SECTION 23 09 00 – HVAC SYSTEM CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The following Specification Section apply this specification section:

1. Bidding Requirements, Contract Forms and Conditions of the Contract.
2. Division 1 - General Requirements.

B. Refer to other HVAC Specification Sections which describe the requirements of the HVAC system components.

C. Refer to Specification Section 23 09 05 “Sequence of Operation – HVAC Controls” for information related to the HVAC system controls.

1.2 SUMMARY

A. This Section includes direct digital control (DDC) equipment for control of HVAC systems and various other systems.

B. Refer to all Division 23 specification sections for controls that may be provided with the associated equipment.

C. Work under this section includes, but is not limited to, providing the required controls and accessories to accomplish the method of control as indicated in Section 23 09 05, Sequence of Operation- HVAC Controls, for the following HVAC equipment:

1. Hydronic pumps.
2. Exhaust, supply and / or relief fans.
3. Air terminal units.
4. Gravity ventilators.
5. Boilers
6. Packaged Outdoor units.
7. Chillers
8. Condensing units.
9. Open and closed cell cooling towers.
10. Modular air handling units.
11. Packaged air handling units.
12. Ductless split system units.
13. Hydronic and electric duct coils.
14. Fan coil units.
15. Unit ventilators.
16. Convectors, cabinet heaters and other terminal heating units.
17. Variable frequency drives.
18. Electronic flow meters.
19. Air flow monitoring units.
20. Lighting Controls.
21. Sequence(s) that are indicated on the construction drawings.

D. The controls sub-contractor will be required to participate in the Start-Up as well as the Testing, Adjusting, Balancing and Commissioning of the HVAC System. Refer to other HVAC specifications for the work required by the controls sub-contractor.

E. The Building Management System (BMS) installer/supplier shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems as specified. Provide a complete and fully operational system.

The system shall allow the Owner to have access through the internet with password security to suit the Owner's needs. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer.

F. The BMS manufacturer/supplier shall be responsible for all BMS control and power wiring for a complete and operable system. All wiring shall be done in accordance with all applicable local, state and national codes.

G. All existing controls, both pneumatic and electronic, are to remain operational during construction. At the completion of the project all existing pneumatic controls and the associated components will be removed. Provide the following to accommodate the phased construction schedule:

1. Temporary control and power wiring as required to accommodate the renovation phasing schedule.
2. Temporary extensions to the existing pneumatic tubing where required.
3. Remove control system components (i.e. wiring, pneumatic tubing, actuators) as phasing allows.
4. As construction phasing progresses provide extensions to the control system as needed and remove existing components that are no longer required.

H. The control system shall be extension of the existing Siemens Building Automation System. The work to be performed on the existing Siemens Building Automation System shall be performed by the Siemens Branch Office located at 5095 Ritter Road, Suite #104, Mechanicsburg, PA 17055. All controllers and software shall match existing or be the latest version of existing. The existing Insight Building Automation Graphics at the Reamstown Elementary School shall be upgraded to the Siemens Desigo CC Automation Platform. See BACnet Advanced Workstation Software Section for further details. Existing control panels shall be upgraded as needed to implement the new Desigo CC system. Please see section "BACnet Building Controllers" for further details. Where noted on the drawings, existing Siemens TEC controllers and associated space sensors shall be upgraded to Siemens DXR controllers with upgraded space sensors and the existing FLN communication shall be upgraded to BACnet IP communication.

I. Provide networking to equipment using industry accepted communication standards. System shall utilize BACnet communication according to ANSI/ASHRAE standard 135-2010 for interoperability with smart equipment, for the main IP communication trunk to the BAS Server and for peer-to-peer communication between DDC panels and devices. The system shall not be limited to only standard protocols, but shall also be able to integrate to a wide variety of third-party devices and applications via drivers and gateways.

1.3 DEFINITIONS

A. DDC: Direct Digital Control

B. BMS: Building Management System.

C. BAS: Building Automation System.

D. EMS: Energy Management System.

E. PC: Personal computer.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

B. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

C. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

D. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

E. Shop Drawings: Provide detailed equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Include the following:

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC hardware including:

    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems including:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

F. 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 the workstations and control systems.
6. All system and software development tools are to allow the owner to independently maintain the system.
7. Software Tools - All software tools needed for full functional use, including programming of BCs, BACnet controllers, network management and expansion, and graphical user interface development, of the BAS described within these specifications, shall be provided to the owner or his designated agent. Any licensing required by the manufacturer now and into the future, including changes to the licensee of the software tools, and the addition of hardware corresponding to the licenses, shall be provided to allow for a complete and operational system for both normal day to day operation and servicing shall be provided. Any such changes to the designated license holders shall be made by the manufacturer upon written request by the owner or his agent. Any cost associated with the license changes shall be identified within the BAS submittals.
8. Programming Tools - Provide available tools to facilitate the programming and configuration of all of the BACnet devices that are provided for the HVAC and lighting control. Wizards shall be provided free of charge and be compatible with the current published versions of the network management tool that is provided as part of this project. The wizard software shall be available for public access from the manufacturer's web site.

G. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1, include the following:

1. Interconnection wiring diagrams with identified and numbered system components and devices.

2. Keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.

1.5 SYSTEM PERFORMANCE

A. System shall have an open architecture utilizing the data infrastructure of fiber optic cables and/or copper cables to communicate between field panels.

B. System server shall include the latest edition of Microsoft© windows operating system. Provide web-based browser graphic software to integrate the systems. System must be accessible remotely via the internet.

