SECTION 230923 - DIRECT DIGITAL CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This section provides information on acceptable Building Automation Systems (BAS) and control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Refer to the Construction Documents for engineers Sequences of Operations for BAS HVAC Controls.

1.2 WORK INCLUDED

A. The BAS Contractor will provide an environmental control/energy management system and control function for the entire HVAC system. The BAS will be a Direct Digital Control (DDC) System manufactured by either:

1. Siemens – Contact Chad Nobles (713)870-8330

B. HVAC Systems or building components to be monitored and/or controlled by the central campus systems include, but are not limited to, the following: temperature control, Air flows, building and room pressurization, indoor & outside building lighting, Fume Hoods and Laboratory Control Systems, and the start and stop of HVAC systems.

C. The BAS Contractor will furnish and install all components but not limited to all temperature, pressure, and flow sensors, transmitters, relays, switches, wire, and all DDC panels as required to meet engineers design and sequence of operations. Also furnish all controls, operators, power supplies, control valves, air and water flow measuring stations, transducers and wiring to connect components. Submit for approval, appropriate product data cut-sheets for all material/components intended for use prior to beginning work. Where BAS is used in specifications and drawings, it is understood to be same as DDC. In addition, when required, provide a complete installation of the Laboratory Control System (LCS) completely integrated into the appropriate Campus BAS Software.

D. All Controls, damper actuators, Valve actuators, shall be electronically controlled, no pneumatics of any type are allowed.

E. The BAS Contractor shall provide Direct Digital Control (DDC) panels complete with all microprocessors, software, terminal strips, transducers, relays, and regulated power supply with battery backup at the mechanical room field equipment controllers and supervisory engines.

F. The BAS Contractor shall furnish a HVAC Terminal Equipment Controller (TEC), electronic damper actuator(s), and electronic HW valve and actuator for installation on each VAV terminal unit and fan coil unit, as applicable, by the terminal equipment manufacturer. These DDC devices shall be delivered to the manufacturer's factory in sufficient time for the terminal equipment manufacturer to meet their scheduled delivery obligations.

G. The BAS Contractor shall furnish all DDC LCS components, including TECs, Lab Supply Air Terminal Units with reheat coils (duct mounted), General Exhaust Air Terminals, Fume Hood Exhaust Terminals, and all other associated controls components required to meet the engineers design and sequence of operation. Installation of all air terminals shall be by the mechanical contractor.

H. The BAS Contractor shall provide for each VAV box an inlet flow sensor suitable for interfacing with a pressure transducer, and for VAV boxes and other terminal equipment as the design engineer requires. Also as required, any necessary devices for proper operation to achieve full functionality as required by the engineers design and sequence of operation. The cost of mounting shall be included in the cost of the terminal equipment. All wiring and terminations related to the lab control system components shall be provided by the BAS contractor.

1. The BAS Contractor shall provide for each TEC, a 24 vac, 40 va power source, and mount and connect these devices and the DDC controller as required for proper operation as required under this Section. All other wiring and terminations related to the TEC shall be provided by the BAS contractor.

I. Room temperature, CO2 sensors and humidity sensors and mounting plates shall be provided and installed by the BAS Contractor.

J. Temperature controls and non-DDC accessories that are standard catalog products as manufactured by Siemens Building Technologies, Inc. will be acceptable. Industrial instrumentation supplied shall be standard catalog products of Rosemount, Dwyer, Honeywell, Bristol, Foxboro, Leeds and Northrup, Taylor or Brown. All coordination and execution of work pertaining to the installation, service, and guarantee, under this Section of the specifications, shall be the sole responsibility of the BAS Contractor.

K. All controls to be installed, calibrated and adjusted by trained instrument technicians in the full-time employ of the BAS Subcontractor & low voltage electrical subcontractor. The BAS Contractor will be responsible for all work performed by their subcontractors.

L. Submit engineering/wiring drawings and receive approval prior to beginning work. These drawings shall be submitted in a timely manner to provide sufficient time to review drawings so as not to hold up the project.

