MEPF SPECIFICATIONS

SECTION 15975 - HVAC CONTROLS

PART 1 - GENERAL

GENERAL CONDITIONS

The work described herein shall be installed in accordance with the "Mechanical General Provisions," Section 15010.

DESCRIPTION OF THE WORK

In general, the work consists of, but is not limited to, the following:

Provide specified controls for new HVAC systems. This work involves procurement and installation of operator workstation, server, and controls (hardware, software, devices, programming, networking, wiring, raceways, current transducers, actuators, sensors, interlocks, etc.) labels, coordinating, troubleshooting, adjusting, training, etc.

Provide programming to accommodate sequence of operations and owner's functions including scheduling, alarms, setpoints, etc.

Provide Owner training and instructions.

The extent of the work is indicated on the Drawings and as described herein. The control system shall consist of operator workstation, server, stand-alone equipment controls and sensors, interlocking relays, current transducers, wiring, smoke detector wiring/interlocking, operator training, installation labor, warranty, and all other necessary material and labor to provide a complete and functioning system in accordance with the design intent and to meet the Owner's satisfaction.

CONTROL SYSTEM DESCRIPTION:

The Building Automation System Controller (BAS) shall be as indicated on the drawings and described in these specifications. System must be fully integrated and coordinated with the new mechanical equipment DDC controllers furnished and installed in the equipment manufacturer's factory as specified in those sections. The intent of the BAS is to integrate all mechanical equipment into one system for global monitoring, control, and alarming. It is the BAS manufacturer's responsibility to provide all the design, engineering, and field coordination required to ensure all equipment sequence of operations are met as specified and the designated BAS operators have the capability of managing the building mechanical system to ensure occupant comfort while maintaining energy efficiency.

The BAS shall meet both BACnet and LonTalk communication standards to ensure the system maintains "interoperability" to avoid proprietary arrangements that will make it difficult for the Owner to consider other BAS manufacturers in future projects. BAS Points within the system, whether hardwired, wireless or virtual, shall not be "locked" by the BAS Manufacturer's software and all BAS points shall be available to anyone using a matching open standard protocol. These open protocol communication standards are discussed in more detail later in this specification.

BAS controllers shall be listed by BACnet Testing Laboratories (BTL) with appropriate classification.

1. System controller shall be BTL listed BACnet Building Controller (B-BC)

2. Equipment Controllers shall be BTL listed BACnet Application Specific Controller (B-ASC) or BACnet Advanced Application Controller (B-AAC), as appropriate for the purpose of the controller.

Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of mechanical systems and terminal devices on this project.

The BAS shall accommodate simultaneous multiple user operation. Access to the control system data should be limited only by the security permissions of the operator role. Multiple users shall have access to all valid system data. An operator shall be able to log onto any workstation on the control system and have access to all appropriate data.

Communication between DDC controllers and all workstation(s) shall be over a high-speed network. All nodes on this network shall be peers. The operator shall not have to know the controller identifier or location to view or control a point (object). Application Specific Controllers shall be constantly scanned by the Building Controllers to update point information and alarm information globally.

The BAS manufacturer shall provide all hardware and software necessary to implement the functions and sequence of operations specified.

APPROVED CONTROL SYSTEM MANUFACTURERS

The Trane Tracer System Controller (SC) Building Automation System (BAS) is the basis of design. Comparable products installed by other manufacturer's corporately owned and supported local Offices may be considered by the Consulting Engineer/Owner if they meet the specifications herein. Independently owned offices will not be considered. All qualified corporately owned offices shall have a fully staffed and established Service Department within 50 miles of the project site and must have at least (2) local, factory trained, control technicians currently fulfilling those roles. The Service Department shall provide 24 hours/day, 7 days/week response in the event of a customer's warranty or service call.

QUALIFICATIONS

The contractor shall be licensed in Florida and have a minimum of 3 years demonstrative service in Tallahassee that includes both full time service and installation staffs.

RELATED WORK

Electrical line voltage power wiring for controls is to be provided by the Electrical Contractor.

Low voltage wiring, power supplies and appurtenances are the responsibility of the Controls Contractor.

Electrical power wiring for equipment is specified in the Electrical Sections.

