SECTION 230923 – DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The Drawings and the General Provisions of the Contract, including General, Supplementary, and Special Conditions, and Division 1 - General Requirements, apply to work specified in this section. Subcontractor must familiarize himself with the terms of the above documents and any sections hereinafter referred to that affect this work.

1.2 SUMMARY / SCOPE OF WORK

A. This Section includes Direct Digital Control (DDC) based control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Scope of Work: The Automatic Temperature Control (ATC) Contractor shall furnish and install a complete Building Automation System (BAS) including all necessary hardware and all operating and applications software necessary to perform the control sequences of operation as called for in this specification. The software shall include color graphics for all mechanical systems and floor plans of the building(s).

C. All components of the system – workstations, application controllers, unitary controllers, etc. shall communicate using industry standard communication protocol, as defined by ASHRAE Standard 135-2010. At a minimum, provide controls for the HVAC equipment that is identified on the contract drawings and that are referred to in the sequences of operation.

D. Control system consists of a complete stand-alone DDC control system. The system shall consist of a graphical workstation (one per school) and web server. The web server and graphical workstation will reside in an area approved by the owner or as indicated on the design drawings. Typical locations include the building engineer's or building & ground supervisor's office. All Ethernet LAN communications will be over the existing and/or new WAN provided by the owner.

E. For Web-based controls: The Web server will allow access to the DDC system from any standard browser over the Internet. All graphics that are generated on the local workstation will be generated for use over the Web.

F. All software will be licensed to the owner with full password capability and access. Under no circumstances will any part of the system or software be licensed or controlled by the control contractor. The entire system including original software discs will be turned over to the owner.

G. The basis of design is a BACnet system that is completely based on ANSI/ASHRAE Standard 135 BACnet. The entire control system shall be in compliance with the BACnet standard, ANSI/ASHRAE 135. The system shall use BACnet protocols and LAN types throughout and exclusively. Non-BACnet compliant or propriety equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

1.3 DEFINITIONS

A. ATC: Automatic Temperature Control.

B. BACnet: Building Automation Control Network. ASHRAE Standard for interoperability between DDC systems.

C. BAS: Building Automation System.

D. BIBBS: BACnet Interoperable Building Blocks.

E. DDC: Direct Digital Control.

F. I/O: Input/Output.

G. MS/TP: Master Slave/Token Passing.

H. PC: Personal Computer.

I. PIC: BACnet's "Protocol Interoperability Conformance Statement" which define compliance with BACnet.

J. PID: Proportional plus Integral plus Derivative.

K. RTD: Resistance Temperature Detector.

1.4 ELECTRICAL WORK FOR CONTROLS

A. Complying with the principle of "unit responsibility" all electrical work for automatic controls, except as otherwise specified, or shown on the electrical drawings shall be included in mechanical sections.

B. Electrical work shall, in general, comply with the following:

1. All low voltage wiring in finished rooms shall be concealed. If any wiring must be exposed in rooms it shall be installed in wiremold raceway.
2. Electrical work may include both line voltage and low voltage wiring, as required.
3. Conduit network for power systems may be used for running control high voltage wiring.
4. All electrical work shall comply with the N.E.C. and local electrical codes.
5. All safety devices shall be wired through both hand and auto positions of motor starting device to insure 100% safety shut-off.
6. All magnetic starters furnished by Mechanical Contractor for control transformers, sized to handle the additional VA needed for the controls – pilots, EP valves, etc.
7. The motor starter supplier shall provide auxiliary contacts as required for interlock by ATC Contractor; the supplier shall estimate an allowance of at least one auxiliary contact per starter. All interlock and control wiring shown on the electrical prints or in the electrical specifications is by the electrical subcontractor.
8. Low voltage plenum rated wiring can be run exposed above accessible ceiling. Wiring shall not laid on ceiling tiles and shall be supported using bridle rings, j-hooks, cable trays, or conduit. All control wiring in mechanical spaces shall be installed in EMT.