M. The DDC field panels will be located in mechanical rooms as shown on the drawings. The BAS cabinets shall be labeled with a permanent labeled indicating its name as shown in the control drawings All sensor and start/stop wiring will be brought back to the panel responsible for controlling/monitoring the mechanical/electrical equipment for which the sensor, start/stop wiring is directly related. The location of these panels may not be shown on the drawings. The DDC panels in the mechanical room shall be provided with a UPS to allow operation of the panels during switchover to emergency power. The UPS shall provide a minimum of 500 va, be similar to an Invensys Powerware 120, and be installed in a NEMA 1 hinged, lockable cabinet.

N. Power to each BAS panel shall be provided from a breakered, 20 amp dedicated circuit on emergency power having an insulated ground wire from the power panel ground buss wired to the duplex receptacle.

O. The BAS Control System will perform all Sequence of Operations as required by the Design Engineer.

P. Furnish and install a network communications trunk (N.C.T.) between DDC panels, and a separate LAN communications network between each terminal unit controller (or group of controllers) back to the DDC panel associated with the AHU which serves the terminal units. Trunks shall be connected to the panels with CAT-6 conductors and required components (switches). In addition, the N.C.T. trunk shall be extended from the nearest Panel to an Owner-provided, network drop(s) location

Q. The project shall provide a dedicated Ethernet network connection between the BAS panel and the Campus BAS Software. The BAS Contractor is responsible for coordinating the network drop (s) required for integration to the Campus BAS Software and will not receive final payment for the project until the BAS system is fully integrated and accepted by SFA Utilities & Energy Services.

R. Provide graphics for all new work, compatible with existing campus front end system. Coordinate and provide BAS graphics that are acceptable to SFA Utilities & Energy Services. See section 1.10 below for more information.

S. All exposed wiring shall be in conduit (3/4” minimum). Concealed wiring shall be plenum rated. All active Ethernet switches, hubs, and routers required for the communication between BAS panels shall be BAS Contractor-provided and installed. The conduit/wiring system required for the BAS shall be a complete, separate, independent system. Conduit sharing with other unrelated electrical systems is not permitted. All conduit shall enter BAS panels enclosures from the bottom of the panel or enclosure.

T. When only electric and domestic water are being metered, the electric meter that is to be installed must have the option of field installable digital input/output modules that can be added at any time thus allowing monitoring of status points, consumption of water, air, gas, and or steam pulses. Also this unit must be easily integrated in the current SFA power and energy management system

U. The BAS contractor will be responsible for the connection and integration from the BAS in the building, to the Campus BAS software. The Contractor will be responsible for programming the DDC panels with operational sequences and set-points as specified.

1.3 RELATED WORK

A. If the project will include Chillers, Boilers, or other DX system the BAS shall have all points mapped through BacNet, Modbus, or other means that will allow for the BAS to see, monitor, trend, alarm, as well as control, at a minimum, the start/stop and set point of each system.

B. If the BAS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

C. Shop Drawings:

1. Schematic flow diagrams & graphic display.
2. Power, signal, and control wiring diagrams.
3. Details of control panel faces.
4. Damper schedule.
5. Valve schedule.
6. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
7. Control System Software: Schematic diagrams, written descriptions, and points list.
8. Sequences of operation.
9. Software and firmware operational documentation.
10. Samples of Graphic Display screen types and associated menus.
11. Field quality-control test reports.
12. Operation and maintenance data.

1.4 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals:

1. Three (3) copies of the Operation and Maintenance Manuals, Control Drawings, and written Sequence of Operation, shall be provided to the Utilities & Energy Services upon completion of the project. The entire Operation and Maintenance Manual, Control Drawings, and written Sequence of Operation, shall be furnished on Compact Disc media, and include the following for the BAS provided:

a. Table of contents.
b. 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.
c. Manufacturer’s product data sheets or catalog pages for all products including software.
d. Archive copy of all site-specific databases and sequences.
e. BAS network diagrams.
f. Interfaces to all third-party products and work by other trades.

