheat valves, or other similar equipment.

b. The standalone thermostat shall include a 4.2 inch LED backlit touch screen with the following configurable icons.

i. Home screen configurable icons include:

- On/Off icon
- Fan override icon
- Zone temperature icon
- Hold temperature icon
- Zone humidity (on applicable models) icon
- Occupancy status (on applicable models) icon
- Temperature setpoint icon
- Alarm icon
- Unit status icon
- Date/Time icon
- Fan override icon

ii. Home screen non-configurable icon includes:

- Menu icon

c. The standalone thermostat shall provide the flexibility to support any one of the following inputs:

i. Integral indoor air temperature sensor.

ii. Analog input for remote air temperature sensing that supports the following sensor types:
- Nickel
- Platinum
- A99B PENN
- 2.25k ohm NTC
- 10k ohm NTC
- 10k ohm NTC Type 3

iii. Universal input that supports the following configurations.
- Analog sensor
- Cooling when switch is closed
- Heating when switch is closed

iv. Remote indoor air temperature sensor

v. Two configurable binary inputs with the following configurations.
- Disabled
- Occupancy
- Override
- Remote PIR
- Dirty filter
- Service
- Fan Lock
- Open door
- Open window

d. The standalone thermostat shall provide 4 digit passcode security.

e. The standalone thermostat shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

f. The standalone thermostat shall have a temperature accuracy of ±0.9F°/±0.5C° at 70.0°F/21.0°C typical calibrated.

g. The standalone thermostat shall have a humidity accuracy of ±5% RH from 20 to 80% RH at 50 to 90°F (10 to 32°C.)

h. On/Off or Floating fan coil and zoning applications.

i. The standalone thermostat shall provide the flexibility to support any one of the following fan outputs:
- Three speed fan control
- Proportional speed fan control configurable from 0 to 10V

ii. The standalone thermostat shall provide the flexibility to support any one of the following valve outputs:

- Two on/off
- Two floating

iii. The standalone thermostat shall provide the flexibility to adjust the following control parameters:

- Adjustable maximum setpoint offset from 0 to 20°F
- Adjustable fan on delay from 0 to 120 seconds
- Adjustable fan off delay from 0 to 120 seconds
- Adjustable minimum cooling on time from 0 to 360 seconds
- Adjustable minimum cooling off time from 0 to 360 seconds
- Adjustable minimum heating on time from 0 to 360 seconds
- Adjustable minimum heating off time from 0 to 360 seconds
- Adjustable minimum reheat on time from 0 to 360 seconds
- Adjustable minimum reheat off time from 0 to 360 seconds
- Adjustable stroke time from 5 to 300 seconds
- Adjustable supply fan minimum command from 0 to 100%
- Adjustable supply fan Medium command from 0 to 100%
- Adjustable supply fan high command from 0 to 100%
- Adjustable reheat minimum damper position from 0 to 100%

iv. Provide Johnson Controls TEC331x or approved equal as indicated on plans.

i. Proportional fan coil and zoning applications

i. The standalone thermostat shall provide the flexibility to support any one of the following fan outputs:

- Three speed fan control
- Proportional speed fan control configurable from 0 to 10V

ii. The standalone thermostat shall provide the flexibility to support the following valve outputs:

- Two proportional configurable from 0 to 10V

iii. The standalone thermostat shall provide the flexibility to adjust the following control parameters:

- Adjustable maximum setpoint offset from 0 to 20°F
- Adjustable fan on delay from 0 to 120 seconds
- Adjustable fan off delay from 0 to 120 seconds
- Adjustable minimum reheat on time from 0 to 360 seconds
- Adjustable minimum reheat off time from 0 to 360 seconds
- Adjustable supply fan minimum command from 0 to 100%
- Adjustable supply fan Medium command from 0 to 100%
- Adjustable supply fan high command from 0 to 100%

- Adjustable reheat minimum damper position from 0 to 100%
- Adjustable proportional valve opened voltage from 0 to 10 VDC
- Adjustable proportional valve closed voltage from 0 to 10 VDC

iv. Provide Johnson Controls TEC322x or approved equal as indicated on plans.

v. Where required by application and indicated on plans or room schedules provide the standalone thermostat with an integral Passive Infra-Red (PIR) occupancy sensor with a field of 94 angular degrees up to a distance of 15 ft., clear line of sight.

vi. Where required by application and indicated on plans or room schedules provide the standalone thermostat with an integral relative humidity sensor.

