1. SECTION 23 09 23
2. BAS Instrumentation and Control
   1. GENERAL
      1. Related Sections
         1. SECTION 23 09 93, BAS Sequences of Operations
      2. References
         1. American National Standards Institute (ANSI)
            1. ANSI/ISA 5.5-1985 Graphic Symbols for Process Displays.
            2. ANSI/IEEE 260.1 2004, Standard Letter Symbols for SI and Certain Other Units of Measurements (SI Units, Customary Inch Pound Units and Certain Other Units).
            3. ANSI/ASHRAE 135-2016, BACnet® - A Data Communication Protocol for Building Automation and Control Networks.
      3. Acronyms, Abbreviations and Definitions
         1. Acronyms used in BAS.
            1. BAS – Building Automation System
            2. EMCS – Energy Management and Control System
            3. GUI – Graphical User Interface
            4. HVAC - Heating, Ventilation, Air Conditioning
            5. I/O - Input/output
            6. ISA - Industry Standard Architecture
            7. O&M - Operation and Maintenance
            8. Niagara4 – Software framework for building device-to-enterprise applications and Internet-enabled products.
      4. Standards Compliance
         1. All equipment and material to be from manufacturer's regular production, UL and/or ULC or CSA certified, manufactured to standard quoted plus additional specified requirements.
         2. Where UL and/or ULC or CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.
         3. Additional applicable codes and standards:
            1. National Electrical Code -- NFPA 70.
            2. Local Electrical Codes
            3. Federal Communications Commission -- Part J.
      5. Work Included
         1. Provide a new building system to control and monitor the building’s mechanical and electrical systems.
         2. Provide control valves, control damper actuators / end switches (gravity, fire and smoke control dampers by others), flow switches, thermal wells for temperature control, air flow stations, and other control devices as necessary.
         3. Provide submittal data sheets, control drawings schematics (in Visio or AutoCAD), data entry, electrical installation, programming, start up, test and validation acceptance documentation, as-built documentation, maintenance manuals and system warranties.
         4. All labor, material, equipment and services not specifically referred to in this specification or on associated drawings that are required to fulfill the functional intent of this specification shall be provided at no additional cost to the Owner.
         5. The work covered by this specification and related sections consists of providing submittals, labor, materials, engineering, technical supervision, and transportation as required to furnish and install a fully operational BAS to monitor and control the facilities listed herein, and as required to provide the operation specified in strict accordance with these documents, and subject to the terms and conditions of the contract. The work in general consists of but is not limited to, the following:
            1. Furnish and install all to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.
            2. Furnish complete operating and maintenance manuals and field training of operators, programmers, and maintenance personnel.
            3. Perform acceptance tests and commissioning as indicated.
      6. Work By Others
         1. Setting in place of valves and dampers, access doors, flow meters, water pressure and differential taps, flow switches, thermal wells, air flow stations, and current transformers shall be by others.
         2. Duct smoke detectors, smoke dampers, fire/smoke dampers, and associated actuators / end switches shall be provided under another Division of this specification. The Division 26 electrical contractor shall interlock these devices to the BAS for shutdown/monitoring unless otherwise outlined in the Sequences of Operations for this project. The BAS contractor shall coordinate where to land wires and programming as needed.
         3. Switches, and power wiring to motors, starters, thermal overload switches, and contactors, is specified under another Division of this specification.
      7. BAS Open System Design and Qualifications
         1. Open System Design: It is the owners expressed goal to implement an open Building Automation System that will allow products from different manufacturers and/or suppliers to be integrated into a single unified system in order to provide flexibility for expansion, maintenance, and service of the system. The BAS manufacturer / contractor must provide proof of open system design as outlined below.
         2. Prior to award of the contract the BAS contractor is to provide proof of “Open System Design” with the following requirements:
            1. Provide proof of having a local office within 35 miles of project for at least 5 years, staffed by trained personnel capable of providing installation, engineering, programming, servicing, commissioning, instruction, routine maintenance, and emergency service on systems.
            2. The controls system shall utilize the Niagara4 software framework.

The Contractor shall have a minimum of 2 years’ experience in the sales, installation, engineering, programming servicing and commissioning of Niagara4.

Submit the Niagara Compatibility Statement (NiCS) via a letter from the manufacturer. The NiCS shall have no connectivity restrictions and all aspects of the Niagara Framework will be provided to maintain an Open System Design. The System as provided shall confirm with the following NiCS properties (Station Compatibility In, Station Compatibility Out, Tool Compatibility In, AND Tool Compatibility Out shall each have a value of “All”).

* + - * 1. The controls system shall conform to the following guidelines for communication protocols.

BACnet shall be used for all BAS provided controllers.

The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International and all controllers used shall be BACnet Listed with documentation on the BACnet website (<https://www.bacnetinternational.net/btl/search.php>)

The use of BACnet Communications protocol alone shall NOT warrant an “Open System Design.” Manufacturers must adhere to all aspects of “BAS Open System Design and Qualifications” and “Acceptable System Manufacturers” sections to comply.

Modbus shall only be acceptable for third party devices.

LonTalk shall only be acceptable for sites with existing LonTalk controls architecture where the owner has explicitly stated that the LonTalk architecture must remain in place.

Proprietary communications protocols shall NOT be acceptable.

* + - * 1. A software programming tool shall be provided for this project and adhere to the following guidelines:

All software tools needed for full functional use, including programming of controllers, Niagara4 Framework network management and expansion, and graphical user interface use and development, of the BAS described within these specifications shall be provided to the owner or his designated agent.

The software programming tool shall be free of charge and openly available for download from the internet.

For any manufacturer that does not have a free programming tool the manufacturer must provide the tool with this project for a minimum of 5 years with proof of availability via letter from the manufacturer.

Any licensing required by the manufacturer now and to the completion of the warranty period, including changes to the licensee of the software tools and the addition of hardware corresponding to the licenses, to allow for a complete and operational system for both normal day to day operation and servicing shall be provided.