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

1.5 BAS WIRING

A. All wiring and conduit shall be installed in accordance with related Specification Section Division 26, Electrical.

B. The conduit/wiring system required for the BAS specification Input/Output summary:

1. Digital Input (D.I.) wiring (Class 2) may be run in a common conduit with Digital Output (D.O.) wiring (Class1) where local codes permit.

2. Analog Input (A.I.), Analog Output (A.O.), Digital Input (D.I.), and Network Communications Trunk (N.C.T.) wiring may be run in a common conduit.
3. Digital Output (D.O.) wiring run in a common conduit with Analog Input (A.I.), Analog Output (A.0.), or Network Communications Trunk (N.C.T.) is not permitted under any circumstances.
4. AC line power to DDC panel shall be #12 THHN.
5. Digital Output (D.O.) wiring shall be #14 THHN.
6. Digital Input (D.I.), Analog Input 4-20 mA (A.I.), and Analog Output (A.0.) wiring shall be #20 TSP (twisted shielded stranded pair with drain wire).
7. Analog Input/Thermistor/or voltage types (A.I.) wiring shall be #20 TSP (twisted shielded stranded pair with drain wire).
8. Network Communications Trunk (N.C.T.) between DDC panels and TEC's shall be 2 individual minimum #24 awg TSP (twisted, shielded stranded pair) cables, not to exceed 12.5 pf capacitance per foot, wire-to-wire, and not to exceed 6 twists per foot. TEC controller LAN networks shall be 1 #24 awg TSP of the same type.

C. Wiring between DDC Panels:

1. Furnish, install and terminate individual CAT-6 cable assemblies to interconnect each BAS panel. Data is passed through an Ethernet switch before continuing to its destination to other main building panels and to the front end. Each cable shall originate and terminate within one designated DDC panel in each mechanical room. Additionally, furnish, install and terminate individual Cat-6 cable assemblies to connect each DDC panel within the mechanical room(s) with others in that same room, as engineered by the BAS Contractor.
2. All cable runs between mechanical rooms and /or DDC panels shall be no longer than allowed as specified in Division 27. Where runs are required that will be longer than Division 27, furnish and install an additional enclosure near the midpoint (coordinate location with architect), to be used as a network junction box, complete with 120VAC emergency power source. Terminate and label the cables within this junction box and show the location on the as built control drawings, as directed for each DDC panel.
3. Furnish, install and make connections of all interlock, power for sensors (if required), line and low-voltage wiring external and internal to DDC panels. All wiring shall be clearly and permanently labeled as outlined below.

D. Field devices requiring a 4-20 mA DC input signal shall be non-ground referenced.

E. All wiring in mechanical rooms, electrical rooms, inaccessible areas, or located in areas exposed to occupant view shall be run in conduit (3/4" minimum). Plenum rated wiring shall be acceptable for installation in concealed, accessible locations. Conduit fill limit shall not exceed 40% in any portion of the conduit system.

F. In order to facilitate maintenance, where multiple sensors or devices are connected to a common raceway or conduit, each sensor or device shall be individually connected to a common (non-sensor or device) junction box, which shall then be attached to the common conduit. Under no circumstances shall sensor or device wiring or tubing be routed through any other sensor or device's specific enclosure or junction box.

G. All wiring shall be labeled at both ends and at any spliced joint in between. Wire shall be tagged using a system similar to the Panduit P1 Self Laminating System that utilizes a thermal transfer (or equivalent) printer with a minimum font size of Arial 10. In addition to tagging at field device end and at spliced joints, a tag shall be placed 6 inches after entering each DDC panel. Identification and tag information shall be included in engineering/wiring submittal which must be submitted for Owner approval prior to beginning work. Tag information shall coincide with equipment/point information as written in the specification input/output summary. Each BAS DDC panel shall include a paper wiring document, in a clear sleeve permanently attached to the inside door that shows the name of each point and what terminal they are connected to.