4. Standalone Thermostat – RTU/heat pump with economizer

a. The standalone thermostat shall be capable of controlling the following types of split or packaged units:

- Cooling only units
- Cooling only units with gas or electric heat
- Heat pumps
- Units with economizers

b. The standalone thermostat shall include a 4.2 inch LED backlit touch screen with the following configurable icons.

i. Home screen configurable icons include:

- On/Off icon
- Fan override icon
- Zone temperature icon
- Hold temperature icon
- Zone humidity (on applicable models) icon
- Occupancy status (on applicable models) icon
- Temperature setpoint icon
- Alarm icon
- Unit status icon
- Date/Time icon
- Fan override icon

ii. Home screen non-configurable icon includes:

- Menu icon

c. The standalone thermostat shall provide the flexibility to support any one of the following inputs:

i. Integral indoor air temperature sensor.

ii. Analog input for remote air temperature sensing that supports the following sensor types:

- Nickel

- Platinum
- A99B PENN
- 2.25k ohm NTC
- 10k ohm NTC
- 10k ohm NTC Type 3

iii. Remote indoor air temperature sensor.

iv. Analog input for outdoor air temperature sensor.

v. Analog input for remote temperature monitoring.

vi. Two configurable binary inputs with the following configurations:

- Disabled
- Occupancy
- Override
- Remote PIR
- Dirty filter
- Service
- Fan Lock
- Open door
- Open window

d. The standalone thermostat shall provide the flexibility to support the following outputs:

i. Up to two heating stages

ii. Up to two cooling stages

e. The standalone thermostat shall provide 4 digit passcode security.

f. The standalone thermostat shall provide the flexibility to adjust the following control parameters:

- Adjustable compressor minimum on time from 0 to 360 seconds
- Adjustable compressor minimum off time from 0 to 360 seconds
- Adjustable maximum setpoint offset from 0 to 20°F
- Adjustable heating minimum on time from 0 to 360 seconds
- Adjustable heating minimum off time from 0 to 360 seconds
- Adjustable cooling lockout temperature from 0 to 100°F
- Adjustable heating lockout temperature from 0 to 100°F
- Adjustable supplemental minimum on time from 0 to 360 seconds
- Adjustable supplemental minimum off time from 0 to 360 seconds
- Adjustable economizer minimum position from 0 to 100%
- Adjustable economizer dry bulb setpoint from 0 to 100°F

- Adjustable compressor low lockout temperature from -20 to 100°F
- Adjustable compressor high lockout temperature from -20 to 100°F

g. Where required by application and indicated on plans or room schedules provide the standalone thermostat with an integral Passive Infra-Red (PIR) occupancy sensor model.

h. The standalone thermostat shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

i. The standalone thermostat shall have a temperature accuracy of ±0.9°F/±0.5°C at 70.0°F/21.0°C typical calibrated.

j. Proportional fan coil and zoning applications.

i. The network thermostat shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters, a pressure dependent VAV system, zoning type systems employing reheat including local hydronic reheat valves, or other similar equipment.

ii. The network thermostat shall provide the flexibility to support any one of the following fan outputs:

- Three speed fan control
- Proportional speed fan control configurable from 0 to 10V

iii. The network thermostat shall provide the flexibility to support the following valve outputs:

- Two proportional configurable from 0 to 10V

iv. The network thermostat shall provide the flexibility to adjust the following control parameters:

- Adjustable maximum setpoint offset from 0 to 20°F
- Adjustable fan on delay from 0 to 120 seconds
- Adjustable fan off delay from 0 to 120 seconds
- Adjustable minimum reheat on time from 0 to 360 seconds
- Adjustable minimum reheat off time from 0 to 360 seconds
- Adjustable supply fan minimum command from 0 to 100%
- Adjustable supply fan Medium command from 0 to 100%
- Adjustable supply fan high command from 0 to 100%
- Adjustable reheat minimum damper position from 0 to 100%
- Adjustable proportional valve opened voltage from 0 to 10 VDC
- Adjustable proportional valve closed voltage from 0 to 10 VDC

k. Provide Johnson Controls TEC362x or approved equal where indicated on plans.

l. Where required by application and indicated on plans or room schedules provide the network thermostat with an integral Passive Infra-Red (PIR) occupancy sensor.

m. Where required by application and indicated on plans or room schedules provide the network thermostat with an integral relative humidity sensor.

5. Network Sensors

a. The Network Sensors (NS) shall have the ability to monitor the following variables as required by the systems sequence of operations:

i. Zone Temperature
ii. Zone Humidity
iii. Zone Setpoint
iv. Discharge Air Temperature
v. Zone CO2

b. The NS shall transmit the information back to the controller on the SA Bus using BACnet Standard protocol SSPC-135.

c. The NS shall be BTL listed/certified and carry the BTL Label.
i. The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).
ii. A BACnet Protocol Implementation Conformance Statement shall be provided for the NS.
iii. The Conformance Statement shall be submitted 10 days prior to bidding.