Coordination: It is the responsibility of the controls' subcontractor to read and conform to all sections of the specification, coordinate with the owner, and to coordinate all equipment supplied by others with his work. General equipment operational controls and starters are provided under other sections.

WARRANTY:

Provide a one-year warranty, including all programming, hardware and software components, including labor and materials. Any manufacturing or installation defects arising during this period shall be corrected without cost to the Owner. Travel for warranty related work shall be inclusive, i.e. no charge to Owner.

Provide updates to web server software, project-specific software, graphic software, database software, and firmware that resolve the contractor-identified software deficiencies at no charge during warranty period. If available, Owner may purchase post-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization. Provide Owner briefing and hands-on training for all upgrades that affect system functionality accessed via the Owner.

The BAS 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.

OWNERSHIP OF PROPRIETARY MATERIAL

Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

DEFINITIONS

Term	Definition
BACnet Interoperability Building Blocks (BIBB)	A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.
BACnet/BACnet Standard	BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.
Control Systems Server	A computer(s) that maintain(s) the systems configuration and programming database.
Controller	Intelligent stand-alone control device. Controller is a generic reference to building controllers, custom application controllers, and application specific controllers.
Direct Digital Control (DDC)	Microprocessor-based control including Analog/Digital conversion and program logic.
Gateway	Bi-directional protocol translator connecting control systems that use different communication protocols.
Local Area Network	Computer or control system communications network limited to local building or campus.
Master-Slave/Token Passing	Data link protocol as defined by the BACnet standard.
Point-to-Point	Serial communication as defined in the BACnet standard.
Primary Controlling LAN	High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.
Protocol Implementation Conformance Statement	A written document that identifies the particular options specified by BACnet that are implemented in a device.
Router	A device that connects two or more networks at the network layer.
Wiring	Raceway, fittings, wire, boxes and related items.

SUBMITTALS

Submit to the Engineer for approval six (6) copies of brochures, technical data and/or shop drawings of the following, and as many additional copies as required for Contractor use:

1. Product Data and Shop Drawings: The contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2006 (or 2008) compatible files on magnetic or optical disk (file format: .dwg) and 11" x 17" prints of each drawing. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall include:

    a. DDC System Hardware number, and relevant technical data of equipment to be used.

    b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

        i. Direct digital controllers (controller panels)

        ii. Transducers and transmitters

        iii. Sensors (including accuracy data)

        iv. Actuators

        v. Valves

        vi. Relays and switches

        vii. Control panels

        viii. Power supplies

        ix. Batteries

        x. Operator interface equipment

        xi. Wiring

    c. Wiring diagrams and layouts for each control panel. Show termination numbers.

    d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware.

    e. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software

    a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical data.

b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

   i. Central Processing Unit (CPU) or web server

   ii. Power supplies

   iii. Battery backups

   iv. Interface equipment between CPU or server and control panels

   v. Operating System software

   vi. Operator interface software

   vii. Color graphic software

   viii. Third-party software

c. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.

d. Network riser diagrams of wiring between central control unit and control panels.

3. Controlled Systems

   a. Riser diagrams showing control network layout, communication protocol, and wire types.

   b. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.

   c. A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.

   d. An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.

   e. A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.

   f. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.

   g. A point list for each control system. List I/O points and software points specified on the drawings. Indicate alarmed and trended points.

QUALITY ASSURANCE

The publications listed below form a part of this Specification. The publications are referenced in the text by basic designation only.

a. National Fire Protection Association (NFPA):

70 National Electrical Code

90A Installation of Air Conditioning and Ventilating Systems

b. American National Standards Institute (ANSI) and American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)

Standard 135, BACnet: A Data Communication Protocol for Building Automation and Control Systems.

Furnish and install equipment having the characteristics and accessories indicated on the drawings or in these specifications. The manufacturer's specifications for the models shown on the drawings or given as basis for design, plus all features, options, and accessories indicated on the drawings or in these specifications, whether or not standard for the model scheduled or offered as a substitute, shall constitute the minimum requirements for equipment furnished under this section.

Skilled electricians and mechanics, all of which are properly trained and qualified for this work, shall install the control system.