**End of Section**

* 1. PRODUCTS
     1. Acceptable System Manufacturers and Contractors
        1. Manufacturers: Subject to compliance with requirements, provide products by the following approved manufacturer:
           1. Distech Controls
        2. Provide a building automation system supplied by a company regularly engaged in the manufacturing and distribution of building automation systems for a minimum of 5 years.
        3. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.
        4. BACnet/IP communication protocol must be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)
     2. Quality Assurance
        1. All new building automation system products on this project shall be provided by a firm that is a registered ISO 9001:2015 manufacturer, for a minimum duration of 5 years, at time of bid.
     3. Computer Hardware
        1. Provide the following computer hardware for this project:
           1. {WORKSTATION}Onsite Server(s)
           2. Workstation Computer(s)
           3. Uniterruptable Power Supplies
        2. Server Hardware Requirements
           1. The Server shall adhere to the following minimum requirements: the latest generation Intel Core i5 processor, 16 GB RAM, and a 1TB solid state hard drive. It shall include the latest Windows 64-bit operating system (Windows 10 pro or newer), VM support, and an ethernet adapter (10/100MB with RJ45 connector).Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.
           2. The server shall support all network/building controllers, OWSs, and 3rd party mechanical / electrical systems connected to the Facility Management Control / Building Automation System Local Area Network.
           3. Workstation Hardware Requirements

The Workstation shall adhere to the following minimum requirements: the latest generation Intel Core i5 processor, 8 GB RAM, and a 500GB solid state hard drive. It shall include the latest Windows 64-bit operating system (Windows 10 pro or newer), Microsoft Office programs, VM support, an ethernet adapter (10/100MB with RJ45 connector), 32X CD-ROM drive, and 2-USB ports.

* + - * 1. A minimum 21”, HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.
        2. A mouse and keyboard shall be provided.
        3. Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.
        4. Workstation(s) should be loaded with Programming Tools
      1. Uninterruptable Power Supplies
         1. Provide the OWS, Server, and each network/building controller with individual UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration.
    1. Remote Access and Cyber Security Best Practices
       1. Remote Access
          1. The BAS contractor shall comply with owner IT infrastructure security policies for remote access. The owner IT team shall provide VPN, firewalls, etc. as needed for secure remote access.
          2. A VPN and firewall must be used for secure remote access.
       2. Cyber Security Best Practices
          1. Unless predetermined by the owner IT team the BAS network shall be separate from the owners IT infrastructure besides a single point connection for remote access (owner provided internet access). All ethernet switches and communication backbone required for a fully operational BAS shall be provided by the BAS contractor.
          2. Refer to “Communication Backbone” section of this specification for further details on segmenting the network (VLANs, subnets) and when edge or managed switches are required based on building size / type.
          3. Do not use factory provided usernames and passwords. Update passwords and usernames regularly for strong system security.
          4. Update software and firmware regularly.
          5. Adhere to controls manufacturer hardening guidelines where applicable.
    2. Operator Software
       1. Real-Time Displays
          1. Provide a visual graphical representation of buildings, floor layouts, each piece of mechanical equipment and/or mechanical system that duplicates the represented system, presented as a web page via any industry standard web browser, where applicable.
          2. Graphics shall include at a minimum the value of each input, each output, each setpoint, alarms and graphical representation of trend logs.
       2. On-Line Help
          1. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.
       3. Security
          1. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data.
          2. System security shall be selectable for each operator.
          3. The system administrator shall have the ability to set passwords and security levels for all other operators.
          4. Each operator password shall be able to restrict the operators’ access for viewing and/or changing each system application, full screen editor, and object.
          5. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.
          6. This auto log-off time shall be set per operator password.
          7. All system security data shall be stored in an encrypted format.
       4. System Diagnostics.
          1. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.
          2. The failure of any device shall be annunciate to the operator.
       5. Third-Party Windows-Based Programs
          1. The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages.
          2. Graphics generation shall be done using standard Windows packages.
          3. No proprietary graphics generation software shall be needed.
       6. Overrides
          1. It shall be possible for the operator to override automatic analog and digital output commands.
          2. Where the BAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BAS control of any particular output and to originate a manual analog or digital output command.
          3. The provision shall exist for the operator to return analog or digital output command functions to automatic BAS software control.
       7. Password Protection
          1. Provide security system that prevents unauthorized use unless operator is logged on.
       8. Trend Data
          1. System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator’s workstation (server) hard disk.

Archived files shall be appended with new sample data, allowing samples to be accumulated over 3 years.

Systems that write over archived data shall not be allowed, unless limited file size is specified.

Samples may be viewed at the operator’s terminal in a trend log.

Logged data shall be stored in spreadsheet format.

Operator shall be able to scroll through all trend log data.

* + - * 1. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colours and these Graphs shall show object type value relative to time.
        2. Operator shall be able to change trend log setup information such as time intervals and objects logged
      1. Graphics
         1. The operator’s workstation shall display all data associated with the project.

Operator’s workstation shall display all data using 3-D graphic representations of all mechanical equipment.

* + - * 1. System shall be capable of displaying graphic file, text, and dynamic object data together on each display.

Information shall be labelled with descriptors and shall be shown with the appropriate engineering units.

All information on any display shall be dynamically updated without any action by the user.

Terminal shall allow user to change all field-resident BAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display.

* + - * 1. Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion.
        2. Analog objects may also be assigned to an area of a system graphic, where the colour of the defined area would change based on the analog objects value.

For example, an area of a floor-plan graphic served by a single control zone would change colour with respect to the temperature of the zone or its deviation from setpoint.

* + - * 1. Separate Displays shall be supplied, specific to the project, to form the following overall presentation style.
        2. All Displays will be linked in a logical fashion using hyperlink style (single left mouse click on text/display object/dynamic to load linked display if programmed)
        3. Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.
      1. Alarms
         1. Operator’s terminal shall provide audible, visual, electronic and printed means of alarm indication.
         2. Any alarm may be handled based on its individual or assigned class actions.

Displayed on the Alarm console.

The system shall be provided with a dedicated alarm window or console.

This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

Alarm reports shall be viewable via the BAS system and available for delivery by electronic mail (e-mail) or printing.

* + - * 1. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator’s terminal.

Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

* + - 1. Scheduling
         1. Operator’s terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule.
         2. Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules.
         3. At the operator’s terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.
      2. Archiving
         1. Store back‑up copies of all controller databases in at least one OWS and the server.
         2. Provide continuous supervision of integrity of all controller databases.
         3. Data base back up and downloading to occur over LAN without operator intervention.
         4. Operator to be able to manually download entire controller database or parts thereof.
      3. Reports
         1. Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section.
         2. Provide the software to automatically generate any report specified; the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device.
         3. As a minimum, the following reports shall be configured on the system:

Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency.