d. The Network Zone Temperature Sensors shall include the following items:
i. A backlit LCD to indicate the temperature, humidity and setpoint
ii. An LED to indicate the status of the Override feature
iii. A button to toggle the temperature display between Fahrenheit and Celsius
iv. A button to program the display for temperature or humidity
v. A button to initiate a timed override command
vi. Available in either surface mount, wall mount, or flush mount
vii. Available with either screw terminals or phone jack

e. The Network Discharge Air Sensors shall include the following:
i. 4 inch or 8 inch duct insertion probe
ii. Ten foot pigtail lead
iii. Dip Switches for programmable address selection
iv. Ability to provide an averaging temperature from multiple locations
v. Ability to provide a selectable temperature from multiple locations

f. The Network CO2 Zone Sensors shall include the following:
i. Available in either surface mount or wall mount
ii. Available with screw terminals or phone jack
iii. Measurement range of 0-2000 ppm
iv. Sensing resolution of 1 ppm
v. Sensing accuracy of +/- 2% of the reading plus 40 ppm

g. Provide Johnson Controls NS series or approved equal where indicated on plans

6. Wireless Field Bus System

a. The Wireless Field Bus System shall employ standard IEEE802.15.4 technology to create a wireless mesh network to provide wireless connectivity for select BACnet devices at multiple system levels. This includes communications from equipment controllers to sensors and from engines to these field

controllers. Wireless devices shall co-exist on the same network with hardwired devices. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.

b. The Wireless Field Bus Router Gateway / Coordinator shall provide a wireless interface between supported equipment controllers and supervisory controllers (engines) via the BACnet field bus. Each wireless mesh network shall be provided with a zone coordinator for initiation and formation of the network.

   i. The Router Gateway / Coordinator shall function as a standard BACnet IP/MSTP Router.

   ii. The Router Gateway / Coordinator shall use direct sequence spread spectrum RF technology.

   iii. The Router Gateway / Coordinator shall operate on the 2.4 GHZ ISM Band.

   iv. The Router Gateway / Coordinator shall meet the IEEE 802.15.4 standard for low power, low duty-cycle RF transmitting systems.

   v. The Router Gateway / Coordinator shall be FCC compliant to CFR Part 15 subpart B Class A.

   vi. The Router Gateway / Coordinator shall operate as a bidirectional transceiver with the sensors and routers to confirm and synchronize data transmission.

   vii. The Router Gateway / Coordinator shall be capable of communication with sensors and routers up to a maximum distance of 250 Feet (typical, 1000 feet line of sight).

   viii. The Router Gateway / Coordinator radio function shall be capable of being mounted at a maximum distance of 100 feet away from the Gateway

   ix. The Router Gateway / Coordinator shall be available in a variety of mounting options including panel, conduit, wall, wall box, or ceiling mount.

   x. The Router Gateway / Coordinator shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VA.

   xi. The Router Gateway / Coordinator shall have multi-color LEDs to provide diagnostic information required for efficient operation and commissioning.

   xii. The Router Gateway / Coordinator shall support the user configuration of the wireless network PAN ID, power levels, and channels.

   xiii. The Router Gateway / Coordinator shall support user configuration of the wireless network sensor reporting times for battery life optimization.

   xiv. The Router Gateway / Coordinator shall support commissioning functionality to enable site optimization.

   xv. The Router Gateway / Coordinator shall support Secure Boot.

   xvi. The Router Gateway / Coordinator shall support 128bit AES secured communication across the wireless network

   xvii. The Router Gateway / Coordinator shall provide a secure user interface via a Wi-Fi or Ethernet connection using a mobile or desktop web browser to:

   xviii. Configure the wireless network settings.

   xix. View the connection status of the wireless enabled controllers.

   xx. View and edit the controller configurations.

c. View, edit and override controller values. The Wireless Field Bus Router shall be used with any model MSTP Equipment Controller or VAV Modular Assembly to provide a wireless interface to network engines, via the Coordinator, and associated Wireless Mesh Room Temperature Sensors.

i. The Router shall use direct sequence spread spectrum RF technology.

ii. The Router shall operate on the 2.4 GHZ ISM Band.

iii. The Router shall meet the IEEE 802.15.4 standard for low power, low duty-cycle RF transmitting systems.

iv. The Router shall be FCC compliant to CFR Part 15 subpart B Class A.

v. The Router shall operate as a bidirectional transceiver with other mesh network devices to ensure network integrity.

vi. The Router shall be capable of communication with other mesh network devices at a maximum distance of 250 feet (typical, 1000 feet line of sight).

vii. The Router shall be capable of being mounted at a maximum distance of 100 feet away from the equipment controller.

viii. The Router shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VA.

ix. The Router shall provide multi-color LED indication for use in commissioning and troubleshooting that can be disabled.

x. The Router shall be available in a variety of mounting options; plenum, conduit, wall, wall box, or ceiling mount.

xi. The Router shall support the ability to be used alternatively as a wireless repeater using 24VAC without the need for an external power supply.

d. The wireless room temperature sensors shall sense and transmit room temperatures, room set point, room occupancy notification, and low battery condition to an associated Router as dictated by specified sensor type.