C. Graphic software shall reside on the system server. The graphic software shall provide a graphical representation of the building floor plan with icons/images to indicate HVAC system components / readings and exterior lighting fixtures. System software must interface with the separate systems to report activities by date, time.

1.6 QUALITY ASSURANCE

A. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer.

B. 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.

C. UL listed to Standards UL864 (Fire), UL2017 (Signaling Systems), UL916 (Energy Management Systems), UL1017 (Security), UL1610 (Central Station) and UL 294 (Access Control).

1.7 CODES AND STANDARDS

A. Meet the requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

B. Underwriters Laboratories: Products shall be UL-916-PAZX listed.

C. Federal Communications Commission -- Part J.

D. ASHRAE/ANSI 135-2016 (BACnet) - (System Level Devices) - Building Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.

E. ASHRAE/ANSI 135-2016 (BACnet) - (Unit Level Devices) - Unit Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.

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.

1.10 WARRANTY

A. The BMS supplier/installer shall warrant all work per the following:

1. All control systems labor, equipment and materials shall be warranted to be free from defects for a period of twelve (12) months after the date of substantial completion. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner. The BMS manufacturer/installer shall respond to the Owner's request for warranty service within 24 hours of the initiated call.
2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the BMS is operational, and has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of the warranty period.
3. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by the Owner must be granted prior to the installation of these updates.
4. The BMS manufacturer shall provide a web-accessible Users Network for the proposed System and give the Owner free access to question/answer forum, user tips, upgrades, and training schedules for a one-year period of time correlating with the warranty period.

PART 2 - PRODUCTS

2.1 INSTALLERS

A. Subject to compliance with all requirements provide new and upgraded DDC controls with products furnished, engineered and installed by the Siemens Branch Office located in Mechanicsburg, PA.

2.2 DDC EQUIPMENT

A. Operator Workstation(s): Provide the required upgrades and modifications to the operator workstation(s).

2.3 BUILDING AUTOMATION SYSTEM NETWORK

A. All networked control products provided for this project shall be comprised of an industry standard open protocol internetwork. Communication involving control components (i.e. all types of controllers and operator interfaces) shall conform to ASHRAE 135-2010 BACnet standard. Networks and protocols proprietary to one company or distributed by one company are prohibited.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs. Software applications, features, and functionality, including administrative configurations, shall not be separated into several network control engines working together.

C. BAS Server shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.

D. Any break in Ethernet communication from the server to the controllers on the Primary Network shall result in a notification at the server.

E. Any break in Ethernet communication between the server and standard client workstations on the Primary Network shall result in a notification at each workstation.

F. The network architecture shall consist of three levels of networks:

1. The Management Level Network (MLN) shall utilize BACnet/IP over Ethernet along with other standardized protocol, such as web services, html, JAVA, SOAP, XML, etc., to transmit data to non-BAS software applications and databases. The BAS Server and Operator Workstations shall reside on this level of the network architecture.
2. The Automation Level Network (ALN) shall utilize BACnet/IP over Ethernet. It shall connect BACnet Building Controllers to the BAS Server and Operator Workstations. Controllers for central plant equipment and large infrastructure air handlers shall reside on the ALN backbone BACnet/IP network. The building's Ethernet LAN shall be utilized for the ALN backbone and all ALN devices shall be connected to the building's LAN. Coordinate IP drops with Owner.
3. The Floor Level Network shall utilize BACnet/IP over Ethernet or BACnet MS/TP over RS-485 to connect all of the DDC-controlled terminal heating and cooling equipment on a floor or in a system that are controlled with BACnet Advanced Application Controllers or BACnet Application Specific Controllers. FLN devices are networked to a router that connects to the Automaton Level Network backbone.

2.4 BACNET ADVANCED WORKSTATION SOFTWARE

A. Interface Description

1. The software shall provide, as a minimum, the following functionality:

a. Real-time graphical viewing and control of the BMS environment.
b. Reporting of both real-time and historical information.
c. Scheduling and override of building operations.
d. Collection and analysis of historical data.
e. Point database editing, storage and downloading of controller databases.
f. Configuration of and navigation through default and personalized hierarchical “tree” views that include workstation and control system objects.
g. Event reporting, routing, messaging, and acknowledgment.
h. Definition and construction of dynamic color graphic displays.
i. Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
j. On-screen access to User Documentation, via online help or PDF-format electronic file.
k. Automatic database backup at the operator interface for database changes initiated at Building Controllers.
l. Display dynamic trend data graphical plot.

1) Must be able to run multiple plots simultaneously.
2) Each plot must be capable of supporting 10 pts/plot minimum.
3) Must be able to command points from selection on dynamic trend plots.
4) Must be able to plot real-time data without prior configuration.
5) Must be able to plot both real-time and historical trend data simultaneously.

m. Program editing
n. Transfer trend data to third-party spreadsheet software
o. Scheduling reports
p. Operator Activity Log

2. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications.
3. Users must be able to build multiple, separate, personalized hierarchical “tree” views that represent the workstation, control systems, geographical facility layouts, and mechanical equipment relationships.
4. 256-character point identification (names) must be supported to provide clearly descriptive identification.
5. On-line help must be available.
6. The user interface shall display relevant information for a selection in multiple panes of a single window without the need for opening multiple overlapping windows on the desktop.

7. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a “drag and drop” approach to inter-application navigation.
8. Software navigation shall be user friendly by utilizing “forward & back” capability between screens and embedded links to graphics, documents, drawings, trends, schedules, as well as external documents (.doc, .pdf, .xls, etc.) or web addresses that are related to any selected object.
9. Primary selection of objects in the operator interface software shall be available from user defined hierarchical Views, from graphics, or from events in an Event List.
10. Secondary selection of objects in the operator interface software shall be available from links to any objects or external documents related to the primary selection.
11. Links to information related to any selected objects shall be displayed in a consistent manner and automatically defined based on where an object is used in the system.
12. The operator workstation shall be capable of displaying web pages and common document formats (.doc, .xls, .pdf) within the operator workstation application.
13. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously.
14. System database parameters shall be stored within an object-oriented database.
15. Standard Windows applications shall run simultaneously with the BMS software.
16. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.
17. Provide automatic backup and restore of all Building Controller databases on the workstation hard disk.
18. System configuration, programming, editing, graphics generation shall be performed on-line from the operator workstation software.
19. User shall be able to edit point configuration of any configurable BACnet point that resides in a device that supports external editing.
20. The software shall also allow the user to configure the alarm management strategy for each point.
21. Users shall have the ability to view the program(s) that is\are currently running in a Building Controller. The display shall mark the program lines with the following: disabled, comment, unresolved, and trace bits.

B. Certifications and Approvals

1. BAS software shall have been tested against the following norms and standards:

   a. BACnet Revision 1.13, certified by BACnet Testing Laboratory as BACnet Advanced Workstation Software (BTL B-AWS)
   b. IT security compliant with the ISA-99/IEC 62443 Security Level: SL1
   c. OPC DA V2.05a and V3.0 Server, certified by the OPC Foundation certification program
   d. UL-listed to UL864 9th edition Standard for Control Units and Accessories (when installed on a UL-approved computer)

C. Client-Server Connectivity

1. Client sessions must be allowed to run on the server and on other devices connected to the server via Intranet, Extranet, or Internet connections.
2. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the owner as required to support remote access features.
3. The following client options must be supported

   a. Installed Client.

      1) Software application installed from installation media on to the client machine.
      2) Installed client software must be configurable to allow it to run in a Closed Mode such that the BAS software can lock down the client machine and prevent users without permission from minimizing the application or running other Windows applications that might cover the BAS software interface.
      3) Communication between the server and Installed Clients must be monitored so that any break in communication between the server and an installed client results in notification at the Server and Installed Client machine
      4) Installed client machines communicate directly with the BAS server.

b. Web Client.

1) Software that runs in a browser on the client machine as a Full Trust client application.
2) Connected to the BAS software server via Microsoft IIS Server.

c. Windows App.

1) Software application downloaded from the BAS server to run on the client machine like an installed application
2) Application must be automatically updated whenever new apps are available at the server.
3) Connected to the BAS software server via Microsoft IIS Server.

4. Each of the client options shall provide the same functionalities including operation and configuration capabilities.

D. Access Rights and User Privileges

1. Access to any client user session must be password protected.
2. Users shall be able to create local user accounts specific to the application software.
3. Users shall be able to link application user accounts to Active Directory user accounts for consistent management with domain user accounts.
4. Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned user name and password.
5. Operator privileges shall follow the operator to any workstation logged onto.
6. The administrator or manager shall be able to further limit operator privileges based on which console an operator is logged on to.
7. The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation application.

E. Activity Logging

1. The operator interface software shall maintain a log of the actions of each individual operator.
2. The software shall provide an application that allows querying based on object name, operator, action, or time range.
3. The software shall provide the ability to generate reports showing operator activity based on object name, operator, action, or time range.

F. Graphics Application

1. All graphics shall be available with the same look and functionality whether they are displayed at an installed client console or in a browser.
2. User shall be able to add/delete/modify system graphics for floor plan displays and system schematics for each piece of mechanical equipment (including, air handling units, chilled water systems, hot water boiler systems, and room level terminal units) from standard user interface without the need of any external or specialized tools.
3. The software shall include all necessary tools and procedures for the user to create their own graphics.
4. The software shall provide the user the ability to display real-time point values by animated motion or custom picture control visual representation.
5. The software shall provide animation that depicts movement of mechanical equipment, or air or fluid flow.
6. The software shall provide users the ability to depict various positions in relation to assigned point values or ranges.
7. The software shall provide the ability to add custom gauges and charts to graphic pages.
8. The software must include a library of at least 400 standard control application graphics and symbols for visualizing common mechanical systems, including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams, piping, and laboratory symbols.

9. The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.
10. The Graphics application shall be capable of automatically assigning the appropriate symbol for an object (point) selected to be displayed on the graphic based on what the object represents (fan, duct sensor, damper, etc.) when the object is placed on a graphic.
11. The Graphics application shall allow a user to manually override the automatically assigned symbol for an object when a different symbol is desired.
12. The user shall have the ability to add custom symbols to the symbol library.
13. The software shall permit the importing of AutoCAD or scanned pictures for use in graphics.
14. Graphics must be automatically associated to any points or system objects that are rendered on the graphic, so that selection of a system object will allow a user to simply navigate to any associated graphic, without the need for manual association.
15. The software must allow users to command points directly off graphics application.
16. Graphic display shall include the ability to depict real-time point values dynamically with text or animation.
17. Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure
18. Graphics viewing shall include dynamic pan zoom capabilities.
19. Graphics viewing shall include the ability to switch between multiple layers with different information on each layer.
20. Graphics shall include a decluttering capability that allows layers to be programmatically hidden and displayed based on zoom level.
21. Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
22. The software must provide the ability to create dashboard views consisting of gauges and charts that graphically display system and/ or energy performance.