1.6 SYSTEM VERIFICATION--PROCEDURE TO BE FOLLOWED

A. Provide minimum 2 week written notice for all inspections.

B. The system verification also includes the Laboratory Control System.

C. Upon completion of all external sensor mounting, terminations, and wiring into and out of the DDC panels, the SFA Project Inspector shall inspect and approve this work. The BAS Contractor shall make his representative(s) available and coordinate with the SFA Project Inspector during this inspection process. At the successful conclusion of this inspection, the BAS Contractor shall provide a written report stating all work is complete. BAS Contractor, General Contractor and SFA Project Inspector shall sign. This should be filed with Project Commissioning/ Startup documents.

D. Upon such approval being achieved, the BAS Contractor shall make terminations within the DDC panels.

E. Following completion of the work in the DDC panel tie-in, a performance test shall be conducted by the BAS Contractor in the presence of the SFA Project Inspector.

F. The BAS Contractor shall conduct testing of proper operation of each and every physical system point to which the Contractor has provided devices, wiring, in order to verify the equipment and installation provided by them (their portion of the work), i.e., when the Owner commands a point, the Contractor verifies in the field that the commanded point operates properly. At the successful conclusion of this inspection, contractor shall provide a written report stating all work is complete, calibrated and functioning properly per the specified sequences of operation. An electronic and paper copy of which will be provided to for signature by the BAS Subcontractor, General Contractor and SFA Project Inspector. This should be filed with Project Commissioning/Startup documents. A representative of the BAS Contractor that can revise control sequences shall be available on site as necessary to make changes during the system verification.

G. SFA Project Inspector shall attend initial inspection and verification of completed punch list for items in paragraphs 1.5C and 1.5F of this Section. Further inspections required due to incomplete/incorrect work shall be at Contractor’s expense.

H. Upon conclusion of final checkout and acceptance, the Contractor's responsibility reverts to warranty of materials and installation herein specified. System shall be warranted for a period of two (2) years.

I. The Contractor shall coordinate and include the Commissioning Agent as required for the above activities. Commissioning agent will coordinate and witness functional performance test procedures. Refer to 01 91 13 for additional details.

1.7 SYSTEM GRAPHICS

A. Provide a cover page for the project to include graphic links including, but not limited to:

1. Air Handling Equipment
2. Chilled and Heating Water Pumps
3. Domestic Water Pumps.
4. Fans
5. Outside Air Handling Equipment
6. Supply Air Floor Plan
7. Exhaust Air Floor Plan
8. Schedules
9. Other items as indicated on the construction documents

B. Floor plans shall show the following:

1. Show room numbers or list of group of rooms within the colored areas
2. Colored areas indicate different graphic links such as 1st floor North, etc.
3. Links to other floors along with chilled and heating water system links.
4. Links to sequence of operations
5. Links to any operations schedules
6. Links to AHU serving that area

C. Floor Plan of supply shall show the following:

1. Indicate room numbers on plan
2. Indicate different AHU coverage with different colored cloud

3. Indicate VAV box locations along with ductwork
4. Indicate room temperatures for each zone.
5. Separate Graphics will be provided to show each of the following information

    a. Location of 24 volt low voltage xfmrs,
    b. Communications trunk,
    c. Duct pressure sensors with location and value.
    d. Routing of communication lines to each DDC panel and TEC

D. Typical VAV box shall show the following:

1. AHU serving VAV box and the Discharge Air Temperature of its AHU
2. Supply CFM and damper position
3. Reheat valve position
4. Box status, heat or cool
5. Fan proof
6. Room temperature and set point.
7. Occupancy sensor state (if available) with its current value

E. Exhaust fan floor plan layout shall show the following:

1. Indicate room numbers on plan
2. Indicate with different colored bubble or cloud the boundaries of each exhaust fan.
3. Link to each exhaust fan that is shown on that floor

F. Schematic of outside air units shall show the following:

1. Schematic indicating what other AHU's the outside air handler serves
2. Indicate flows to each AHU with set points, run status/proof, damper locations (isolation and fire damper.)
3. Indicate which AHU's are served.
4. Show fire alarm status for AHU's on the AHU graphic

G. Air Handling Units shall show the following:

1. Provide feedback on devices, but not limited to items such as temperatures, fan speed, static pressure set point and actual, valve position, filter status, airflow measuring station CFM, etc.
2. Graphics to be a true representation of the actual field equipment.
3. Chilled and Heating Water systems shall show the following:

H. Pumping Units shall show the following:

1. Pumps along with their speed and proof of status
2. Flow meters
3. Temperature and pressure sensors and their values
4. Building control valve
5. Where pumps are lead / lag set up, indicate run time in hours for each pump

I. Other

1. Refer to construction documents for other systems that require graphics.
2. Graphics shall include feedback on all devices including set point and actual values.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. The Building Automation System (BAS) shall use a BacNet open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BAS shall support BacNet open communication

protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other Owner provided networks.