Upon completion of the installation, the Control System Contractor shall start up the system and perform all necessary testing and run diagnostics to ensure proper operation. An acceptance test in the presence of the Owner's representative, the Architect, and the Engineer shall be performed and the contractor shall provide a certificate of completion stating that control systems have been tested and adjusted for proper operation.

OWNER'S INSTRUCTION & DOCUMENTATION

The Contractor shall give four (4) hours of physical demonstration, training and verbal instructions for proper operation and maintenance of equipment to the Owner or his designated representative. Schedule demonstrations and instructions at the Owner's convenience.

Provide "As-Built" Wiring, Controls' Diagrams, and Sequence of Operations:

Wiring and terminals shall be coded or numbered. A system point-to-point wiring diagram showing wire and terminal codes or numbers shall be furnished to the Owner. Wires shall maintain color-coding at throughout their runs.

Wiring diagrams shall be schematic in nature, but shall show all wire runs from point-to-point, and point connections to terminal blocks, control devices, or sensors. Diagrams shall be in "ladder" format, with hot on the left and neutral or common on the right. Location of components shall be indicated by dashed boundaries with the enclosure designation and room number indicated. A comprehensive legend shall be included. A control device schedule shall be included, showing make and model of control devices cross-referenced to wiring diagram codes. Conductors, terminals, terminal blocks, enclosures, and control devices shall have alphanumeric identification numbers or color codes, which shall be shown on the wiring diagram.

Control Diagrams shall identify all controlled equipment, points names, point type, and be in agreement with the sequence of operations.

Sequence of Operations shall be in detail to explain the operation sequences, safeties, etc. and updated for the specific application.

Submit copies of controlled equipment manufacturer's wiring diagrams indicating where relays and other devices have been introduced.

Project Record Documents. Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2006 (or newer) compatible files on magnetic or optical media (file format: .DWG, .DXF, Operation and Maintenance (O&M) Manual.

2. As-built versions of submittal product data.

3. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.

4. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints, etc.) and as 11" x 17" prints.

5. Programming manual or set of manuals with description of programming language of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

6. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.

7. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.

8. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

9. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.

10. Licenses, guarantees, and warranty documents for equipment and systems.

11. Graphic files, programs, and database on magnetic or optical media.

Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class.

PART 2 – PRODUCT DESCRIPTION

General: The control system shall be based upon BACnet standards and protocols and consist of a high-speed, peer-to-peer BACnet MS/TP network of DDC controllers, a control system server, and a web-based operator interface to provide an “open” controls’ system.

System software shall be based on a server/thin-client architecture, designed around the open standards of web technology. The control system server shall reside in the vicinity of the Owner's operator workstation (located in the basement main mechanical room) and shall be accessed using a Web browser over the control system network, the owner's local area network, and (at the owner's discretion) over the Internet.

The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a Web browser shall be required to access graphics, displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.

Whether hard-wired BACnet MS/TP or wireless BACnet/Zigbee (802.15.4) wireless platform, the System shall use the BACnet protocols for communications.

SYSTEM PERFORMANCE

System performance shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5ºC (±1ºF)
Ducted Air	±0.5ºC (±1ºF)
Outside Air	±1.0ºC (±2ºF)
Dew Point	±1.5ºC (±3ºF)
Water Temperature	±0.5ºC (±1ºF)
Delta-T	±0.15ºC (±0.25ºF)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±50 ppm

Note 1: Accuracy applies to 10% - 100% of scale
Note 2: For both absolute and differential pressure

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0-1.5 kPa (0-6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1-150 psi) 0-12.5 kPa (0-50 in. w.g.) differential

MATERIALS

Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

COMMUNICATION

This project shall be comprised of a high speed Ethernet network utilizing BACnet/IP communications between System Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall be hard wired as shown on the drawings or wireless as defined below.

1. Each System Controller shall perform communications to a network of Custom Application and

Application Specific Controllers using BACnet/Zigbee (802.15.4) wireless platform as defined by the Zigbee Standard.

2. Each communication interface shall be Zigbee Building Automation Certified product as defined by the BACnet Standard and the Zigbee Alliance.

3. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.