1.5 SYSTEM PERFORMANCE

A. System shall be open protocol technology utilizing standard accepted BACnet protocol.

B. Comply with the following performance requirements:

1. Front End PC shall provide animated graphics, scheduler graphics, alarm screens, point and click set-point adjustments, point and click alarm acknowledgements and resets and other graphics displays required by end user. Graphics screens may have up to 20 dynamic points with current data updating every 3 seconds or less.
2. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
3. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
4. Alarm Response Time: Annunciate alarm at workstation within 5 seconds. Multiple workstations must receive alarms within five seconds of each other.
5. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
6. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
7. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

a. Water Temperature: Plus or minus 1 deg F.
b. Water Flow: Plus or minus 5 percent of full scale.
c. Water Pressure: Plus or minus 2 percent of full scale.
d. Space Temperature: Plus or minus 1 deg F.
e. Ducted Air Temperature: Plus or minus 1 deg F.
f. Outside Air Temperature: Plus or minus 2 deg F.
g. Dew Point Temperature: Plus or minus 3 deg F.
h. Temperature Differential: Plus or minus 0.25 deg F.
i. Relative Humidity: Plus or minus 5 percent.
j. Electrical: Plus or minus 5 percent of reading.

1.6 SUBMITTALS

A. Shop Drawings shall include the following requirements:

1. Provide Index Sheet, listing contents in alphabetical order.
2. Prepare all shop drawings in AutoCAD Software. In addition to the drawings, the Contractor shall furnish a CD containing the identical information.
3. Riser Diagrams shall depict the locations of all controllers and workstations, with associated network wiring.
4. System Schematics of each mechanical system shall show all connected points with reference to their associated controller. Typicals will be allowed where appropriate. Shop drawings shall be depicted in point to point schematics, showing controllers, power supplies, system diagram, end device details, termination points and wire and type required from control panel to end device.
5. Wiring Diagrams: Power, signal, and control wiring.
6. Submittal Data shall contain manufacturer's data on all hardware and software products required by the specification.

7. Valve Schedules shall indicate size, pattern, connections, flow, pressure drop, CV rating, pressure rating, and location.
8. Damper Schedules shall indicate size, airflow, pressure drop, leakage, manufacturer, model number, and location.
9. Computer Work Station.
10. Point's List.
11. Sequence of Operation for each system.
12. Software Submittals shall contain narrative descriptions of program listings and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software.
13. Color Graphics: Provide a list of the standard and custom color graphic screens for all mechanical systems and floor plans of the building(s). For each screen, provide a conceptual layout of pictures and data.
14. Information shall be bound or stapled with an index and tabs.
15. Submit the Required Copies of submittal data and shop drawings for review prior to ordering or fabrication of the equipment.

B. BACnet System:

1. Control Contractor / Manufacturer shall have a solid reputation of installing, servicing and maintaining "open protocol" HVAC Control systems that are compliant with present BACnet standards ASHRAE 135-2001. BIBB's and PIC statements shall be provided for each controller and must comply with the specified requirements, below. Contractor must provide documentation that its systems can communicate with multiple manufacturers over a MSTP (master slave token passing) network and that future system extensions can be competitively bid among a multitude of Contractors / Manufacturers whose operating protocol is also based on the BACnet standard. Contractors who represent product-lines, which are based on a proprietary operating system, utilizing proprietary networks, which cannot be extended by third party DDC System manufacturers, will not be acceptable. DDC System manufacturers who utilize drivers, RS 232 communication ports or field server type interface devices to communicate with a BACnet system will not be acceptable. As part of submittal package, provide sample PIC (product information conformance) statement for each DDC Controller indicating controller conforms with ASHRAE BACnet standard.

2. BIBB's for controllers shall be as follows:

   a. BACnet LAN Router BIBB's: The central system shall use the building Local Area Network (LAN) for communication. The communication between the central server and the controllers shall be BACnet/IP. A router shall be provided, as required, to bridge BACnet/IP and the data link used between the controllers (BACnet over ARCNET or MS/TP). Proprietary protocols are NOT acceptable.
   b. BACnet LAN Router BIBB's: BACnet Routers must use BACnet as the native communication protocol and must, as a minimum, support the following BIBBS:

      1) Data Sharing: DS-RP-A, B, DS-RPM-B, DS-WP-A, B, DS-WPM-B, DS-COVU-A, B
      2) Alarm Event: AE-N-B, AE-ACK-B, AE-ASUM-B
      3) Device Man.: DM-DDB-A, B, DM-DOB-B, DM-DCC-B
      4) Network Man.: NM-RC-A

   c. Firmware Updates: The BACnet Router utilizes FLASH memory to allow firmware updates to be performed remotely.
   d. General Purpose Multiple Application Controllers:

1) BACnet BIBBS: General Purpose Multiple Application controllers must use BACnet as the native communication protocol between controllers and must, as a minimum, support the following BIBBS:

a) Data Sharing: DS-RP-A, B, DS-RPM-B, DS-WP-A, B, DS-WPM-B, DS-COVU-A, B
b) Alarm Event: AE-N-B, AE-ACK-B, AE-ASUM-B
c) Schedule: SCHED-B
d) Trend: T-VMT-BT-ATR-B
e) Device Man.: DM-DDB-A, B, DM-DOB-B, DM-DCC-B DM-TS-B, DM-UTC-B, DM-RD-B

e. General Purpose Single Application Controllers:

1) BACnet BIBBS: The General Purpose Single Application Controllers must use BACnet as the native communication protocol between controllers and must, as a minimum, support the following BIBBS:

a) Data Sharing: DS-RP-A, B, DS-RPM-B, DS-WP-A, B, DS-WPM-B, DS-COVU-A, B
b) Alarm Event: AE-N-B, AE-ACK-B, AE-ASUM-B
c) Schedule: SCHED-B
d) Trend: T-VMT-BT-ATR-B
e) Device Man.: DM-DDB-A, B, DM-DOB-B, DM-DCC-B DM-TS-B, DM-UTC-B, DM-RD-B

2) Communication Speed: Controllers shall communicate at a minimum of 156 Kbps using ARCNET implemented over EIA-485 using an unshielded twisted pair at the Data Link Layer.

f. Zone Controller Network:

1) Zone Controllers (Note: Unitary Controllers, non-stand-alone and MS/TP controllers are not acceptable, a clock must be in each controller and a trend shall exist for every point). BACnet BIBBS: The Zone Controllers shall use BACnet as the native communications protocol between controllers on the Zone controller network and must, as a minimum support the following BIBBS:

a) Data Sharing: DS-RP-B, DS-WP-B
b) Device Man.: DM-RD-B, DM-PT-B

C. Operation and Maintenance (O&M) Manuals: These shall be as-built versions of the shop drawing submittal product data. In addition to that required for the shop drawing submittals, the O & M manual shall include:

1. Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.
2. Maintenance instructions and lists of spare parts for each type of control device.
3. Interconnection wiring diagrams with identified and numbered system components and devices.
4. Keyboard illustrations and step-by-step procedures indexed for each operator function.
5. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

6. Calibration records and list of set points.
7. Licenses, Guarantee, and Warrantee documents for all equipment and systems.
8. Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.

D. Testing and Commissioning Reports and Checklists.

E. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

F. Program Software Backup: Include the following:

1. On approved media or compact disc, provide program software backup complete with data files.

1.7 QUALITY ASSURANCE & QUALIFICATIONS OF BIDDER/MANUFACTURER

A. Control Contractor shall have an established local branch office staffed with trained engineers, technicians and service mechanics within 50 miles of project site. The Control Contractors primary business shall be that of designing, installing and maintaining HVAC Control systems.

B. Control Contractor shall be a direct factory branch office or authorized representative for DDC System manufacturer. Contractor shall have at least five successful installations utilizing similar open protocol technology. Contractor shall be representative for DDC System manufacturer for at least five years and shall have proven track record of successful installations with the manufacturer of Control equipment proposed for the project.

C. Control Contractor shall be a direct factory branch office or authorized representative for DDC System manufacturer. Contractor shall have at least ten successful installations of similar size and scope utilizing similar open protocol technology. Contractor shall be representative for DDC System manufacturer for at least five years and shall have proven track record of successful installations with the control equipment proposed for the project. Contractors or Manufacturer's representatives who have not been representing their present product lines for at least three years will not be acceptable. The Control Contractor must be pre-qualified by the State of New Jersey, Department of Property Management and Construction (DPMC) and Schools Development Authority (NJSDA) under classification CO43 Control Systems and CO98 Energy Management Systems. This pre-qualification may not be less than $6 million in aggregate. This requirement insures that the Owner will contract with a firm that has good financial standing and necessary resources to install, maintain and provide future service to the installed Building Control System.

D. Bids by wholesalers, service companies or any other firm that cannot document a (minimum) five year direct relationship with the DDC manufacturer shall not be acceptable.