B. 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. In existing installation, re-use existing controls equipment System architectural design shall eliminate dependence upon any single device for control execution:

1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
2. The System shall maintain all settings and overrides through a system reboot.

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

2.2 ACCEPTABLE MANUFACTURERS:

A. Approved Manufacturers:

1. Siemens Building Technologies

B. Integration with Existing Siemens BAS:

1. The BAS Contractor a project shall provide the following:

a. The BAS contractor shall provide any and all necessary software connectivity licenses within the cost of the bid. Software licenses shall allow specified BAS point information to be broadcast out of the BAS expansion to the existing Siemens BAS server software.

2.3 FIELD DEVICES

A. Acceptable Immersion Temperature Sensors and Thermowells

1. Dwyer Series TTE Explosion Proof RTD Temperature Probe with Dwyer Series W 316 Stainless Steel Thermowells
2. Rosemount
3. Honeywell

B. The above Immersion Temperature Sensors shall be equal/better to the specifications below:

1. Temperature Sensor: RTD using a Pt1000, or Pt 100.
2. Output Temperature Ranges: User selectable any range between -30 to 250 deg.f. with minimum span of 40 deg.f
3. Temperature Limits: Ambient: 0 – 158 deg.f. Process: -30 to 250 deg.f.
4. Accuracy: Transmitter: +/- 0.1%F.S. Probe: +/- 0.3% F.S.
5. Thermal Drift Effects: +/-0.02% deg.C max.
6. Response Time: 250 ms.
7. Wetted Materials: 316 Stainless Steel.
8. Process Connection: ½” male NPT.
9. Conduit Connection: ½” female NPT.
10. Probe Length: 2” to 18” depending on model
11. Pressure Limits: 2000 PSI.
12. Power Requirements: 10 to 35 VDC.
13. Output Signal 4-20mA (two wire loop powered).
14. Display: 2 lines X 8 character LCD.
15. Enclosure Rating: NEMA 4X (IP66) and explosion proof for Class I , Groups B, C, D; Class II, Groups E, F, G; Class III.
16. Agency Approvals: FM, CE

C. Thermowells shall be equal/better to the specifications below:

1. Hard Ware: 316SS Sheath
2. Taper/Bore: Straight/0.260
3. Inside Threads: ½ NPSF
4. Process Connections: ½" NPT
5. Mounting: Threaded
6. Lag: None
7. Sheath O.D. Base/Taper: ½" Straight
8. Length: From 4" to 24" as needed to fit Temperature sensor length required for tip of probe to be in center of piping.

D. HVAC Air Duct Temperature Sensors:

1. Duct temperature sensors shall be averaging type. Outside air wall mounted sensors shall be provided with a sun shield. Accuracy of transmitter shall be unaffected by wiring distances up to 700 feet. Siemens Building Technologies, Rosemount or Dwyer only.

E. Room Thermostats:

1. Each room thermostat shall come complete with a terminal jack and override switch integral to the sensor assembly. The terminal jack shall be used to connect the portable operator's terminal to control and monitor all hardware and software point associated with the terminal unit.
2. Humidity Sensors shall provide a 0 to 100% range corresponding to an isolated 4 to 20 Ma output. Accuracy of ±2% RH, with maximum drift of 1% per year.
3. An override switch will initiate override of the night setback or unoccupied mode to normal (day) operation when activated by the occupant. The switch function may be locked out, canceled or limited as to time or temperature in software by an authorized operator or a central or remote operator's terminal.
4. Space thermostats may be Thermistor or 4-20 mA output RTD. The room thermostats shall be firmly attached to the wall using approved construction techniques. Double-sided adhesive tape in lieu of screws is not acceptable.
5. The room thermostats shall be accurate to within ±.5°F and have a setpoint adjustment range of 45°Fto 85°F.
6. Room carbon dioxide sensors shall provide a range from 0 to 2,000 ppm CO_2, and be accurate to within ±100 ppm. The CO_2 sensor shall experience less than 1% drift per year for the first two years of operation and negligible drift thereafter, no calibration of the CO_2 sensor is necessary.
7. Room thermostats shall be a full featured unit in all areas.