Summary Report: To permit the display or printing of the dynamic values for the user specified points.

Trend Reports: To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.

Historical Data Collection: Provision shall be made to ensure historical data is not lost.

Alarm Summary: Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.

Disable Point Summary: Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.

Run Time Summary: Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.

Schedule Summary: Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.

User Record Summary: Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

* + 1. BAS Controllers
       1. All controllers on the job shall have the following minimum requirements:
          1. IP Communication (BACnet/IP)

BACnet/IP communication protocol shall be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)

Support for IPv4 addressing

DHCP support and Auto DNS

Baud rate of not less than 100 Mbps

2 - RJ45 ports each capable of supporting 10/100 Base-T.

Supporting controller daisy chaining on the Ethernet network via integral switch functionality.

Integrated fail-safe should allow for communication when the controller is powered down.

All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (such as JACE, NAE, etc.) and shall be capable of assuming all responsibilities typically assumed by a Network Control Unit.

Any controller on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

The resulting network will be a ‘Flat’ topology with all devices (controllers, workstations, …) connecting at the same physical network level

* + - * 1. Memory and Processing

512MB of RAM and 4GB of non-volatile flash memory.

32-bit microprocessor operating at a minimum of 600 MHz

* + - * 1. Each individual controller shall have an embedded web-based HTML5 visual interface with the following functionality without reliance on any other controller for access:

Typical and custom control processes

Scheduling

Energy management applications

Alarm management applications

Historical/trend data for points specified

MMaintenance support applications

Graphical interface

* + - * 1. Shall be capable of monitoring/controlling the following types of inputs/outputs:

Digital inputs from dry contact closure, pulse accumulators, voltage sensing.

Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.

Digital outputs including Form C relay outputs and Triac outputs

Analog outputs of 4-20 mA and 0-10 Vdc.

* + - * 1. A minimum of 10% spare capacity shall be provided for each point type for future point connection.
        2. Any software required for programming shall be unlicensed and openly available
        3. Auto commissioning features shall be available for VAVs and FCUs to schedule automatic testing and record values (air flows, pressures, temperatures, etc.) for different operating modes. The auto commissioning feature shall be able to email reports and run commissioning on a specified schedule.
        4. Power and Environmental Requirements:

24 VAC with local transformer power

The controllers shall also function normally under ambient conditions of 32 ˚F [0 ˚C] to 122 ˚F [50 ˚C] and 0% to 90% RH (non-condensing).

Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

* + - * 1. Code Compliance:

“FIPS 140-2 Level 1 Compliant” cryptographic module

BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

UL916 Energy management equipment

FCC rules part 15, subpart B, class B

UL94-V0 flammability rating

* + 1. Control Panels
       1. Indoor control cabinets located in offices or dry/dust free environments shall be fully enclosed NEMA 1 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.
       2. All outdoor control cabinets and control cabinets located in mechanical/electrical rooms shall be NEMA 4.
       3. Control panels containing more than 4 controllers shall be provided with a terminal strip for field wiring. All control wiring inside the panel shall be between a terminal strip and controller inputs/outputs. All field control wiring shall be terminated at the terminal strip. Field control wiring inputs/outputs shall not be run directly to inputs/outputs of controller.
    2. Automatic Control Dampers
       1. Provision of dampers shall be provided by another section of this specification (the BAS contractor shall only be responsible for providing actuators/end switches for control dampers).
    3. Variable Frequency Drives (VFDs)
       1. Provision of variable frequency drives shall be provided by another section of this specification (the BAS contractor shall only be responsible for providing associated low voltage wiring and controls programming for the VFDs).
    4. Auxiliary Control Devices, Sensors, and Transmitters
       1. Control Valves
          1. Hydronic System Two and Three-way Control Valves :

Ball Valve (only acceptable for valves 2” [50 mm] and smaller): Nickel-plated forged brass body rated at no less than 400 psi [2760 kPa], stainless steel ball and blowout proof stem, NPT female end fittings, with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seats, and a Tefzel flow characterizing disc.

Globe Valve (valves 2” [50 mm] and smaller): ANSI Class 250 bronze body, stainless steel stem, brass plug, bronze seat, and a TFE packing.

Globe Valve (valves 2.5” [62.5 mm] to 5” [125 mm]): ANSI Class 125 cast iron body, stainless steel stem, bronze plug, bronze seat, and a TFE V-ring packing. End connections shall be flanged.

Sizing

Two-Position: Line size or size using a pressure differential of 1 psi.

2-way Modulating: 5 psig [ 35 kPa ]or twice the load pressure drop, whichever is greater.

3-way Modulating: Twice the load pressure drop, but not more than 5 psig [35 kPa].

Flow Characteristics: 2-way valves shall have equal percentage characteristics; 3-way valves shall have linear characteristics.

Close-off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of total system head pressure for 2-way valves and 150% of the design pressure differential across the 3-way valves.

Power Requirements: 24 VAC, 24 VDC, or 120VAC as required by manufacturer

* + - * 1. Steam Control Valves:

Globe Valve (valves 2” [ 50 mm] and smaller): ANSI Class 250 bronze body; stainless steel seat, stem and plug; and a TFE packing.

Globe Valve (valves 2.5” [ 62.5 mm] to 6” [150 mm]): ANSI Class 125 [250] cast iron body; stainless steel seat, stem and plug; and a TFE V-ring packing.

Sizing:

Two-Position: Line size or sized using 10% of inlet gauge pressure.

Modulating: 15 psig [105 kPa] or less inlet steam pressure, the pressure drop shall be 80% of inlet gauge pressure. Higher than 15 psig [105 kPa] inlet steam pressure the pressure drop shall be 42% of the inlet absolute pressure.

Flow Characteristics: Linear or equal percentage characteristics.

Close-off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of operating (inlet) pressure.