E. Installer Qualifications: Automatic control system manufacturer's authorized factory representative who is trained and approved for installation of system components required for this Project.

F. All controls shall be manufactured in the USA as follows:

1. Title 52 of N.J.S.A. refers to State owned buildings or State contracts. N.J.S.A. 52:33-2 provides that only domestic materials are to be used on public works. N.J.S.A. 18A:18A-1 et seq. is the Public School Contracts law. This applies to all public schools in the State of New Jersey. N.J.S.A. 18A:18A-20 also requires American goods and products to be used.

G. The ATC Subcontractor shall be certified by the State of New Jersey, Department of the Treasury, Division of Construction, Trenton, New Jersey. A copy of this certification shall be part of the bid and/or submitted prior to awarding of a contract and include the following:

1. Class 030-Subclass 10 Automatic Control Systems (HVAC): 5 million dollars.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

I. Comply with ASHRAE 135 for DDC system components.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

C. Coordinate equipment with the appropriate Divisions of the Electrical Specifications for Power, Wiring, Conduit, Fire Alarm, Motor-Control Centers, etc. to achieve compliance, compatibility, and interfaces.

D. Coordinate equipment with the appropriate Divisions of the Mechanical Specifications for Motor Controllers, Manufacturer Supplied Controls, etc. to achieve compliance, compatibility, and interfaces.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replacement Materials:

a. One replacement space and duct temperature and humidity sensor.
b. One replacement damper actuator.
c. One DDC Controller for every 24 of one type installed on project.

1.11 WARRANTY

A. The Control Contractor shall warrant the system for 12 months after system acceptance and beneficial use by the owner. During the warranty period, the Control Contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the Sequence of Operation section of the specification.

B. Updates to the manufacturer's software shall be provided at no charge during the warranty period.

C. Provide and alternate price for a second and third year of full warranty. Service Contract costs shall include all warranty items covered under the base project and shall effectively be an extension of the new System warranty. See bid form for alternate price breakouts (as applicable).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
2. Listed manufacturers must comply with all technical details of this specification.

B. Manufacturers (DDC Systems):
1. Andover Controls by Schneider Electric (Jersey State Controls, Brick, NJ).
2. Trane, Commercial Controls Group (Trane NY/NJ, Pine Brook, NJ).
3. Siemens Building Technologies (Branch Office, Florham Park, NJ).

2.2 CONTROL SYSTEMS

A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

B. In addition for DDC systems, it shall consist of software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 COLOR GRAPHIC SOFTWARE/GRAPHICAL USER INTERFACE

A. The Computer Work Station (or Web Browser) Graphical User Interface shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated gif's or jpg's active setpoint graphic controls shall be used to enhance usability. Tools used to create graphics shall conform to the following basic criteria:

1. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
2. Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings, which provide a display of temperature relative to their respective setpoints.
3. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units.
4. Minimum System Color Graphics: Color graphics shall be selected and displayed for the following:

    a. Each piece of equipment monitored or controlled including each terminal unit.
    b. Each floor and zone controlled.

2.4 DDC EQUIPMENT

A. Front End; Administration and Programming Workstation(s)

1. The BAS Contractor shall furnish Administration and Programming Workstation Computer(s) and printer(s) as required. These workstations must be running the standard workstation software developed, tested and supported by the manufacturer of the network controllers and the standalone controllers.

B. Web-Based Operator Workstations

1. The BAS Contractor shall furnish licenses for ten concurrent users to the BAS system. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control set-points and other parameters. A central web server shall be provided to manage the web-based users. Any browser, without the need for "Plug-in" software, shall have full control capability of all Trends, Graphics, Reports, Software changes and revisions, via a thin-client browser.

C. Ethernet-based Network Router/Controller(s)

1. The BAS Contractor shall furnish one Ethernet-based network controller for every fifty controllers that reside on the MSTP network. These controllers will connect directly to the Operator Workstation over Ethernet, using standard IP protocol at a minimum of 100 mbps, and provide communication to the Standalone Digital Control Units and/or other Input/Output Modules.

D. Standalone Digital Control Units (SDCUs)

1. General:

a. Provide the necessary quantity and types of standalone digital control units to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each standalone digital control unit will operate completely standalone, containing all of the I/O and programs to control its associated equipment.

b. Standalone Digital Control Units shall provide control of HVAC and lighting, including air handling units, rooftop units, variable air volume boxes, unit ventilators, and other mechanical equipment. Each controller shall be fully programmable, contain its own control programs and will continue to operate in the event of a failure or communication loss to its associated NRC (Network Router Controller).