i. The sensors shall use direct sequence spread spectrum RF technology.

ii. The sensors shall operate on the 2.4 GHZ ISM Band.

iii. The sensors shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.

iv. The sensors shall be FCC compliant to CFR Part 15 subpart B Class A.

v. The sensors shall be available with:

- Warmer/cooler setpoint adjustment
- No setpoint adjustment
- Setpoint adjustment scale – 55 to 85°F
- Temperature and humidity sensing
- Support for 10K and 3K ohm refrigerator/freezer temperature probe
- Support for NIST rated 3K ohm refrigerator/freezer temperature probe

vi. Wireless sensors shall be provided with display of room temperature, signal strength, fan mode, occupancy and network status as required by application and indicated on plans or in schedules.

vii. The sensors shall be assembled in NEMA 1 plastic housings.

e. Provide Johnson Controls ZFR coordinators and routers, with WRZ sensors, or approved equals, as shown on plans

7. One-to-One Wireless Room Temperature Sensor System
    a. The One-To-One Wireless Receiver shall receive wireless RF signals containing temperature data from multiple Wireless Room Temperature Sensors and communicate this information to the appropriate controller via the SA Bus.
        i. The Receiver shall use direct sequence spread spectrum RF technology.
        ii. The Receiver shall operate on the 2.4 GHZ ISM Band.
        iii. The Receiver shall meet the IEEE 802.15.4 standard for low power, low duty-cycle RF transmitting systems.
        iv. The Receiver shall be FCC compliant to CFR Part 15 subpart B Class A.
        v. The Receiver shall operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.
        vi. The Receiver shall be capable of communication with from one to five WRZ sensors up to a distance of 200 Feet.
        vii. The Receiver shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.
        viii. The Receiver shall have LED indicators to provide information regarding the following conditions:
            - Power
            - SA Bus – Receiver Activity/No Activity
            - Wireless RF – Transmission from sensors/No Transmission
            - Wireless Rapid Transmit Mode – No transmission/ weak signal/Adequate signal/Excellent signal
    b. The Sensors shall sense and report room temperatures to the WRZ Receiver.
        i. The sensors shall use direct sequence spread spectrum RF technology.
        ii. The sensors shall operate on the 2.4 GHZ ISM Band.
        iii. The sensors shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.
        iv. The sensors shall be FCC compliant to CFR Part 15 subpart B Class A.
        v. The sensors shall be available with:
            - Warmer/cooler setpoint adjustment
            - No setpoint adjustment
            - Setpoint adjustment scale – 55 to 85°F
        vi. The sensors shall be assembled in NEMA 1 plastic housings.
    c. Provide Johnson Controls WRZ series Receivers and Sensors, or approved equals, as shown on plans.

Automation Network

1. The automation network shall be based on a IT industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.

Note: Remove in (2) the following reference to BMS Server as required:

2. The BMS shall network multiple user interface clients, supervisory controllers, and equipment controllers. Provide BMS server as required for systems operation.
3. All BMS devices on the automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
4. Supervisory controllers and BMS server shall reside on the automation network.
5. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

Note: Item g specifies a BMS Server (FX Server). Remove from spec if not used on the project.

BMS Server (optional)

1. Where necessary and as dictated elsewhere in these Specifications, a BMS Server shall reside on the automation network and be used for the purpose of:
   a. Providing a location for extensive archiving of historical data, alarms, and operator transactions sourced from all supervisory controllers on the automation network.
   b. Centralizing the user interface for all supervisory controllers on the automation network.
   c. Centralizing the scheduling for all supervisory controllers on the automation network.
2. The BMS server software shall support being hosted on the following computer platforms:
   a. Processor: Intel® Xeon® CPU E5-2640, 64-bit (or better), compatible with dual and quad core processors
   b. Operating System: 64-bit: Windows® 10, Windows Server 2012 R2 Standard, Windows Server 2016.
   c. Memory: 6 GB minimum; 8 GB or more recommended for larger systems
   d. Hard Drive: 4 GB minimum, more recommended depending on archiving requirements.
   e. Display: video card and monitor capable of displaying 1024 x 768 pixel resolution or greater.
   f. Network Support: Ethernet adapter (10/100 Mb) with RJ-45 connector)
   g. Connectivity: Always on, high-speed Internet Service Provider (ISP) connection recommended for remote site access (DSL, T1, or cable modem) and IPv6 compliant
3. The BMS server shall include an embedded web server to support standard web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.
4. The BMS server shall support the automatic importing of one or more histories from the supervisory controller(s) for long term archival.
5. The BMS server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2. Non-standard and/or proprietary database APIs are **not** acceptable.
6. The BMS server's configuration software shall be embedded into the BMS server, enabling an authorized user to access the configuration software using a web browser.

Distributed user interface(s)

7. The BMS system shall utilize a distributed, web browser-based, graphical user interface, served up by the supervisory controller(s) and/or BMS server.