Power Requirements: 24 VAC, 24 VDC, or 120VAC as required by manufacturer

* + - * 1. Butterfly Control Valves:

Butterfly Valve (valves 6” [150 mm] to 12” [300 mm]): Valve body shall be full lugged cast iron 200 psig [1380 kPa] body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize an internal spline. External mechanical methods to achieve this mechanical connection, such as pins or screws, are not acceptable. The shaft shall be supported at four locations by RPTFE bushings. Close-off pressure rating of 200 psi [1380 kPa] bubble tigher shut-off.

Butterfly Valve (valves 14” [350 mm] and larger): Valve body shall be full lugged cast iron 150 psig [1035 kPa] body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize a dual-pin method to prevent the disc from settling onto the liner. The shaft shall be supported at four locations by RPTFE bushings. Close-off pressure rating of 150 psi [1035 kPa] bubble tigher shut-off.

Sizing:

Two-Position: Line size or size using a pressure differential of 1 psi.

Modulating: [5 psig [35 kPa]] or twice the load pressure drop, whichever is greater. Size for the design flow with the disc in a 60° open-position with the design velocity less than 12 feet [3.7 m] per second.

Power Requirements: 24 VAC, 24 VDC, or 120VAC as required by manufacturer

* + - * 1. Zone Control Valves (On/Off, Two-Position Applications):

Zone Valve (valves 1” [25 mm] and smaller): Forged brass body, rated at no less than 300 psi,[2070 kPa] female NPT union or sweat with a stainless steel stem and EPDM seals.

Sizing:

Two-Position: Line size or size using a pressure differential of 1 psi.[7 kPa]

Close-off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of total system head pressure for 2-way valves and 125% of the design pressure differential across the 3-way valves.

The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory.

Power Requirements: 24 VAC or 24VDC

* + - 1. Damper Actuators
         1. Features:

Electronic Damper Actuators: Actuators shall be sized for torque required for sealing the damper at load conditions, shall utilize v-bolt dual nut clamp with v-shaped tooth cradle coupling, and shall be capable of bing mechanically or electrically paralleled to increase torque if required. Electronic overload protection or digital rotation-sensing circuitry shall be used to prevent any damage to the actuator during a stall condition (and shall not require the use of end switches for protection). Fail-safe operation shall be provided as mechanical spring return (or electrical if spring return is not available for actuator size).

Terminal Unit Actuators: Actuators shall be sized for torque required for sealing the damper at load conditions and shall utilize V-bolt dual nut clamp with a V-shaped toothed cradle or an ISO-style direct-coupled mounting pad coupling. Close of differential pressure rating of 200psi.

* + - * 1. Operating Temperature: -22° F to 122° F (-30° C to 50° C)
        2. Protection / Rating: Minimum requirement NEMA type 2 / IP54 mounted in any orientation, NEMA 4X for outdoor applications, and UL94-5V(B) flammability for terminal unit actuators
        3. Input/Output:

Two Position: Digital output including Form C relay output

Modulating: 4-20 mA and 0-10 Vdc.

End Switches / Auxiliary Switches (if applicable): SPDT, digital inputs from dry contact closure

* + - * 1. Power:

Electronic Damper Actuators: Two position spring return shall be 24 or 120VAC as required by manufacturer and proportional actuators shall be 10VA at 24VAC or 8W at 24VDC

Terminal Unit Actuators: maximum of 1 VA at 24VAC or 1 W at 24VDC

* + - * 1. Agency Approvals:

Electronic Damper Actuators: ISO 9001, UL, UL(C) and CSA C22.2 No. 24-93.

Terminal Unit Actuators: CE, UL 60730-1A/-2-14, CAN/CSA E60730-1, CSA C22.2 No. 24-93, CE according to 89/336/EEC.

* + - 1. Air Flow Measuring Station
         1. Features:

Duct Air Flow Measuring Station: Highly accurate thermal dispersion airflow and temperature measuring probe(s) designed for duct sizes 8 – 120”. Multiple velocity and temperature points on one or more probes installed in the duct or plenum are averaged to arrive at air measurements. Capable of displaying the flow and temperature at each sensing point. Moisture resistant flex sensors protected from the elements with a thin conformal coating. Includes airfoil-Shaped aluminum probes with LCD screen digital display controller and the correct number of ancillary probes based on the size of the duct.

Fan Inlet Air Flow Measuring Station: Shall be capable of monitoring and reporting the airflow and temperature at each fan inlet location scheduled through two or four sensing circuits and a control transmitter that communicates with the building automation system (BAS). Includes aerodynamically shaped, surface mount fan inlet sensors and LCD screen control transmitter.

* + - * 1. Operating Temperature: -20° F to 120° F (-29° C to 49° C)
        2. Protection / Rating: U.L. 94 flame rated, high impact ABS
        3. Input/Output:

Velocity Output : 4-20mA or 2-10 VDC with 500 ohm resistor

Temperature Output : 4-20mA or 2-10 VDC with 500 ohm resistor

BACnet MS/TP (for duct air flow measurement stations)

* + - * 1. Power: 24 VAC (+/- 15%); 15 VA
        2. Accuracy: ±3% of reading with ±0.25% repeatability and ±0.10° F (0.06˚ C)
        3. Range: 0-5000 FPM for ducts and 0-10,000 FPM for fan-inlet
        4. Agency Approvals: All components are U.L. Listed and compliant with RoHS directive 2002/95/EC, AMCA, and ISO 9001. In addition duct airflow measuring stations are compliant with Part 15 of the FCC rules and BTL.
      1. Liquid Flow Meters
         1. Features:

Insertion Turbine Flow Meter: Only acceptable for closed loop systems, otherwise ultrasonic flow meters shall be used. Accurate, reliable flow measurement suitable for use in 1.25” – 72” diameter pipes (dual turbine shall be used for all pipes exceeding 2.5” diameter to reduce effects of flow distortion). 316 Stainless steal construction with high temperature adapter and isolated analog output capable of operating at pressures up to 400 psi.

Ultrasonic Flow Meter: Clamp-on transducers and signal processing circuitry to accurately measure the flow of most liquids over a wide velocity range using differential transit time velocity measurement. Includes transducers and easy-to-use mounting hardware, factory supplied transducer cabling, and a wall mount enclosure with an LCD and user interface keypad.