2. Memory:

a. Both the operating system of the controller, plus the application program for the controller, shall be stored in non-volatile, FLASH memory. Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.

3. Communication Ports:

a. Standalone digital control units shall have a RS-485 communication port to the BACnet MS/TP field bus, operating at a speed of at least 19.2 kbps.

4. Input/Output:

a. Each standalone digital control unit shall have enough inputs and outputs to meet the application's required point count. Each standalone digital control unit shall support universal inputs, whereas any input may be software-defined as:

1) Digital Inputs for status/alarm contacts
2) Counter Inputs for summing pulses from meters.
3) Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
4) Analog inputs for pressure, humidity, flow and position measurements.

b. Standalone digital control units must support both digital and analog output types:

1) Digital Outputs for on/off equipment control.
2) Analog Outputs for valve and damper position control, and capacity control of primary equipment.

5. Expandability:

a. For larger controllers (16 base inputs and up), provide input and output expansion through the use of plug-in modules. At least two I/O modules must be capable of being added to the base standalone digital control unit.

6. Hardware Override Switches:

a. All digital outputs on air handling unit controllers shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition each analog output on air handling unit controllers shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

7. Room Sensor Support:

a. The standalone digital control unit shall support a basic room thermistor in plain plastic cover; a room sensor with override and setpoint adjust slider; and, a sensor with a one-line display and 6-button keypad. The display sensor shall be able to display the current temperature, setpoint, outside air temperature, relative humidity and setpoint, occupancy mode, and CFM of the individual zone.

8. Networking:

a. Each standalone digital control unit will be able to exchange information on a peer-to-peer basis with other Standalone Digital Control Units, according to the BACnet MS/TP protocol. Each standalone digital control unit shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each standalone digital control unit shall be able to have its program viewed and/or enabled/disabled through a workstation connected to an NRC.

9. Indicator Lamps:

a. Standalone digital control units will have as a minimum, LED indication of CPU status, and field bus status.

10. Real Time Clock (RTC):

a. All standalone digital control units shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The RTC shall provide the following information: time of day, day, month, year, and day of week. Each standalone digital control unit shall receive a signal, every hour, over the network from the NRC, which synchronizes all standalone digital control unit's real time clocks.

11. Automatic Restart After Power Failure:

a. Upon restoration of power, the standalone digital control unit shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

12. Battery Back Up:

a. All standalone digital control units shall store all programming in non-volatile FLASH memory. All standalone digital control units except terminal controllers shall include an on-board lithium battery to back up the controller's RAM memory. The battery shall have a shelf life of over 10 years, and provide accumulated backup of all RAM and clock functions for at least 3 years. In the case of a power

failure, the standalone digital control unit shall first try to restart from the RAM memory. If that memory is corrupted or unusable, then the standalone digital control unit shall restart itself from its application program stored in its FLASH memory.

13. Software – General:

    a. The standalone digital control unit shall contain FLASH memory to store both the resident operating system AND the application software. There will be no restrictions placed on the type of application programs in the system. Each standalone digital control unit shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

14. User Programming Language:

    a. The application software shall be user programmable, using the same language as that defined for Network Router/Controllers. Controllers that use a “canned” program method will not be accepted.
    b. Control Software, Mathematical Functions, and Energy Management Applications must be identical to that which is provided with the Network Router/Controller.

15. History Logging:

    a. Each controller shall be capable of LOCALLY logging any input, output, calculated value or other system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system can be logged in history. A minimum of 1000 values shall be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.

16. Alarm Management:

    a. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the standalone digital control unit and can result in the display of one or more alarm messages or reports.
    b. Up to 8 alarms can be configured for each point in the controller.
    c. Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided.
    d. If communication with the Operator Workstation is temporarily interrupted, the alarm will be time-stamped and buffered in the controller. When communications return, the alarm will be transmitted to the Operator Workstation if the point is still in the alarm condition.
    e. Alarms must be capable of being routed to any BACnet workstation that conforms to the BACnet Operator Workstation device profile and uses the BACnet/IP protocol.