F. Acceptable Water Flow Meters and Remote Transmitters:

1. Rosemount Series 8705 Magnetic Flowmeter Flow Tube with Rosemount 8712E Remote Mount Magnetic Flow Meter Transmitter
2. Yokogawa AXF Magnetic Flow Meter with AXFA11G Magnetic Remote Converter
3. Siemens Mag 5100 W with MAG 5000/6000 Remote Transmitter

G. The above Water Flow Meters and Remote Transmitters shall be, or equal/better to the specifications below:

1. The Flow Tube and Transmitter shall be calibrated to each other and shall be flow-calibrated and assigned a calibration factor at the factory. The calibration factor is entered into the transmitter, enabling interchangeability of sensors without calculations or a compromise in standard accuracy
2. Accuracy: Includes the combined effects of linearity, hysteresis, repeatability, and calibration uncertainty. ±0.15% of rate ±1.0 mm/sec from 0.04 to 13 ft/s (0.01 to 4 m/s); above 13 ft/s (4 m/s), the system has an accuracy of ±0.2% of rate.
3. Each Flow Tube shall be sized specifically for the pipe and flow in which it is to be installed and to ensure flow velocity is within 2 to 20 ft./s.
4. A calibration certificate shall be provided from the manufacture
5. Class 150 carbon steel flanges, Teflon (PTFE) or EDPM lining, and Type 316L stainless steel or Hastelloy C electrodes.

6. Transmitter: 115Vac/1ph/60hz power supply, NEMA 4X enclosure, 4 – 20 ma output, battery-backup totalizer, and local operator interface.
7. Ambient Temperature Limits: -20 to 140deg.f.
8. Humidity Limits: 0 to 95% RH to 120deg.f
9. Safety Approvals: FM Class 1 Division 2 for non-flammable; CSA Class 1 Division 2

H. Temperature Transmitters: Temperature transmitters shall be designed for 4-20 mA output for Platinum RTD millivolt input sensor (as specified above). Accuracy shall be the same as specified for the temperature sensors. Stability shall be ±0.2% of calibrated span for 6 months. Transmitter shall be a part of the temperature sensor assembly and shall be in a moisture-proof housing with a moisture-proof seal between the sensor and transmitter. Immersion sensors for piping shall be Dwyer Series TTE explosion-proof RTD temperature transmitter with fully configurable ranges and display options or equal by Rosemount.

I. Humidity Transmitter Space: Sensor shall provide a 0 to 100 percent range corresponding to an isolated 4-20 mA or 0-10 VDC output. Accuracy of + / - 2 percent RH, with maximum drift of 1 percent per year. Sensor shall be equipped with LCD display.

J. CO2 Duct-Stat Indoor AQ Sensor: C02 sensor shall be Siemens model number QPA63. The unit shall be self-contained for wall mounting application. The unit shall have a fast response and shall have 0-1 percent range corresponding to an isolated 4-20 mA or 0-10 VDC output. Visual alarm is not to be provided. The monitor shall utilize the photo acoustic sensor with VOC sampling capability.

K. Electric Room Thermostats: Provide line voltage room thermostats with cover. Set point must be adjustable from approximately 50 to 100 Deg. F. Minimum rating is 6 amps at 120 VAC. Provide removable setting knob. Housings shall not contain thermometers.