2.5 BUILDING CONTROLLERS

A. Provide all necessary hardware for a complete operating system as required. The Building Controller shall be able to operate as a standalone panel and shall not be dependent upon any higher-level computer or another controller for operation. Basis of design is Siemens PX Modular and Compact Controllers (PXC).

B. This controller shall have the BTL listing and meet the BACnet device profile of a Building Controller (B-BC) and shall support the following BACnet BIBBs:

1. Data Sharing:

   a. Data Sharing-Read Property-Initiate, Execute (DS-RP-A,B)
   b. Data Sharing-Read Property Multiple- Initiate, Execute (DS-RPM-A,B)
   c. Data Sharing-Write Property- Initiate, Execute (DS-WP-A,B)
   d. Data Sharing-Write Property Multiple- Execute (DS-WPM-B)
   e. Data Sharing-COV- Initiate, Execute (DS-COV-A,B)
   f. Data Sharing-COV-Unsolicited- Initiate, Execute (DS-COVU-A,B)

2. Scheduling

   a. Scheduling-Internal- Execute (SCHED-I-B)
   b. Scheduling-External- Execute (SCHED-E-B)

3. Trending

   a. Trending-Viewing and Modifying Trends - Initiate (T-VMT-A)
   b. Trending-Viewing and Modifying Trends Internal- Execute (T-VMT-I-B)
   c. Trending-Viewing and Modifying Trends-External- Execute (T-VMT-E-B)
   d. Trending-Automated Trend Retrieval- Execute (T-ATR-B)

4. Network Management

    a. Network Management-Connection Establishment- Initiate (NM-CE-A)

5. Alarming

    a. Alarm and Event-Notification- Initiate (AE-N-A)
    b. Alarm and Event-Notification Internal- Execute (AE-N-E-B)
    c. Alarm and Event-Notification External- Execute (AE-N-E-B)
    d. Alarm and Event-ACK- Initiate, Execute (AE-ACK-A,B)
    e. Alarm and Event –Alarm Summary- Execute (AE-ASUM-B)
    f. Alarm and Event –Enrollment Summary- Execute (AE-ESUM-A,B)
    g. Alarm and Event –Information- Initiate, Execute (AE-ESUM-A,B)

6. Device Management

    a. Device Management-Dynamic Device Binding- Initiate, Execute (DM-DDB-A,B)
    b. Device Management-Dynamic Object Binding- Initiate, Execute (DM-DOB-A,B)
    c. Device Management-Device Communication Control- Execute (DM-DCC-B)
    d. Device Management-Private Transfer- Initiate, Execute (DM-PT-A,B)
    e. Device Management-Text Message- Initiate, Execute (DM-TM-A,B)
    f. Device Management-Time Synchronization- Execute (DM-TS-B)
    g. Device Management-Reinitialize Device- Execute (DM-RD-B)
    h. Device Management-Backup and Restore- Execute (DM-RD-B)
    i. Device Management-List Manipulation- Execute (DM-RD-B)
    j. Device Management-Object Creation and Deletion- Execute (DM-OCD-B)

7. The Building Level Controller shall support the following Data Link Layers:

    a. BACnet IP Annex J
    b. BACnet IP Annex J Foreign Device
    c. MS/TP Master (Claus 9)

8. The Building Level Controller shall be able to interact with all of the BACnet objects in the controllers. In addition, the software shall be able to support the following objects as they relate to features in the workstation software:

    a. Calendar – Creatable, Deletable
    b. Command – Creatable, Deletable
    c. Event Enrollment – Creatable, Deletable
    d. Notification Class – Creatable, Deletable
    e. Schedule - Creatable, Deletable

9. The Building Level Controller shall support transmitting and receiving segmented messages.
10. The Building Level Controller shall have the capability to be the BACnet/IP Broadcast Management Device (BBMD) and support foreign devices.
11. The Building Level Controller shall have the capability to act as a BACnet router between MS/TP subnetworks and BACnet/IP.

C. This level of controller shall be used for the following types of systems:

1. Chiller plant systems
2. Heating plant systems
3. Cooling Towers
4. Pumping systems
5. VAV air handlers
6. Air handlers
7. Systems with over 24 input/output points
8. Rooftop systems

D. Computing power and memory minimum:

1. A 32-bit, stand-alone, multi-tasking, multi-user, real-time 100MHz digital control microprocessor module.
2. Inputs shall be 16-bit minimum analog-to-digital resolution
3. Outputs shall be 10-bit minimum digital-to-analog resolution
4. Memory module (24 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases (see Controllers Software section), including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.
5. Real time clock and battery
6. Data collection/ Data Trend module sized for 10,000 data samples.
7. Flash Memory Firmware: Each Building Level Control Panel shall support firmware upgrades without the need to replace hardware.

E. Onboard or Modular hardware and connections:

1. Primary Network communication module, if needed for primary network communications.
2. Secondary Network communication module, if needed for secondary network communications.
3. RJ45 port 10/100Mbaud
4. RS485 ports for subnetworks and point expansion
5. Man to Machine Interface port (MMI)
6. USB Port

F. Input and Output Points Hardware

1. Input/output point modules as required including spare capacity.
2. Input/output point modules shall have removable terminal blocks.
3. Monitoring of the status of all hand-off-auto switches.
4. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
5. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
6. Graduated intensity LEDs or analog indication of value for each analog output.