E. Air Handler Controllers

1. AHU Controllers shall be capable of meeting the requirements of the sequence of operation found in the Execution portion of this specification and for future expansion.
2. AHU Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.
3. AHU Controllers shall be fully user programmable to allow for modification of the application software.
4. A manual override switch shall be provided for all digital and analog outputs on the AHU Controller. The position of the switch shall be monitored in software and available for operator displays and alarm notification.

F. Local Keypad/Display:

a. For each air handler standalone digital control unit, provide an option for a local display of at least 4 lines, providing current display of all critical inputs and outputs that the standalone digital control unit is controlling. Provide a keypad such that an operator can log on, scroll through point values, and change setpoints that are changeable. The keypad/display must be capable of being mounted either on the controller, or on a control panel door.

G. Unitary Controllers

1. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:

a. Unit Ventilators
b. Packaged Rooftop Units
c. Fan Coils (2 or 4 Pipe)

2. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of this specification. In addition, each controller shall have the capability for local time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending. Unitary controllers shall support smart room sensor inputs with one line display and keypad capable of adjusting room temperature, humidity and override duration.

2.5 FRONT END, OPERATOR WORKSTATION REQUIREMENTS

A. General.

1. The operator workstation portion of the BAS shall consist of one or more full-powered configuration and programming workstations, and one or more web-based operator workstations. For this project provide (1) web based programming workstation per school.
2. The programming and configuration workstation software shall be configurable as either a single workstation system (with a local database) or multi-workstation system where the database is located on a central file server. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at 100 MBPS.
3. The web-based user interface software must be capable of expansion up to 10 concurrent users.
4. All configuration workstations shall be PC-based personal computers operating under the Microsoft Windows operating system. The application software shall be capable of

communication to all Network Router/Controllers and Standalone Digital Control Units, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions.

5. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations without the requirement for manual copying of files. Multi-workstation systems with no central database will not be acceptable. Multi-workstation systems with distributed/tiered file servers and a central (master) database will be acceptable.

B. P.C. Workstation Requirements (Single workstation or multi-workstation configuration).

1. The workstation shall consist of the following:

a. Microsoft Windows operating system
b. High resolution (minimum 1024 x 768), 17" flat panel display
c. Optical mouse and full function keyboard
d. Audio sound card and speakers
e. License agreement for all applicable software.

C. File Server Hardware Requirements (if server is required for LAN / Web Access).

1. The file server computer shall contain of the following:
a. Microsoft Windows Server operating system
b. High resolution (minimum 1024 x 768), 17" flat panel display
c. Mouse, full function keyboard
d. License agreement for all applicable software.

D. Web-Based Operator PC Requirements

1. Any user on the network can access the system, using the following software:

a. Windows 7 or later
b. Internet Explorer 10.0 and above
c. Java-enabled

E. Printer

1. Provide a report/graphics printer. The printer shall be an HP LaserJet or equal.

F. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

G. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.

2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.6 TEMPERATURE SENSORS

A. Temperature sensors shall be Resistance Temperature Device (RTD) or Thermistor.

B. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 5 feet in length.

C. Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.

D. Space sensors shall be equipped with set-point adjustment, override switch, display, and/or communication port as shown on the drawings.

E. Provide matched temperature sensors for differential temperature measurement. Differential accuracy shall be within 0.2 F.

2.7 HUMIDITY SENSORS

A. Duct and room sensors shall have a sensing range of 20% to 80% with accuracy of ±5% R.H.

B. Duct sensors shall be provided with a sampling chamber.

C. Outdoor air humidity sensors shall have a sensing range of 20% to 95% R.H. It shall be suitable for ambient conditions of -40 F to 170 F.

D. Humidity sensor's drift shall not exceed 1% of full scale per year.

E. Single point calibration for making adjustments.

2.8 STATIC-PRESSURE TRANSMITTER

A. Nondirectional sensor with suitable range for expected input, and temperature compensated.

1. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
2. Output: 4 to 20 mA.

B. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

C. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.

D. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.9 LOW LIMIT THERMOSTATS

A. Safety low limit thermostats shall be vapor pressure type with an element of 20 feet minimum length. Element shall respond to the lowest temperature sensed by any one foot section.

B. Low limit shall be manual reset only or manual software reset through the BMS system.

2.10 THERMOSTATS

A. Combination Thermostat and Fan Switches: Line-voltage thermostat with two-, three-, or four-position, push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF," "FAN HIGH-LOW-OFF," "FAN HIGH-MED-LOW-OFF." Provide unit for mounting on two-gang switch box.