* + - * 1. Operating Temperature: -40° F to 250° F (-40° C to 121° C)
        2. Protection / Rating: Nema 4 (turbine) and Nema 4X (ultrasonic)
        3. Input/Output: {&&CSensor,FLOWMETER}

4-20 mA, 0-10 V or 0-5 V (jumper selectable)

Scaled pulse output

RS485 serial interface, BACnet MS/TP or MODBUS RTU (for ultrasonic)

* + - * 1. Power: 24 V AC/DC, 10 VA max
        2. Accuracy:

Turbine: ±0.5% of reading accuracy at the calibrated (typical) flow velocity and within ±1-2% of reading over a 50:1 flow range

Ultrasonic: ± 1.0% of reading from 1 to 20 ft/s, ± 0.01 ft/s for velocities below 1 ft/s with ±0.25% repeatability

* + - * 1. Range: 0.4 to 30 ft/s (turbine) and 0.1 to 20 ft/s (ultrasonic)
        2. Agency Approvals: UL Listed and NIST Traceable Standards. Ultrasonic flow meters are also CSA and CE approved.
      1. BTU Meter
         1. Features: Energy measurement system is suitable for metering cold or hot systems. Flow sensor, energy calculator and temperature sensors compute energy using flow and temperature differential. BTU system provides highly accurate thermal energy measurement and includes two RTD temperature sensors. The flow sensor shall be ordered separately and shall comply with “flow meter” specifications as outlined above. One temperature probe is mounted directly in the flow sensor tee, the second temperature probe is installed either the supply or the return line depending on application. Energy rate, flow rate, supply temperature, return temperature, and differential temperature shall all be available through serial communications.
         2. Operating Temperature: -20° F to 140° F (-29° C to 60° C)
         3. Protection / Rating: Nema 4 enclosure with LCD display
         4. Input/Output:

4-20 mA, 0-10 V or 0-5 V

Scaled pulse outputs

BACnet/IP or RS485 serial interface (BACnet MS/TP or MODBUS RTU)

* + - * 1. Power: 24 V AC or 120 V AC
        2. Accuracy:

Temperature: ±0.15° F over the stated temperature range (temperature range selectable based on application)

Flow: based on flow meter selected – refer to flow meter specifications above

BTU Calculation: computing nonlinearity within ±5%

* + - * 1. Range: 32° F to 77° F (chilled/condenser water) and 140° F to 212° F (hot water)
        2. Agency Approvals: EN1434 / CSA C900.1 class 1 and NIST Traceable Standards.
      1. Room Pressure Monitor
         1. Features: The room pressure monitors shall be capable of monitoring the differential pressure at all specified locations on the drawings. Each monitor shall have a 4.3” [109 mm] TFT, dimmable, full color touch-screen display with a 480 x 272 resolution and password protection capabilities. The touch screen shall display the current differential pressure, the room status (green – ok, red – in alarm, yellow - warning) as well integral “Room Condition Banner” in one device. The monitor shall have the ability to be set in Negative, Positive, or Neutral status and occupied/unoccupied through the touch screen interface. The monitor will have an internal pressure sensor as well as the capability to use an external (remote) pressure sensor input.
         2. Operating Temperature: 32° F to 120° F (0° C to 49° C)
         3. Protection / Rating: Fire Retardant Plastic UL94 V-0 with LCD display
         4. Input/Output:

0-10 VDC or 0-5 VDC

RS485 serial interface (BACnet MS/TP)

* + - * 1. Power: 24 V AC
        2. Accuracy: ±0.25% of full scale
        3. Range: selectable pressure range from ±0.05 inches W.C. to ±5.00 inches W.C.
        4. Agency Approvals: NIST Traceable Standards.
      1. Water Pressure Sensor
         1. Features: Provide water pressure sensors as indicated within the sequences of operations and/or controls diagrams with operating range suitable for application. Select range such that it covers from zero pressure to twice the amount of pressure desired for control purposes or that could be encountered. Sensor shall include over pressure input protection of a minimum two times rated input, burst pressure of a minimum five times rated input, and 17-4PH stainless steel wetted parts
         2. Operating Temperature: -40° F to 185° F (-40° C to 85° C)
         3. Protection / Rating: 17-4 PH Stainless Steel or NEMA 4X if enclosure provided
         4. Input/Output: 4-20 mA output proportional to water pressure
         5. Power: 3-wire circuit for power and output (COM, OUT, EXC) with EXC being 15-30 VDC (18-30 VAC)
         6. Accuracy: ± 1% of full scale
         7. Range: selectable pressure range 1 – 10,000 psi
         8. Agency Approvals: CE & RoHS Compliant
      2. Water Differential Pressure Sensor
         1. Features: Provide water differential or gage pressure sensors as indicated within the sequences of operations and/or controls diagrams suitable for application. Select range such that it covers from zero differential pressure up to a differential static pressure of 20% to 50% in excess of the maximum static pressure that could be encountered. Remember that if the sensor is used for the control of a chilled water bypass and is located across, for example, a chilled water AHU coil, the pressure drop of both the coil and the associated valve at full design flow have to be taken into account. Sensor shall include over pressure input protection of a minimum two times rated input, burst pressure of a minimum five times rated input, and 17-4PH stainless steel wetted parts.
         2. Operating Temperature: -4° F to 185° F (-20° C to 85° C)
         3. Protection / Rating: NEMA 4 or NEMA4X if enclosure provided
         4. Input/Output: 4-20 mA output proportional to pressure sensed
         5. Power: 3-wire circuit for power and output (COM, OUT, EXC) with EXC being 15-30 VDC (18-30 VAC)
         6. Accuracy: ± 1% of full scale
         7. Range: selectable pressure range 1 – 500 psi
         8. Agency Approvals: CE & RoHS Compliant
      3. Air Pressure Sensor – Duct / Space / Air Differential (Filter/Coil Monitoring)
         1. Features: Provide air pressure sensors as indicated within the sequences of operations and/or controls diagrams suitable for application. Select range as detailed below based on application type. Sensor shall include over pressure input protection of a minimum two times rated input or 20 psi (whichever is greater).

Duct Mounted Static Pressure Sensor: Select range such that it covers from zero duct static pressure relative to the exterior of the duct up to a static pressure of between 20% and 50% in excess of the maximum static pressure that could be encountered in the duct relative to the duct exterior. Typically, for low pressure commercial duct consider using a range of 0 to 2” wc. (0 to 500Pa), for medium pressure duct use a range of 0 to 6” wc. (0 to 1500Pa) and for high-pressure duct use a range of 0 to 10” wc (0 to 2500 Pa).