G. Code compliance

1. Approvals and standards: UL916; CE; FCC
2. Provide UL864-UUKL where called for in the sequences of operations.

H. Accessories:

1. Appropriate NEMA rated metal enclosure.
2. Power supplies as required for all associated modules, sensors, actuators, etc.

I. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.

J. Each Building Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.

K. Panel setup, point definitions and sequencing diagrams shall be backed up on EEPROM memory.

L. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

M. Building Level control panels shall provide at least two serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal communications, operation of permanently connected modems, printers or terminals.

N. Building Level Controllers shall have the capability to serve as a gateway between Modus subnetworks and BACnet objects. Provide software, drives and programming.

O. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

P. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be “future” on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

Q. Environment.

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
4. Controller hardware shall be optionally suitable for rooftop environments.

R. Immunity to power and noise.

1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

    a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V.
    b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
    c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power.
    d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).

4. Isolation shall be provided at all Building Controller’s AC input terminals to suppress induced voltage transients consistent with:

    a. IEEE Standard 587 1980
    b. UL 864 Supply Line Transients
    c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.6 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Humidity Sensors: Bulk polymer sensor element.

1. Duct sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.

2. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 22 to plus 185 deg. F.

C. Static pressure transmitters: non-directional sensor with suitable range for expected input, and temperature compensated.

1. Accuracy: 2 percent full range with repeatability of 0.5 percent.
2. Output: 4 to 20 mA.
3. Building Static-Pressure Range: 0- to 0.25-inch w.g.
4. Duct Static-Pressure Range: 0- to 5-inch w.g.

D. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure.

E. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig.

F. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

G. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system.

2.7 ROOM SENSORS

A. Sensors shall be of the thermistor type and shall be recessed wall box mounting type per the following:

1. LCD display to indicate sensed values
2. Set points: warmer/cooler adjustment, which can be programmed in the system to a maximum number of +/- degrees of adjustment
3. Temperature sensing accuracy: +/- 1 degree F.

a. Range: 40 to 104 deg. F.
b. Accuracy: +/- 1 deg. F.

4. Humidity sensing accuracy:

a. Range: 20% to 90%
b. Accuracy: +/- 3%.

5. CO2 sensing where indicated on the drawings or in specification section 230905.

a. Range: 0 to 2000 ppm.
b. Accuracy: +/- 30 ppm or 3% of the reading.

6. Where noted in specification 230905 provide override pushbutton on the room sensor. The override time to be programmed through the BMS.
7. Where indicated in Part 3 provide cage style metal wire guards for room sensors including but not limited to temperature sensor, temperature/humidity sensors and CO2 sensors.

2.8 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.9 CO2 SENSORS

A. Carbon Dioxide sensors shall measure CO2 in PPM in a range of 0-2000 ppm. Accuracy shall be +/- 3% of reading with stability within 5% over 5 years. Sensors shall be duct or space mounted as indicated on the drawings or in the sequence of operation.

2.10 ACTUATORS

A. Modulating valves and dampers: provide proportional modulating control capable of positioning the valve or damper at all points across the full range of operation with continuous control action. The sensor, controller and control device (damper, valve, etc.) shall act as one unit to maintain a constant and precise control of the controlled medium. Actuator drives proportional to input signal and modulates throughout its angle of rotation.

B. Two-position valves and damper: provide two-position actuators only where indicated.

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

1. 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.
2. Non-spring Return Motors for Valves Larger than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
3. Spring-Return Motors for Valves Larger than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
4. Non-spring Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. Size for running and breakaway torque of 150 in. x lbf.

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

1. Provide full modulating damper and valves actuators unless otherwise noted.
2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: size for required torque calculated as follows:

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

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 non-spring return actuators.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

2.11 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. Unless otherwise indicated heating system control valves are to fail in the closed position and chilled water system fails are to fail in the last position.

C. Hydronic system globe valves to have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with back seating capacity re-packable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Sizing: 3-psig maximum pressure drop at design flow rate.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
5. 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.

D. Butterfly valves: 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals. Size at 1 psig max pressure drop at design flow rate.

E. Terminal unit control valves: bronze body, bronze trim, two or here ports, replaceable plus and seats with 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; three-way valves shall have linear characteristics.

2.12 ELECTROMAGNETIC FLOW METERS

A. Provide an ONICON Model F-3500 Insertion Electromagnetic Flow Meter (or FB-3500 for Bi-directional flow applications), complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand-insertable up to 400 psi. For installations in non-metallic pipe, install grounding rings or probes. Materials of construction for wetted metal components shall be 316 SS. The flow meter shall average velocity readings from two sets of diametrically opposed electrodes. Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST*. A certificate of calibration shall be provided with each flow meter. Accuracy shall be within ± 1% of rate from 2-20 ft/s. Overall turndown shall exceed 100:1.

B. Output signals shall be completely isolated and shall consist of the following: (1) analog output; 4-20mA, 0-10V, or 0-5V jumper selectable, (1) scalable dry contact output for totalization, and (1) high resolution frequency output for use with peripheral devices such as an ONICON display module or Btu meter. FB-3500 for Bi-directional applications shall provide additional contact outputs for direction and flow totalization in each direction. Each flow meter shall be covered by the manufacturer's two-year warranty.

2.13 DAMPERS

A. Dampers: AMCA-rated, opposed blade design; 0.108-inch minimum thick, galvanized-steel 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.

B. Edge Seals: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 4 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lb f; when tested according to AMCA 500D.