8. The distributed user interface shall require user login upon launching the web browser and selecting the appropriate domain name or IP address.
    a. Login shall require the user to enter username and strong password and be successfully authenticated.
    b. User access and control privileges within the system shall be based on the user's defined role as assigned by the system administrator.
9. The distributed user interface shall include the following features to allow operators to quickly find information within the system:
    a. A home page displaying the following information:

Note: Adjust items (i) through (v) below to match actual project requirements.

        i. Image of the building
        ii. Current outside air temperature, today's weather forecast, and tomorrow's weather forecast.
        iii. Links to devices
        iv. Links to schedules
        v. Links to point summaries
    b. A navigation tree listing a hierarchy of system components, including devices and data points.
    c. A navigation tree listing a hierarchy of the building's spaces, including any buildings, floors, and rooms, with links to the equipment, devices, and data points serving those spaces.
    d. Graphical, floor plan view of the building's spaces, embedded with dynamic links to the views of the equipment, devices, and data points serving those spaces.
10. The distributed user interface shall provide authorized operators with the following information about each data point in the system database:
    a. Identification
    b. Present value
    c. Status, including normal, overridden, offline, and in alarm.
11. The distributed user interface shall provide authorized operators a check-the-box method to add alarm, trend, and totalization extensions to any data point in the system.
12. The distributed user interface shall include the following point summaries to allow operators to quickly view data points that share certain attributes:

Note: Adjust items (a) through (e) below to match actual project requirements.

    a. All point summary
    b. Points-in-alarm summary
    c. Points-in-override summary
    d. Points-offline summary
    e. Non-normal points summary
13. The distributed user interface shall allow authorized operators to manually command writable data points in the system as part of a 16-level priority write method, defined as:
        i. 1-Emergency/Life Safety Manual Command

ii. 2-Automatic Life Safety
iii. 3-User Defined
iv. 4-User Defined
v. 5-Critical Equipment Control
vi. 6-Minimum On/Off
vii. 7-User Defined
viii. 8-Override (Manual Operator Command)
ix. 9-Demand Limiting
x. 10-User Defined
xi. 11-Temperature Override
xii. 12-Stop Optimization
xiii. 13-Start Optimization
xiv. 14-Duty Cycling
xv. 15-Outside Air Optimization
xvi. 16-Schedule

14. The distributed user interface shall allow authorized operators to issue temporary (adjustable time) or permanent manual commands to writable data points in the system.
15. The distributed user interface shall include an alarm console for authorized users to perform the following alarm management functions:
    a. Authorized operators shall be allowed to view all alarms routed to the alarm console, with the following information:
        i. Time stamp
        ii. Source state
        iii. Acknowledge state
        iv. Source
        v. Alarm class
        vi. Priority
        vii. Message text
    b. Authorized operators shall be allowed to apply the following filters to include or exclude alarms shown on the alarm console:
        i. Source state
        ii. Acknowledge state
        iii. Acknowledge required
        iv. Source
        v. Alarm class
        vi. Priority

vii. Normal time range
viii. Acknowledge time range
ix. User
x. Alarm data
xi. Alarm transition
xii. Last update time range

c. Authorized operators shall be allowed to acknowledge alarms, either individually or in bulk using the Shift or Ctrl keys.

d. Authorized operators shall be allowed to select an alarm occurrence in the alarm console and link to the view in the system showing the alarm source.

e. Authorized users shall be allowed to add a note to one or more alarm records simultaneously to provide historical context for the event that trigged the alarm.

f. Authorized operators shall be allowed to silence the audible alarm for one or more alarm sources.

16. The distributed user interface shall include an alarm database maintenance view for authorized users to delete alarm records from the alarm database, but only after the alarms have been acknowledged and the alarm source has returned to a normal (no longer in alarm) state.

17. The distributed user interface shall include a history chart view for operators to view historical and live data in a chart over time.

a. The distributed user interface shall allow authorized operators to customize the appearance of the history charts in on or more of the following ways:

i. Chart type, included any one of the following:

- Line chart
- Area chart
- Bar chart
- Stacked bar chart
- Discrete line chart
- Discrete area chart
- Pie chart

ii. X and Y axis range
iii. Data, background, and status colors
iv. Axis orientation
v. Data source zooming
vi. Turning the chart grid on/off
vii. Data popups

b. The distributed user interface shall allow operators to view multiple data points simultaneously per history chart.

c. The distributed user interface shall provide a “time zone-less” time range configuration so that operators can plot each history chart with reference to its own time zone, resulting in charts that are aligned by local time.

18. The distributed user interface shall include a history database maintenance view allowing authorized users to delete history records from the history database.

19. The distributed user interface shall allow authorized operators to export selected histories as either a table of data in a comma separated variable (*.csv) format or as the selected chart view.