Space Static Pressure Sensor: Input range of -0.2” to + 0.2” wc (–50 to +50 Pa).

Air Differential Pressure Sensor: Select range as required, taking into consideration pressure drop across filter or coil. Typically 0-2” wc (0 to 500 Pa) range for low-pressure commercial duct.

* + - * 1. Operating Temperature: 32° F to 140° F (0° C to 60° C)
        2. Protection / Rating: Polycarbonate (UL 94 V-0 Approved)
        3. Input/Output: 4-20 mA, 0-5V, or 0-10V output proportional to pressure sensed
        4. Power: 24VAC or 24VDC
        5. Accuracy: ± 1% of full scale
        6. Range: selectable pressure range 0- 20” w.c.
        7. Agency Approvals: UL listed
      1. Air Pressure Switch
         1. Features: Provide air pressure switches as indicated within the sequences of operations and/or controls diagrams suitable for application. Select range as required, taking into consideration pressure drop across filter or coil. Typically 0.2-2” wc (0 to 500pa) range for low-pressure commercial duct. Sensor shall include over pressure input protection of a minimum two times rated input or 20 psi (whichever is greater).
         2. Operating Temperature: -4° F to 140° F (-20° C to 60° C)
         3. Protection / Rating: IP54 (NEMA 13) polycarbonate
         4. Input/Output: SPDT switch digital input from dry contact closure
         5. Power: N/A
         6. Accuracy: ± 1% of full scale
         7. Range: selectable pressure range 0- 12” w.c.
         8. Agency Approvals: N/A
      2. Gas Sensor and Control System
         1. Features: Self-contained dual gas sensor that is network ready for either peer-to-peer (master slave) operation or central control for a smooth integration into new or existing energy management system. Impact resistant water proof enclosure, 3 adjustable alarm relays, indicators and strobe (Red LED alarm indicators, level 1 and 2 High intensity white LED strobe and audible alarm on level 3). The sensor shall include an 85db audible alarm and LCD display for calibration, user settings, and displaying gas concentrations. Sensor shall be placed in locations outlined within sequences of operations, mechanical plans, and/or control diagrams. Mounting heights and distance covered shall also adhere to manufacturer recommendations. Sensor shall be factory calibrated and will only require calibration after a minimum one (1) year service.
         2. Operating Temperature: -4° F to 104° F (-20° C to 40° C)
         3. Protection / Rating: ABS UL-94-V0, UL-94 - 5VA, Nema 4
         4. Input/Output:

4-20 Ma or 2-10V analog output

2 Relays SPDT, 5 amp @ 125 vac, non-inductive

RS-485 serial interface BACnet MS/TP

* + - * 1. Power: 24 V AC
        2. Accuracy: ± 2% of full scale
        3. Range: ppm or %LEL based on manufacturers recommendations
        4. Agency Approvals: UL61010-1, CSA C22.2 61010-1-12, ANSI/ISA 61010-1, CSA C22.2 no. 205-12
      1. Air Quality Sensor
         1. Features: Air quality sensor that is able to detect poor air quality from a broad range of volitle organic compounds (VOCs) such as cooking odors, smoke, bioeffluence, outdoor pollutants and from human activities. The air quality sensor shall detect volatile organic compounds beyond typical CO2 applications. Sensor shall be space mounted or duct mounted in locations outlined within sequences of operations, mechanical plans, and/or control diagrams.
         2. Operating Temperature: 32° F to 122° F (0° C to 50° C)
         3. Protection / Rating: Polycarbonate, UL94-V0, IP65 (NEMA 4X)
         4. Input/Output:

0-5V or 0-10V analog output

* + - * 1. Power: 24 V AC
        2. Accuracy: ± 2% of full scale
        3. Range: 450-2000ppm CO2 equivalent
        4. Agency Approvals: UL94-V0
      1. Carbon Dioxide (CO2) Sensor
         1. Features: Provide a space or duct carbon dioxide gas detection sensor as indicated within the sequences of operations and/or control diagrams. Optional features include BACnet communication, LCD display, setpoint adjustment, or integral temperature/humidity sensors (optional features shall be provided if necessary based on project scope).
         2. Operating Temperature: 32° F to 122° F (0° C to 50° C)
         3. Input/Output: 4-20 mA, 0-10 or 0-5 Vdc output compatible with BMS proportional to carbon dioxide concentration
         4. Power: 24VAC or 24VDC
         5. Accuracy: ± 3% of full scale
         6. Range: 0 to 2000 ppm
      2. Duct / Immersion / Outdoor Temperature Sensors
         1. Features: Provide Thermistor or RTD temperature sensors as indicated within the sequences of operations and/or control diagrams. Install sensor as detailed below.

Outside Air Temperature Sensor: Provide outside air temperature sensors with Aluminum LB with PVC sun and windscreen weatherproof enclosure with conduit entrance. Install in an area where exhaust or roof heat will not affect readings.

Duct Mounted Temperature Sensor (ducts less than 10ft² [1m²] in cross-sectional area): Provide duct mounted, single point probe temperature sensor with 0.25” [6.35 mm] stainless steel probe of length between one-third and two-thirds of the duct width.

Duct Mounted Averaging Temperature Sensor (ducts greater than 10ft² [1m²] in cross-sectional area): Provide duct mounted, averaging, temperature sensor with probe length of 12 feet [3.66m] minimum or 1ft per ft² (3.25m per m²) of duct cross-sectional area, whichever is greater. Copper sheathed or plenum rated flexible construction.

Liquid Temperature Sensor: Provide immersion thermowell mounted temperature sensors for liquid temperature sensing. Rigid 0.25” [6.35mm] stainless steel probe of length, which is, at minimum, 20% of the pipe width. Provide Brass or Stainless steel thermowell (316 or 304) with thermal grease to aid temperature sensing.

Strap-on Temperature Sensor: Provide strap-on mounted temperature sensors where thermo well mounted sensors cannot be mounted.