2.14 WATER METERS

A. Manufacturers: Subject to compliance with requirements provide water meters manufactured by Neptune Technology Group or equal.

B. All meters to be displacement type - magnetic drive 5/8" - 2" and shall be produced from an ISO 9001 manufacturing facility and conform to the "Standard Specifications for Cold Water Meters" C700, latest revision issued by AWWA or as otherwise stated. Only magnetic-driven, positive displacement meters of the flat disc type will be accepted because of enhanced low flow accuracy performance.

C. The size, capacity, and meter lengths shall be as specified in AWWA Standard C700 (latest revision). The maximum number of disc nutations is not to exceed those specified in AWWA C700 latest revision. All meter maincases shall be made of a no-lead high copper alloy containing a minimum of 85% copper that meets the ANSI/NSF 61 standard. The serial number should be stamped between the outlet port of the maincase and the register. Maincase markings shall be cast raised and shall indicate size, model, direction of flow, and NSF 61 certification. Plastic maincases are not acceptable. Maincases for 5/8", 3/4" and 1" meters shall be of the removable bottom cap type with the bottom cap secured by four (4) bolts on 5/8" and 3/4" sizes and six (6) bolts on the 1" size. Intermediate meter maincases shall also be made of the same lead-free brass material in sizes 1-1/2" and 2" with a cover secured to the maincase with eight (8) bolts. Meters with a frost plug, a screw-on design or no bottom cap shall not be accepted in 5/8"-1" sizes. The 5/8" meters shall have a synthetic polymer or cast-iron bottom cap option. All no-lead maincases shall be guaranteed free from manufacturing defects in workmanship and material for the life of the meter. All meters must be adaptable to a field programmable absolute encoder register without interruption of the customer's service.

D. Direct Read Standard Register: The register shall be of the straight reading sealed magnetic drive type and shall contain six (6) numeral wheels. Registers must be roll sealed and dry. All direct reading register cups shall be copper to prevent corrosion and be covered with a high strength, impact resistant flat glass lens to prevent breakage. The lens shall be positioned above the register box to allow for run off of debris. The register lid shall overlap the register box to protect the lens. Register boxes and lids shall be of high-strength synthetic polymer or approved equivalent. All registers shall have the size, model and date of manufacture stamped on the dial face. The dial shall have a red center sweep hand and shall contain 100 equally divided graduations at its periphery. The register must contain a low flow indicator with a 1:1 ratio to disc nutations to provide leak detection. Registers shall be secured to the main case by means of a plastic tamper-proof seal to allow for inline service replacement. Register seal screws are only accepted when supplied with attached sealing wire to at least one bottom cap bolt with seal wire holes of not less than 3/32" in diameter.

E. Strainers: All meters shall contain a removable polypropylene plastic strainer screen. The strainer shall be located near the main case inlet port, before the measuring chamber. The strainer shall also function as the device that holds the measuring chamber in place within the main case.

F. Remote Transmitter Interface: Where indicated provide Neptune Tricon/E3 Transmitter or equal. The transmitter shall provide a digital pulse output with a 4-20mA signal.

2.15 AIR FLOW MONITORING

A. Where indicated and/or scheduled on the drawings provide duct mounted airflow monitoring stations capable of continuously monitoring air flows.

B. Each element shall be designed and built to comply with, and provide results in accordance with, accepted practice for duct system traversing as defined in the ASHRAE Handbook of Fundamentals, AMCA publication #203, as well as the Industrial Ventilation Handbook. The number of sensing ports on each element, and the quantity of elements utilized at each installation, shall comply with ASHRAE Standard #111 for equal area duct traversing.

C. Each airflow measuring element shall contain multiple total and static pressure sensing ports placed along the leading edge of the cylinder. The static pressure chamber shall incorporate dual offset static taps on opposing sides of the averaging chamber, so as to be insensitive to flow angle variations of as much as ± 20 degrees in the approaching airstream.

D. The airflow traverse elements shall be capable of producing steady, non-pulsating signals of true total and static pressure, with an accuracy of 2% of actual flow for operating velocities as low as 100 feet per minute.

E. The airflow traverse elements shall not induce a measurable pressure drop, greater than 0.18 inch at 4,000 fpm. The units shall have a self-generated sound rating of less than NC40 and the sound level within the duct shall not be amplified, nor shall additional sound be generated.

F. The probes shall be manifolded together in a 16-gauge galvanized steel duct section with 90 degree undrilled flanges, fabricated to the duct size, and shall contain multiple airflow traverse elements interconnected as required.

G. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be sized to facilitate matching connecting ductwork.

2.16 PRESSURE TRANSDUCERS

A. Transducer shall have linear output signal. Zero and span shall be field adjustable. Sensor accuracy shall be 1 percent of full scale with repeatability/long-term stability of 0.25 percent.

B. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.

C. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.

D. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.

E. Selectable rate pulse output for kWh reading, 4-20 mA output for kW reading, N.O. alarm contact, and the ability to operate with 5.0-amp current inputs or 0-0.33 volt inputs.

F. 1.0% full-scale true RMS power accuracy, +0.5 Hz, voltage input range 120-600V, and auto range select.

G. Under voltage/phase monitor circuitry.

H. NEMA 1 enclosure.

I. Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0 - 0.33 V output. If 0-5 A current transformers are provided, a three-phase disconnect/ shorting switch assembly is required.