20. The distributed user interface shall allow authorized operators to view, define, and change the normal, regular, and repeating events in the system schedule using a weekly scheduler view.

21. The distributed user interface shall allow authorized operators to view, define, and change partial day exceptions to the system schedule.

22. The distributed user interface shall include a calendar view to allow operators to define, and change the special events in the system schedule.

System Tools

1. Supervisory Controller Configuration Tool (FX Workbench)

   a. The supervisory controller configuration tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a supervisory controller or BMS server.

   b. The supervisory controller configuration tool shall create a station database for the configuration and application data.

   c. The supervisory controller configuration tool shall have the same look-and-feel as the distributed user interface, regardless of whether the configuration is being done online or offline.

   d. The supervisory controller configuration tool shall include the following features:

      i. System component navigation tree for configured networks

      ii. Integration of BACnet, N2, Lonworks, MODBUS, and supported 3rd party integrated devices

      iii. Configuration of customized user navigation trees

      iv. Graphic view design, layout, and data source binding

      v. Alarm and event configuration

      vi. Historical data management configuration

      vii. Schedule configuration

      viii. Graphical logic connector tool for custom programming

      ix. Copying, transferring, and archiving databases

   e. The supervisory controller configuration tool shall have the capability to automatically create the following station components for Facility Explorer brand FX-PC Programmable Controllers (FX-PCG, FX-PCA, FX-PCV), Equipment Controllers and Expansion Modules (CV Series, CG Series, XPMs), TEC3000 Network Thermostats, Legacy FX Field Controllers (FX07, FX14, FX16, FXVMA), EM-1000 and EM-2000 Series Electric Meters, and Legacy Facility Explorer Application Specific Controllers (DX-9100, UNT, VMA14xx).

      i. Devices

      ii. Points

      iii. Default trend, alarm, and totalization extensions

iv. Graphic views (Px views)

2. Controller Configuration Tool (CCT)

a. As part of the single software tool environment including system and controller elements, the Controller Configuration Tool (CCT) shall be used to configure, simulate and commission equipment controllers (For example, the CG Series, the CV Series, XPMs, PCAs, PCGs, PCVs, and PCXs) and the F4-SNC Supervisory Controller.

b. The CCT shall operate in distinct modes to facilitate efficiency at various steps in the steps leading to project completion as well as future upgrades and maintenance:

i. The configuration mode allows users to select various mechanical and control logic options through selection trees for typical air handling, terminal unit, central plant, and VAV applications.

ii. The simulation mode allows the user to review all application logic as if the device were operating in a connected systems environment.

iii. The commissioning mode allows users to validate all sensor and control point interfaces and to adjust key setpoints and setup parameters once the device is mounted and connected in an operational environment.

c. The configuration tool shall be capable of programming the equipment controllers.

i. The configuration tool shall provide the capability to configure, simulate, and commission the equipment controllers.

ii. The configuration tool shall allow the equipment controllers to be run in Simulation Mode to verify the applications.

iii. The configuration tool shall contain a library of standard applications to be used for configuration.

d. The CCT shall provide multiple options for downloading files to the controllers including direct wired, wireless and Ethernet pass thru as dictated by controller type and location.

e. Provide Johnson Controls CCT or approve equal.

Note: Delete any the System Tools that are not being supplied to the owner at project completion for troubleshooting and systems maintenance

3. Handheld VAV Balancing Sensor (FX-ATV7003)

a. The sensor shall be a light weight portable device of dimensions not more than 3.2 x 3.2 x 1.0 inches.

b. The sensor shall be capable of displaying data and setting balancing parameters for VAV control applications.

c. The sensor shall be powered through a connection to either the Sensor-Actuator (SA) or the Field Controller (FC) Bus.

d. The sensor shall be a menu driven device that shall modify itself automatically depending upon what type of application resides in the controller.

e. The sensor shall contain a dial and two buttons to navigate through the menu and to set balancing parameters.

f. The sensor shall provide an adjustable time-out parameter that will return the controller to normal operation if the balancing operation is aborted or abandoned.

g. The sensor shall include the following

i. 5 foot retractable cable

ii. Laminated user guide

iii. Nylon caring case

h. The sensor shall be Underwriters Laboratory UL 916 listed and CSA certified C22.2 N. 205, CFR47.

4. System Configuration Tool
   a. The Configuration Tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a supervisory controller.
   b. The configuration tool shall provide an archive database for the configuration and application data.
   c. The configuration tool shall have the same look-and-feel at the Site Management Portal user interface regardless of whether device configuration is being done online or offline.
   d. The configuration tool shall include the following features:
      i. Basic system navigation tree for connected networks
      ii. Integration of Johnson Controls N1, LonWorks, and BACnet enabled devices
      iii. Customized user navigation trees
      iv. Point naming operating parameter setting
      v. Graphic diagram configuration
      vi. Alarm and event message routing
      vii. Graphical logic connector tool for custom programming
      viii. Downloading, uploading, and archiving databases
   e. The configuration tool shall provide a site discovery feature to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:
      i. BACnet Devices
   f. A wireless access point shall allow a wireless enabled portable PC to make a temporary Ethernet connection to the automation network.
   g. The wireless connection shall allow the PC to access configuration tool through the web browser using the user interface.
   h. The wireless use of configuration tool shall be the same as a wired connection in every respect.
   i. The wireless connection shall use the Bluetooth Wireless Technology.
   j. Provide Johnson Controls SCT or approved equal.