B. Electric solid-state, microcomputer-based room thermostat with remote sensor.

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set up for four separate temperatures per day.
4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
5. Short-cycle protection.
6. Programming based on weekdays, Saturdays and Sundays
7. Selection features include deg F or deg C display, 12- or 24-hour clock, keyboard disable, remote sensor, fan on-auto.
8. Battery replacement without program loss.
9. Thermostat display features include the following:

a. Time of day.
b. Actual room temperature.
c. Programmed temperature.
d. Programmed time.
e. Duration of timed override.
f. Day of week.
g. System mode indications include "heating," "off," "fan auto," and "fan on."

C. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater.

D. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, integral manual on-off-auto selector switch.

1. Equip thermostats, which control electric heating loads directly, with off position on dial wired to break ungrounded conductors.
2. Dead Band: Maximum 2 deg F.

E. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature, with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.

3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit, adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches, with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

F. Room Thermostat Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Concealed.
2. Set-Point Indication: Concealed.
3. Thermometer: Concealed.
4. Color: Color from manufacturer's standard colors.
5. Orientation: Vertical Horizontal.

G. Room thermostat accessories include the following:

1. Insulating Bases: For thermostats located on exterior walls.
2. Thermostat Guards: Locking; heavy-duty, transparent plastic; mounted on separate base
3. Adjusting Key: As required for calibration and cover screws.
4. Aspirating Boxes: For flush-mounted aspirating thermostats.
5. Set-Point Adjustment: 1/2-inch- diameter, adjustment knob.

H. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

I. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type, with adjustable set point in middle of range and adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

J. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

K. Electric High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

2.11 FLOW SWITCHES

A. Flow-proving switches shall be either paddle or differential pressure type, as shown.

B. Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum). Adjustable sensitivity with NEMA 1 Type enclosure unless otherwise specified:

C. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 Type enclosure, with scale range and differential suitable for intended application, or as specified.

D. Current sensing relays may be used for flow sensing or terminal devices.

2.12 RELAYS

A. Control relays shall be UL listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application.

B. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 Type enclosure when not installed in local control panel.

2.13 TRANSFORMERS & POWER SUPPLIES

A. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.

B. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.

C. Unit shall operate between 32 F and 120 F.

D. Unit shall be UL recognized.

2.14 CURRENT SWITCHES

A. Current-operated switches shall be self-powered, solid state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

2.15 HUMIDISTATS

A. Duct-Mounted Humidistats: Electric insertion, 2-position type with adjustable 2 percent throttling range, 20 to 80 percent operating range, single- or double-pole contacts.

2.16 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Section "Motors."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

a. Belimo Aircontrols (USA), Inc.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: Size for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24 or 120-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: Minus 22 to plus 122 deg F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
12. Run Time: 12 seconds open, 5 seconds closed.

2.17 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Hydronic system globe valves shall have the following characteristics:

1. NPS 3 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 4 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

    a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
    b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing:

    a. Water: 3-psig preferred, 5-psig maximum pressure drop at design flow rate.
    b. Steam: Maximum of 80 percent of valve inlet pressure.

5. Configuration:

    a. Two or three way as per the drawings.
    b. Modulating or two-position as per the drawings.

6. Flow Characteristics: Two-way valves shall have equal percentage characteristics;.
7. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

C. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics.

D. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Where indicated on the drawings, provide self-contained (thermostatic) control valves.
2. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
3. Thermostatic Operator: Wax or Liquid-filled integral or remote sensor with integral or remote adjustable dial.

2.18 DAMPERS

A. Manufacturers:

1. Greenheck.
2. Johnson Controls

3. Ruskin.

B. Control Dampers: AMCA-rated, parallel-blade design (for two position applications) or opposed-blade design (for modulating applications); 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches. Parallel blades shall be used for two position applications. Opposed blade dampers shall be used for modulating applications.

1. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.

2.19 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Electrical Section "Voice and Data Communication Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Cafeterias.
4. Gymnasiums.
5. Weight Rooms.
6. Where indicated.