L. Duct Relative Humidity Sensor: Duct relative humidity sensors used in the calculation of enthalpy shall be Siemens QFM Series Duct Relative Humidity or similar. The sensor shall have an accuracy of +/- 2% RH. Provide unit with housings suitable for return air plenum installations. Filter material shall be Teflon. The unit shall be operating range of 0 to 100% RH and have a 4 to 20 mA or 0 to 10 Vdc linear output.

M. Pressure Transmitters: Transmitters for water pressure shall provide a 4-20 mA DC signal output directly proportional to pressure. Device shall be constructed with corrosive resistant stainless steel wetted parts and have a die-cast aluminum enclosure specifically designed for NEMA4/IP65 service. Accuracy of ±0.5% of calibrated span. Span not over 200% of sensed pressure. Stability ±0.5% of upper range limit for 6 months. Stainless steel diaphragm, viton 0-rings. Temperature limits: -20°F to 220°F.

N. Fan proof-of-flow switches shall be UL listed adjustable setpoint and differential pressure type. Switches shall be piped to fan inlet and outlet. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inch w.c. All pressure tubing on roof shall be stainless steel.

O. Pump motor proof-of-flow Current Status Switch: Provide a high performance miniature split-core current status switch with adjustable set point (where indicated). The current status switch shall have an operating range of between 1.25 – 50 amps and be able to detect belt loss and mechanical failure.

P. Air flow and static pressure analog sensors shall be ±.5% accuracy, range suitable for the low velocity pressures to be encountered, be selected for approximately 50% over-range, and have an electronic 4 to 20 mA analog output. These differential pressure sensors shall be connected to the air flow measuring station with valved lines for testing and calibration, and shall have adjustments for zero and span.

Q. Electric Low Limit Duct Thermostat: Snap-acting, two pole, single throw, manual reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint, requiring minimum 15 feet length of bulb. Provide one thermostat for every 20 sq ft of coil surface.

R. Air Flow Measurement Station:

1. Industrial Thermal Dispersion Technology Type, Similar to Ebtron, Inc. Model GT. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter.

2. Each unit shall operate on 24 VAC.
3. Each sensing point shall independently determine the airflow rate and temperature, and shall equally weight and average by the transmitter prior to output. Pitot tube arrays are not acceptable.
4. A single manufacturer shall provide probe and transmitter.
5. The operating range shall be from 0 - 5000 fpm with accuracy of ±2% over the entire operating airflow range and be verified against standards that are traceable to NIST.
6. The transmitter shall be capable of communicating with the host controls using 0-10VDC and 4-20ma, RS-485 and BACnet.
7. Sensors shall be UL listed.
8. Manufacturer shall have review and approve placement in field, and provide written report to engineer indicating airflow measuring stations are installed in accordance with manufacturer's installation requirements.

2.4 CONTROL VALVES

A. Terminal Unit Control Valves:

1. Characterized Ball, Forged brass body, Stainless Steel trim, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.
2. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
3. Sizing: 5-psig maximum pressure drop at design flow rate, to close against pump shutoff head. Select control valves for a minimum Cv of 1.0 to reduce the risk of system dirt accumulating in very small orifices in characterizing-discs.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

B. Butterfly Valves:

1. 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
2. Body Style: Lug.
3. Disc Type: Elastomer-coated ductile iron.
4. Sizing: 1-psig maximum pressure drop at design flow rate.

PART 3 - EXECUTION

3.1 GENERAL

A. All DDC and LCS panels shall be connected to emergency power system.

3.2 INPUT/OUTPUT SUMMARY

A. The I/O Summary on the drawings is provided as a list of the minimum points required by this contract for connection to the Energy Automation system. Furnish all devices, wiring, tubing, etc., necessary to serve and transmit to the DDC panels. Any points not shown on the I/O Summary yet required to accomplish the sequence of operation shall be provided under this contract at no additional cost to the Owner.

3.3 EQUIPMENT, AIR HANDLING UNIT AND FAN START-UP AFTER POWER FAILURE

A. In case of power failure, all AHUs and fans with 7-1/2 HP and larger motors shall be started sequentially at 15 second intervals (adjustable) through the DDC system.

B. DDC to send alarm if any equipment does not start within 15 minutes and omit that item from remaining starting sequence.

END OF SECTION