Miscellaneous Devices

1. Variable Frequency Motor Speed Control Drives
   a. The variable speed drives and all components shall be designed, manufactured and tested in accordance with the latest applicable standards.
      i. Institute of Electrical and Electronic Engineers (IEEE)
         - IEEE 519-1992: Guide for harmonic content and control
      ii. Underwriters Laboratories (UL508C: Power Conversion Equipment)
         - UL
         - cUL
      iii. National Electrical Manufacturer’s Association (NEMA)
         - ICS 7.0: Industrial Controls & Systems for VSD’s.
      iv. EN 61000-3-12, EN 61800-3 (1996) +A11 (2000) Category C2
         - Fulfill all EMC immunity requirements

b. Variable speed drives through 250 HP shall have the following features:

i. The VSD may be designed in a NEMA Type 1, NEMA 12, or NEMA 3R enclosure.

ii. Incoming Power: Three-phase, 208 / 240 / 480 (+10% to -10%) and 50/60 Hz (+10 to -5%). The VSD shall provide microprocessor-based control for three-phase induction motors. The controller's full load output current rating shall be based on a low overload application at 40° C ambient and 1.5 - 10 kHz switching frequency with automatic switching frequency de-rating in case of overload.

iii. Humidity: 0 to 95% (non-condensing and non-corrosive).

iv. Altitude: 0 to 3,300 feet (1000 meters) above sea level.

v. Ambient Temperature: -10 to 40°C (VT).

vi. Storage Temperature: -40 to 70°C.

vii. The VSD's shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation.

viii. The VSD's shall have an efficiency at full load and speed that exceeds 97%. The efficiency shall exceed 90% at 50% speed.

ix. The VSD's shall maintain a minimum line side displacement power factor of 0.96, regardless of speed and load for VFD's less than 75 HP. The VSD's shall maintain a minimum line side displacement power factor of .99, regardless of speed and load for motors greater than 75 HP.

x. The VSD's shall have a one (1) minute overload current rating of 110% for low overload applications.

xi. The current withstand rating of the drive shall be 100,000 AIC.

xii. The VSD's shall be capable of operating any NEMA design B squirrel cage induction motor, regardless of manufacturer, with a horsepower and current rating within the capacity of the VSD.

xiii. The VSD's shall have an integral EMI/RFI filter as standard.

xiv. VFD must contain a circuit breaker or fused disconnect as an option.

xv. Total harmonic distortion shall be calculated based on total demand distortion conditions as defined in IEEE 519-1992.

xvi. Any harmonic calculations shall be done based on the kVA capacity, X/R ratio and the impedance of the utility transformer feeding the installation, as noted on the drawings, and the total system load.

xvii. Built in Communication capability for interface with RS-485 (ModBus RTU) (Johnson Controls N2) (MS/TP BACnet) or Ethernet (BACnet/IP) (Modbus/TCP).

xviii. Communication capability via expansion card to support RS-485 includes Johnson Controls SA Bus or LonWorks

Note: VFD specifications can be removed from here and used in other specification sections. Edit as required based on project scope.

2. Local Control Panels

a. All control panels shall be factory constructed, incorporating the BMS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance.

b. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.

Note: Delete items (c) and (d) below if not required

c. Control panels shall include panel louvers.

d. Control panels shall include keyed lock.

e. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.

f. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.

g. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.

h. All wiring shall be neatly installed in plastic trays or tie-wrapped.

i. A 120 volt convenience outlet, fused on/off power switch, and required transformers shall be provided in each enclosure.

3. Power Supplies

a. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.

b. Input: 120 VAC +10%, 60Hz.

c. Output: 24 VDC.

d. Line Regulation: +0.05% for 10% line change.

e. Load Regulation: +0.05% for 50% load change.

f. Ripple and Noise: 1 mV rms, 5 mV peak to peak.

g. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.

h. A power disconnect switch shall be provided next to the power supply.

Part 3 – Performance/Execution

BMS Specific Requirements

Note: Edit or delete item (1) below according to project requirements.

1. Graphic Displays

a. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

b. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

2. Custom Reports:

a. Provide custom reports as required for this project

Note: Edit or delete item (3) below according to project requirements.