2.17 LIGHTING RELAY PANELS

A. Mechanical:

1. Panels shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).
2. Panels shall be wall or recess mountable. Enclosure shall be NEMA Type 1 and IP-20 rated as specified by IEC 60529. Panel shall be constructed of steel with steel gauge of type required by UL508. Contractor shall reinforce wall as required.
3. Panels shall be completely pre-assembled and factory tested by the manufacturer prior to shipment. The contractor shall be required to provide input feed wiring, load wiring, and control wiring. No other wiring or assembly by the contractor shall be permitted. Panels requiring field assembly are not acceptable.

4. All input feed, load, and control terminals shall be front accessible without the need to remove switching assemblies or other components.
5. Panels shall be passively cooled via free-convection and unaided by fans. Systems that are fan dependent or fan assisted for cooling of components are not acceptable. Systems that require or recommend regularly scheduled maintenance for air filtration components are not acceptable.

B. Electrical:

1. Panel shall contain the number of switched outputs as per the drawings. Each output may be controlled independently or in combination with any other output within the panel or with outputs from other panels within the system.
2. The panels shall be dedicated feed-through-type without the use of branch circuit protection.
3. Panels shall be rated for 120/240 volt, or 277/480 volt as dictated by the feeding circuit breakers.
4. Panel should have minimum UL listed short circuit current rating (SCCR) of 14,000A.
5. Panels shall be equipped with an electronic module BYPASS feature which electronically switches outputs to ON by toggling the individual branch circuit breakers (for individual circuits) or main breaker (for all circuits) when there is no data available from the control system.
6. Panel shall be capable of operating from a normal feed, an emergency feed, or a normal/emergency feed.

a. Normal/Emergency Panels

1) Upon the loss of normal input power, a panel operating from a normal/emergency feed shall immediately turn all circuits within that panel to full-on condition when emergency input power is present.
2) During the presence of normal power, circuits designated as emergency circuits shall be controlled via the same controls as circuits designated normal.
3) Emergency power feed may be provided by an emergency generator. Alternatively, the generator can be turned on only under emergency conditions.
4) Normal/Emergency loads shall be fed by Normal /Emergency feeds through the use of a line side (upstream) normal/emergency power transfer switch supplied by others.
5) Under Emergency input power feed, all local control stations shall be inoperable. Once normal power is restored, all lighting circuits shall revert back to their status prior to the emergency condition without requiring any action on the part of the user.
6) Use of a separate UL 924 listed emergency relays shall be an acceptable alternative to Normal Emergency panel; however, the emergency relays shall be located directly above or adjacent to the relay panel, be clearly labeled and be wired to match the above sequences. Individual emergency relays shall be provided for each individual circuit, plus spares as specified on the drawings.

b. 3 Phase detection/sensing device shall:

1) Be UL924 listed as Emergency Lighting and Power Equipment
2) Have two dry contact closure inputs (normally open and "supervisory" normally closed). The normally open input requires a maintained dry contact closure to activate the Emergency mode. The "supervisory" normally closed input will activate the Emergency mode when a dry contact closure is opened. A status indicator will indicate when this closure is activated.
3) Have a function test switch with status indicator to simulate a phase failure
4) Have a phase status indicator

c. 1 Phase detection/sensing device shall:

1) Have two dry contact closure inputs (normally open and "supervisory" normally closed). The normally open input requires a maintained dry contact closure to activate the Emergency mode. The "supervisory" normally closed input will activate the Emergency mode when a dry contact closure is opened. A status indicator will indicate when this closure is activated.
2) Have a function test switch with status indicator to simulate a phase failure
3) Have a phase status indicator.

C. Switching Module:

1. Under fully-loaded operating conditions, all semiconductor devices shall operate at a minimum 20ºC (36ºF) safety margin below the component manufacturer's maximum component temperature rating at a 40ºC (104ºF) ambient room temperature.
2. A positive air gap switch shall be employed by each switched output in the panel to ensure that the load circuits are open when the "off" function is selected from the control system.
3. Switched output shall be capable of withstanding inrush current of 75 times operating current typically generated by a full circuit of switching electronic non-dim ballasts.
4. Each switched output shall be rated for 16A continuous duty for the following load types: resistive (incandescent/tungsten), inductive (magnetic low voltage (MLV), electronic low voltage (ELV), neon/cold cathode, magnetic and electronic fluorescent lamp ballasts, high intensity discharge (HID)) and Motor Loads (1/3HP at 100-127V, 1/2Hp at 220-347V). Relays rated only for resistive loads shall not be acceptable.
5. Switching modules shall be tested to 300,000 cycles.

D. Dimming Module:

1. Where dimming is indicated, provide 0-10V dimming interface, and control via time schedule or wall control as indicated.

E. Low-Voltage Wall Stations:

1. Product: Provide low-voltage wall station controls as defined on project drawings with multiple buttons, or single button as indicated. Key switch style stations shall be provided where indicated on the drawings.
2. Wall stations shall be provided with finish to match wall device finishes throughout the building. Selection shall be made from manufacturer full list of finish options.
3. Wall stations shall fit in standard wall switch or decora style wall plates.
4. Wall stations shall be labeled with lights being controlled.

2.18 Bi-Polar Ionization

A. Provide control relay for control of all bi-polar ionization units. Multiple ionizer modules can be powered and controlled from a single relay where multiple modules are included in a single air handling unit.