* + - * 1. Operating Temperature: -58° F to 212° F (-50° C to 100° C) dependent upon application
        2. Input/Output: thermistor or RTD compatible with BAS
        3. Power: dependent upon sensor type – provide as per manufacturers recommendations
        4. Accuracy: ± 1.0°F (0.5 °C)
        5. Range: -58° F to 212° F (-50° C to 100° C) dependent upon application
      1. Duct / Outdoor Humidity Sensors
         1. Features: Provide duct / outdoor humidity sensors as indicated within the sequences of operations and/or control diagrams. Outside air humidity sensors shall have ABS hinged weatherproof housing with conduit entrance and shall be installed in an area where exhaust or roof heat will not affect readings. Duct humidty sensors shall have ABS housing with conduit entrance. In addition all humidity sensors shall have 9” probe length, 60 micron HDPE filter, reverse voltage protection, and be output limited.
         2. Operating Temperature: 32° F to 122° F (0° C to 50° C)
         3. Input/Output: 4-20 mA two wires, 0-10 Vdc and/or 0-5 Vdc output proportional to relative humidity range of 0% to 100%
         4. Power: 24VAC or 24VDC
         5. Accuracy: ± 3% of full scale
         6. Range: 5-95%RH
      2. Space Temperature Sensors
         1. Features: Provide space temperature sensors as indicated within the sequences of operations and/or control diagrams. Shall consist of an element within a ventilated cover. Space sensors located in mechanical rooms and large public spaces shall contain a network jack, but shall have no ability to adjust temperature setpoint (Set Point Adjustment). Space sensors located in other spaces shall include options (setpoint adjustment, network jack, fan speed selection, override switch, and/or digital display) in accordance with the drawings and sequences of operations.
         2. Operating Temperature: 32° F to 122° F (0° C to 50° C)
         3. Input/Output: dependent upon sensor type – provide as per manufacturers recommendations
         4. Power: dependent upon sensor type – provide as per manufacturers recommendations
         5. Accuracy: ± 1.0°F (0.5 °C)
         6. Range: 32° F to 122° F (0° C to 50° C)
      3. Space Humidity Sensors
         1. Features: Provide space humidity sensors as indicated within the sequences of operations and/or control diagrams. Sensor shall have reverse voltage protection and be output limited.
         2. Operating Temperature: 32° F to 122° F (0° C to 50° C)
         3. Input/Output: dependent upon sensor type – provide as per manufacturers recommendations
         4. Power: dependent upon sensor type – provide as per manufacturers recommendations
         5. Accuracy: ± 3% of full scale
         6. Range: 5-95%RH
      4. Combination Relative Humidity And Temperature Sensors
         1. Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, the BMS Contractor shall provide a combination relative humidity sensor and temperature sensor. The individual sensors must each meet the specifications details above.
      5. Low Limit Thermostats
         1. Features: Provide low limit thermostats as indicated within the sequences of operations and/or control diagrams. Safety low limit thermostats shall be vapor pressure type with an element 20 ft [6.1 m] minimum length. Element shall respond to the lowest temperature sensed by any one foot section. Low limit shall be manual reset only.
         2. Operating Temperature: -60° F to 160° F (-51° C to 71° C)
         3. Input/Output: 2 SPDT switches, digital inputs from dry contact closure
         4. Power: N/A
         5. Accuracy: ± 1.0°F (0.5 °C)
         6. Range: adjustable range 34° F to 70° F (1° C to 21° C)
      6. Current Relay/Switch
         1. Features: Provide current sensing relays as indicated within the sequences of operations and/or control diagrams. The current sensing relay shall be rated for the applicable load, , shall have input and output isolation via current transformer, and the output relay shall have an accessible trip adjustment over its complete operating range. Whenever the status of a single speed motor is monitored it shall be done via a current sensing relay. The BAS contractor shall provide current sensing relays at the MCC starters (or at the local starter for motors without a MCC starter).
         2. Operating Temperature: 5° F to 140° F (-15° C to 60° C)
         3. Input/Output: digital input from dry contact closure
         4. Power: Current relay shall be self-powered with no insertion loss
         5. Accuracy: ± 2% of full scale
      7. Current Sensor
         1. Features: Provide current sensors as indicated within the sequences of operations and/or control diagrams. The current sensors shall be rated for the applicable load, and shall be reverse polarity protected and output limited.
         2. Operating Temperature: -20° F to 120° F (-29° C to 49° C)
         3. Input/Output: 4-20 mA, 0-10 or 0-5 Vdc output proportional to current draw
         4. Power: Current sensor shall be self-powered with no insertion loss
         5. Accuracy: ± 1% of full scale
      8. Leak Detection Monitoring – Water
         1. Features: Provide leak detectors as indicated within the sequences of operations and/or control diagrams. The , appropriate leak detector type should be provided based on application (i.e spot leak detector for drain pans and rope leak detector for floors). Leak detectos shall be corrosion and abrasion resistant.
         2. Operating Temperature: 50° F to 104° F (10° C to 40° C)
         3. Input/Output: (2) Form C relays, digital input from dry contact closure
         4. Power: 24 VAC
      9. Damper End Switch
         1. Features: Provide damper end switches as indicated within the sequences of operations and/or control diagrams. End switches shall prove a damper has reached the position specified. End switches shall be integral to damper actuator unless otherwise specified.
         2. Input/Output: SPDT switch, digital input from dry contact closure
      10. Wireless Space Sensors / Switches
          1. Provide for wireless sensing of the designated sensors and or switches as shown on the Point List Chart.
          2. Wireless sensors shall be able to operate at a designated frequency of 315 MHz or 868 MHz, to be determined local regulation.
          3. Controllers shall be field upgradable to receive wireless communications from switches and sensors (become wireless-enabled) by connecting a plug-in wireless transceiver.
          4. Wireless temperature sensor/switch – the wireless sensing technology provided shall transmit a RF message indicating the value or position of the sensor. The transmission range shall be a minimum of 305 ft. [100 m] unobstructed line of sight and 100 ft. [30 m] in buildings.
          5. Each sensor or switch shall be provided with energy harvesting technology such that no battery will be required to maintain normal operations. If using a Solar Cell for energy harvesting, normal operation parameters shall be defined as a minimum of 4 hours of 200lx of light to produce an operation of the sensor for a period of no less than 20 hours in total darkness. In sufficient light levels are not available, provide a battery backup.
          6. All sensor locations shall be verified to be in compliance with manufacturer’s installation requirements and be tested for acceptable signal strength.