3. Actuation / Control Type

a. Primary Equipment

i. Controls shall be provided by equipment manufacturer as specified herein.

ii. All damper and valve actuation shall be electric.

b. Air Handling Equipment

i. All air handlers shall be controlled with a HVAC-DDC Controller

ii. All damper and valve actuation shall be electric.

c. Terminal Equipment:

i. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.

ii. All Terminal Units shall be controlled with HVAC-DDC Controller)

Installation Practices

1. BMS Wiring

a. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.

b. All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.

c. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BMS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BMS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

d. Class 2 Wiring

i. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.

ii. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5’ from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.

e. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.

f. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

2. BMS Line Voltage Power Source

a. 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 16.

b. Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.

c. DDC terminal unit controllers may use AC power from motor power circuits.

3. BMS Raceway

a. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2”.

b. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.

c. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and

shall follow the contours of the surface to which they are attached.

d. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

4. Penetrations

a. Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.

b. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.

c. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.

d. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

5. BMS Identification Standards

a. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.

b. Cable types specified in Item A shall be color coded for easy identification and troubleshooting.

6. BMS Panel Installation

a. The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.

b. The BMS Contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

7. Input Devices

a. All Input devices shall be installed per the manufacturer recommendation

b. Locate components of the BMS in accessible local control panels wherever possible.

8. HVAC Input Devices – General

a. All Input devices shall be installed per the manufacturer recommendation

b. Locate components of the BMS in accessible local control panels wherever possible.

c. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.

d. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.

e. Outside Air Sensors

i. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.

ii. Sensors shall be installed with a rain proof, perforated cover.

f. Water Differential Pressure Sensors

i. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.

ii. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.

iii. The transmitters shall be installed in an accessible location wherever possible.

g. Medium to High Differential Water Pressure Applications (Over 21" w.c.):

i. Air bleed units, bypass valves and compression fittings shall be provided.

h. Building Differential Air Pressure Applications (-1" to +1" w.c.):

i. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.

ii. The interior tip shall be inconspicuous and located as shown on the drawings.

Note: Edit or delete item (i) below according to project requirements.

i. Air Flow Measuring Stations:

i. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.

ii. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

j. Duct Temperature Sensors:

i. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

ii. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.

iii. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.

iv. The sensor shall be mounted to suitable supports using factory approved element holders.

k. Space Sensors:

i. Shall be mounted per ADA requirements.

ii. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

l. Low Temperature Limit Switches:

i. Install on the discharge side of the first water or steam coil in the air stream.

ii. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.

iii. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.

m. Air Differential Pressure Status Switches:

i. Install with static pressure tips, tubing, fittings, and air filter.

n. Water Differential Pressure Status Switches:

i. Install with shut off valves for isolation.

o. HVAC Output Devices

i. All output devices shall be installed per the manufacturers recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.

ii. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

iii. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.

iv. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.

v. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building

Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

Note: Edit or delete item (3.C) below according to project requirements.

Training

1. The BMS Contractor shall provide the following training services:
    a. One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

Note: Edit or delete item (3.D) below according to project requirements.

Commissioning

1. Fully commission all aspects of the Building Management System work.
2. Acceptance Check Sheet
    a. Prepare a check sheet that includes all points for all functions of the BMS as indicated on the point list included in this specification.
    b. Submit the check sheet to the Engineer for approval
    c. The Engineer will use the check sheet as the basis for acceptance with the BMS Contractor.
3. VAV box performance verification and documentation:
    a. The BMS Contractor shall test each VAV box for operation and correct flow. At each step, after a settling time, box air flows and damper positions will be sampled. Following the tests, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.
    b. The BMS Contractor shall issue a report based on a sampling of the VAV calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance.
4. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

23 09 93 Sequence of Operation for HVAC Controls

Sequence of Operation

Note: Insert applicable sequences from standards library here.

Point Lists

Note: Insert applicable sequences from standards library here.

Sample

Systems

AHU 1,2,3,4

Point	Description	Type	Units	Trend	Alarm	Totalize
DA-P	Discharge Static Pressure	AI	in WC	X		
DA-T	Discharge Air Temperature	AI	Deg F	X		
PH-T	Preheat Temperature	AI	Deg F	X		
SF-S	Supply Fan Status	BI	Off On	X	X	X
PH-O	Preheat Output	AO	%	X		
RH-O	Reheat Output	AO	%	X		
CLG-O	Cooling Output	AO	%	X		
SF-O	Supply Fan Output	AO	%	X		
SF-C	Supply Fan Command	BO	Off On	X		
PH-LCKO	Preheat Lockout Command	BO	Off On	X		
CLG-LCKO	Cooling Lockout Command	BO	Off On	X		
RH-LCKO	Reheat Lockout Command	BO	Off On	X		
DAT-SP	Discharge Temperature Setpoint	AO	Deg F	X		
PHT-SP	Preheat Temperature Setpoint	AO	Deg F	X		
DAP-SP	Discharge Static Pressure Setpoint	AO	in WC	X		