E. Install automatic dampers according to Section "Air Duct Accessories."

3.3 DEMOLITION

A. Remove controls, which do not remain as part of the building automation system, all associated abandoned wiring and conduit, and all associated pneumatic tubing. The Owner will inform the Contractor of any equipment, which is to be removed, that will remain the property of the Owner. All other equipment, which is removed, will be disposed of by the Contractor.

3.4 CODE COMPLIANCE

A. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring specifications in this section and Electrical sections, the stricter wiring requirements will prevail.

3.5 WIRING, CONDUIT, AND CABLE

A. All wire will be copper and meet the minimum wire size and insulation class listed below:

B. Power Wiring: must meet NEC / Local standards; minimum 12 gauge, stranded, THHN Control Wiring may be plenum / fire rated Teflon jacketed where concealed but accessible. Wiring must be in ¾" EMT where concealed or exposed. Control wire shall be stranded #18 gauge with minimum 300v insulation. Input wiring shall be shielded.

1. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.
2. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.
3. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 3/4 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit sealoff fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
4. Flexible metallic conduit (max. 5 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.
5. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers. ¨
6. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to monitor critical life safety systems or control critical equipment shall be in conduit.
7. Fiber optic cable shall include the following sizes: 50/125, 62.5/125 or 100/140.
8. Only glass fiber is acceptable, no plastic.
9. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

3.6 HARDWARE INSTALLATION

A. Installation Practices for Wiring

1. All controllers are to be mounted vertically and per the manufacturer's installation documentation.
2. The 120 VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.
3. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.
4. Wires are to be attached to the building proper at regular intervals such that wiring does not droop. Wires are not to be affixed to or supported by pipes, conduit, etc.
5. Conduit in finished areas will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exception: metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.
6. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit will run parallel to or at right angles to the building structure.
7. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.
8. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.
9. Wire will not be allowed to run across telephone equipment areas.

B. Installation Practices for Field Devices

1. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
2. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
3. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
4. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
5. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.
6. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.

C. Enclosures

1. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure, which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
2. FIPs shall contain power supplies for sensors, interface relays and contactors, and safety circuits.
3. The FIP enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.

4. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.
5. All outside mounted enclosures shall meet the NEMA-4 rating.
6. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

D. Identification

1. Identify all control wires with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
2. All field enclosures, other than controllers, shall be identified with a bakelite nameplate. The lettering shall be in white against a black or blue background.
3. Junction box covers will be marked to indicate that they are a part of the BAS system.
4. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with name plates.
5. All I/O field devices inside FIP's shall be labeled.

E. Existing Controls

1. Existing controls, which are to be reused, must each be tested and calibrated for proper operation. Existing controls, which are to be reused and are found to be defective requiring replacement, will be noted to the Owner.

F. Location

1. The location of sensors is per mechanical and architectural drawings.
2. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.
3. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.
4. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

3.7 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install signal and communication cable according to all applicable codes and standards and the following:

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway or use plenum cable installed in workmanlike fashion.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

B. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

C. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.8 COMMISSIONING

A. Control system shall be set up and checked by factory trained competent technicians skilled in the setting and adjustment of the ATC/DDC equipment used in this project. This technician is to be experienced in the type of HVAC systems associated with this project.

B. At the completion of the commissioning, this Contractor will demonstrate the sequence of operations for each system to the Architect or his representative.

C. Point-to-Point Checkout.

1. Each I/O device (both field mounted as well as those located in field interface panels) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the ATC contractor for submission to the owner or owner's representative.

D. Controller and Workstation Checkout.

1. A field checkout of all controllers and front end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project. All approved submitted sequences will be tested by the control contractor in presence of owner before acceptance testing described below.

E. System Acceptance Testing

1. All points will be tested and verified with the control contractor for system acceptance with the owner's representative.
2. All application software will be verified and compared against the sequences of operation. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.
3. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.
4. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.
5. Perform an operational test of each third party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

F. Report results in writing.

3.9 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.10 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.11 DEMONSTRATION & CUSTOMER TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

B. Refer to Division 1 Section "Demonstration and Training."

C. Control contractor shall provide a minimum of 40 hours of on-site training specifically geared to the operation, maintenance and functionality of the control system. This shall include general HVAC System instructions, control system operation and integration to the HVAC components, programming, operation of graphics through front-end software, remote dial up, alarm acknowledgement and other general functions of the Control System. Additional training shall be provided, if requested, at the customer's expense. Factory training shall be available.

END OF SECTION 230900