B. Associated control transformers shall be capable of supplying additional power required for the bipolar ionizers.

C. Provide all wiring required to power ionization units when supply fan is energized

PART 3 - EXECUTION

3.1 INSTALLATION

A. Electrical power:

1. Verify that power supply is available to the operator workstation, all actuators, valves and all other components of the HVAC Control System. Where required, provide low and/or line voltage power from the nearest electrical panel.
2. Unless noted otherwise, line voltage power for system equipment shall be derived from the nearest electrical panel, and shall not be common with other HVAC, plumbing, electrical or architectural equipment. Unless noted otherwise, low voltage power shall be derived from transformers/drivers associated with the system equipment only, and shall not be connected to control power transformers associated with other HVAC equipment (i.e. air handling units, chillers, etc.). System equipment may share transformers/drivers with other system equipment, provided the transformers/drivers are sized to handle the total load.
3. Control panels for equipment being fed from the emergency generator, including, but not limited to boilers, heating pumps, selected air handling and terminal equipment, etc., power shall be derived

from the nearest 120/208 volt normal/emergency panel. Verify equipment that is connected to emergency power with the Electrical Contractor.

4. Install all power and control wiring and cable per the National Electric Code and applicable Division 26 and 27 Sections. Install raceways, boxes, cabinets according to Division 26 and 27 Sections.
5. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
6. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

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

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

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

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

F. Install guards on thermostats and other sensors in the following areas:

1. Entrances.
2. Public areas.
3. All Gymnasiums.
4. Locker Rooms.
5. Where indicated.

G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

H. Furnish and install hydronic instrument wells, valves, and other accessories where required.

I. Install refrigerant instrument wells, valves, and other accessories where required.

J. Space sensors:

1. Verify location of thermostats, humidistats, and other control sensors with Drawings and room details before installation. Mount sensors in occupied spaces to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
3. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
4. In finished areas, recess electrical box within wall.
5. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted.
6. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

K. Flow Meters:

1. Install flow meters is welded and/or copper pipe per manufacturer’s standard installation requirements to allow for removal and reinstallation of the flow meter without the need to drain the system. Provide full port ball valve at connection to pipe.

L. Air Flow Monitoring:

1. Install monitors in straight sections of duct with manufacturer recommended straight duct upstream and downstream of the monitors. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.
2. Provide all wiring and controls for duct mounted and air handling unit mounted air flow monitors.

3.2 LIGHTING CONTROL SYSTEM INSTALLATION

A. Lighting relay panels shall be furnished by the Division 23 contractor and turned over to the Division 26 contractor for installation. Backboxes shall be turned over separately from the internal components to allow phasing and rough-in of the project.

B. The Division 23 contractor shall furnish and install all low voltage lighting wall stations.

C. The Division 23 contractor shall refer to the E series drawings for locations of relay panels and locations of all low voltage lighting wall stations.

1. The following panels shall be provided as part of this project:

a. Panel ‘RP1’: (4) 20 amp, 1 pole relays ((2) used).
b. Panel ‘RB2’: (12) 20 amp, 2-pole relays and (8) 20 amp, 1-pole relays ((10) 2-pole, and (4) 1-pole used).

D. The Division 23 contractor shall provide all low voltage wiring required for the lighting control relay panels and controls.

E. Lighting relay panels shall be provided with clearly typed directory cards labeling what loads are being fed, and from what circuit breaker it is being fed from.

3.3 QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust all control system components. Report results in writing to the owner's representative.

B. Perform field tests and inspections. Ata minimum perform the following:

1. Operational Test: After electrical circuitry has been energized, start all equipment to confirm proper operation. Remove and replace malfunctioning units and retest.
2. Test and adjust all 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 System 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 instrument tubing for proper fittings, slope, material, and support.
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 dampers. Verify that proper blade alignment, either parallel or opposed, has been provided.
9. Verify that DDC controller power supply is from emergency power supply, if applicable.
10. Verify that wires at control panels are tagged with their service designation and approved tagging system.
11. Verify that spare I/O capacity has been provided.
12. Verify that DDC controllers are protected from power supply surges.

3.4 CALIBRATION AND ADJUSTMENTS

A. Calibrate instruments. Make three-point calibration test for both linearity and accuracy for each analog instrument. 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.

1. Verify 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.

2. Verify 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.

3. 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.

4. 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.

5. 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.
6. 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.
7. Provide diagnostic and test instruments for calibration and adjustment of system.
8. 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.

3.5 SYSTEM DEMONSTRATION AND ON-SITE ASSISTANCE

A. Pre-installation demonstration: the Controls Manufacturer/Installer shall provide a complete demonstration of the proposed control system software architecture prior to final programming of the software. This demonstration is required to have the owner's representative agree on the system architecture. The method and location of the demonstration shall be acceptable to the owner. The Controls Manufacturer/Installer will be required to make any changes in the proposed system architecture, if desired by the owner's representative.

B. Post installation demonstration: provide documented (paper or electronic) proof of testing prior to scheduling post-installation demonstration. Documentation to provide proof of testing/verification of all system inputs and outputs, including verification of analog input values (temp, CO2, etc.) with independent handheld NIST calibrated device. Post installation testing will engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. The training shall be comprised of a minimum of 40 hours on-site training at a time suitable to the owner's representative.

C. On-site assistance: during the warranty period, the Controls Manufacturer/Installer shall provide additional on-site assistance for training and re-programming, when requested by the owner. This on-site assistance shall be for a period of 8 hours for each visit, with a total of 4 visits.

3.6 FINAL REVIEW

A. Submit written report to Architect and Owner's representative when DDC system is 100% complete. Report shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

END OF SECTION 23 09 00