1. End of Section
   1. EXECUTION
      1. Communication Backbone
         1. To allow for future expandability, cyber security measures, optimal bandwidth, and enhanced data trending this project shall adhere to the below communication backbone requirements.
         2. BACnet IP
            1. BACnet/IP communication protocol shall be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)
         3. Modbus RTU, Modbus TCP, and BACnet MS/TP (RS-485)
            1. Modbus RTU and BACnet MS/TP shall only be used for third party systems / equipment that do not have IP provisions (VFDs, boilers, etc.)
            2. Modbus TCP shall only be used for third party systems / equipment that do not support BACnet/IP
      2. Installation of Sensors
         1. Install sensors according to manufacturer's recommendations.
         2. Mount sensors rigidly and adequately for operating environment.
         3. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft.[9 m] of sensing element for each 1 ft2 [1 m2] of coil area.
         4. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.
         5. Install outdoor air temperature sensors on north wall at designated location with sun shield.
         6. Install building pressure pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.
         7. High and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.
      3. Coordination
         1. All work shall be performed at times acceptable to the Engineer/Construction Manager. Provide work schedule at the start of the job for the approval of the Engineer / Construction Manager. Schedule shall show when all staff and sub-contractors shall be on-site.
      4. Electrical Work, Wiring and Safety
         1. Electrical work shall be in accordance ANSI/NFPA 70 and the local Electrical Code.
         2. Based on project location, Regional Regulation Compliance Certifications (CSA C22.1) will be required.
         3. Electrical wiring, terminal blocks and other high voltage contacts shall be fully enclosed or properly guarded and marked to prevent accidental injury to personnel.
         4. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26 00 00, and manufacturer's recommendations. Where the requirements of this Section differ from other Divisions, this Section shall take precedence.
            1. Power wiring to mechanical equipment, variable air volume boxes, and motor controllers shall be provided by the Electrical contractor (Division 26).
            2. EMT conduit shall be used in mechanical/electrical rooms and exposed spaces.
            3. Rigid Galvanized Steel conduit shall be used outdoors.
            4. Plenum rated cable shall be used in concealed spaces/hung ceilings.
         5. All wiring associated with and required by the BAS shall be the responsibility of this contractor.
            1. The term "wiring" shall be construed to include furnishing of wire, conduit, and miscellaneous material and labor as required to install a total working system.
            2. If departures from the contract documents are deemed necessary by the contractor, details of such departures, including changes in related portions of the project and the reasons therefore, shall be submitted with the drawings to the Engineer for approval.
         6. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.
         7. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.
         8. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.
         9. Each run of communication wiring shall be a continuous length without splices when that length is commercially available.
         10. Label communication wiring to indicate origination and destination.
         11. Fiber optic cable shall comply with the following requirements:
             1. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125 µm.
             2. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.
      5. Submittals
         1. Schematic diagram of each controlled system. Label control points with point names.
         2. Bill of Material for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
         3. Specification sheets for each item including manufacturers descriptive literature, drawings, diagrams, performance and characteristic curves, manufacturer and model number, size, layout, dimensions, capacity, etc.
         4. Control schematics with narrative description and control descriptive logic fully showing and describing operation and/or manual procedures available to operating personnel to achieve proper operation of the building, including under complete failure of the BAS.
         5. Shop drawings for each input/output point showing all information associated with each particular point including sensing element type and location; details of associated field wiring schematics and schedules; point address; software and programming details associated with each point; and manufacturer's recommended installation instructions and procedures for each type of sensor and/or transmitter.
         6. Riser diagrams showing control network layout, communication protocol, and wire types.
         7. Network diagram of control, communication, and power wiring for BAS Server and OWS installation.
      6. As-built Documentation
         1. As-built documentation shall consist of 4 hard copies and one soft copy for all information described below
         2. The final documentation package shall include:
            1. As-built Submittals: Final as built control submittals and technical data sheets.
            2. Programming, Sequences, and Graphics: All programming, sequences, and graphics saved to an external hard drive.
            3. Operation and Maintenance Manuals: Factory operating and maintenance manuals with any customization required.
            4. Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as test procedures.
      7. Warranty
         1. The BAS system labor and materials shall be warranted free from defects for a period of 1 year(s) after final commissioning and owner acceptance.
      8. Training
         1. BAS Contractor shall provide a minimum of 16 hours of training with course outline and materials for personnel designated by the owner.
         2. If desired manufacturer provided training on the use and operation of all products provided within these specifications shall be available for purchase and attendance by the Owner or his designated agent. A list of training courses with detailed course outline and duration with the associated cost shall be provided as part of the BAS submittals.
      9. Balancing and Commissioning
         1. BAS Contractor shall provide a minimum of 16 hours of commissioning assistance with a commissioning agent and 16 hours of balancing assistance with a balancing agent. Balancing and commissioning agents shall NOT be provided by BAS contractor – BAS contractor is responsible for assistance only.
         2. For projects without balancing and commissioning agents the BAS contractor shall self commission the system utilizing the allotted hours stated above.
         3. For projects including gas detection / air quality sensors involved in life safety operations a minimum of 8 hours shall be provided within BAS scope of work for the gas sensor manufacturer to provide checkout, calibration, and owner training.
         4. Provide commissioning data sheets prior to acceptance testing.
      10. Alternates
          1. Maintenance Contract:
             1. The BAS Contractor shall present a two year maintenance contract for the Owner's acceptance within sixty days after installation of the system begins. Show the price for each year with all payment terms and conditions.
             2. The Maintenance Contract shall include the following provisions: on-line diagnostic and troubleshooting service, quarterly software maintenance/consultation/database backup, repair and replacement as needed (T&M proposals), and emergency service (per predetermined agreement).
             3. Maintenance Routines include, but are not be limited to the following: checking performance of equipment and components (with diagnostic testing, examination, adjustment, and calibration) and 2 training sessions per year.
             4. The Maintenance Contract shall be renewable at the Owner’s option and include provision for increased charges due to expansion of the system, changes in service coverage, and/or inflation.
2. End of Section