4. Wireless equipment controllers shall be compatible with wireless or hard-wired applications without the need of replacing the controller . Wireless equipment controllers and auxiliary control devices and shall conform to:

5. IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and range.

6. Communication between equipment controllers shall conform to ZigBee Building Automation (ZBA) standard as BACnet tunneling devices to ensure future integration of other ZBA certified devices.

7. Operating range shall be a minimum of 200 feet (60 m); open range shall be 2,500 ft. (762 m) with less than 2% packet error rate.

8. To maintain robust communication, mesh networking and two-way communications shall be used to optimize the wireless network health.

9. Wireless communication shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.

10. Certifications shall include FCC CFR47 - RADIO FREQUENCY DEVICES - Section 15.247 & Subpart E

<u>The Owner will provide all communication media</u>, connectors, repeaters, network switches, and routers necessary for the high speed Ethernet network. An active Ethernet port will be provided adjacent to each System Controller (SC) and operator interface (PC) for connection to this high speed Ethernet network.

1. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

2. Network. Use existing Ethernet backbone for network segments marked "existing" or Owner’s LAN on project drawings.

3. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

4. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

   a. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

b. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified on the plans. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

5. Workstations, Building Control Panels, and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated device via the internet. The system shall automatically adjust for daylight saving and standard time as applicable.

6. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

7. The Operator Workstation or server shall conform to the BACnet Operator Workstation (B-OWS) or BACnet Advanced Workstation (B-AWS) device profile as specified in ASHRAE/ANSI 135 BACnet Annex L. Operator Interface. Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information.

8. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J.

SYSTEM HARDWARE

Local Operator Touch Sensitive Display: AHU, Zone (Terminals Future)

1. Local Operator Touch Sensitive Display shall be provided for Central Plant and Air Handler Controllers at building locations where specified in the sequence of operations or point list. The operator interface shall enable the user to view and edit data. A system security password shall be available to prevent unauthorized use of the keypad and display. Local operator display shall meet the minimum specification as listed below:

2. 15 inch diagonal WVGA Touch-Sensitive Color Screen (Allow for easy navigation for viewing data and making operational changes)

3. Display Preferences (Ability to choose how to view dates, times, units (SI/IP), screen brightness, data format, and set backlight timeout)

4. For ease of operator interface, the display shall be capable of accepting and displaying on screen custom graphics.

5. The display shall show an editable time of day schedule (with exception creating ability) for standalone applications.

6. Icon-Labeled Alarm Categories (Ability to easily and quickly identify alarm severities with distinctive, colorful icons)

7. Three Customizable Reports (Ability to select up to 36 pieces of data per report with a maximum of 3 custom reports)

8. Point Overrides With Timeout Feature (Ability to set up point overrides to expire at designated times)

9. Optional User Security (Ability to setup security for overriding/releasing points, release all overrides, custom report editing, date and time edit)

10. Multiple Mounting Options (Ability to be mounted inside a Trane metal enclosure, on a VESA mount (75 mm x 75 mm), or remotely mounted up to 100 meters

11. Language Options (24 built in languages are supported and selectable for all screen displays)

12. The Local Operator Display shall have a cleaning mode that allows the screen to be cleaned while preventing inadvertent activation of touch controls.

13. Additional Local Operator Touch Sensitive Display Requirements:

Input power: 24 VAC +/- 15%, 50 or 60 Hz

Storage conditions:

Temperature: -67°F to 203°F (-55°C to 95°C)

Humidity: Between 5% to 100% (condensing)

Operating Conditions:

Temperature: -40°F to 158°F (-40°C to 70°C)

Humidity: Between 5% to 100% (condensing)

Mounting Type: VESA (75 mm x 75 mm)

Environmental rating (enclosure): IP56 (dust and strong water jet protected)

Local Operator Touch Sensitive Display must meet the following Agency Compliance:

UL916 PAZX, Open Energy Management Equipment

UL94-5V, Flammability

FCC CFR Title 47, Part 15.109: Class A Limit, (30 MHz – 4 GHz)

CE EMC Directive 2004/108/EC

<u>The building operator web interface shall be accessible via any PC with a compatible web browser</u>, without requiring any “plug-ins” (i.e. JAVA Runtime Environment (JRE), Adobe Flash). No dedicated PC workstation shall be required to operate, monitor or control the building’s mechanical systems connected to the BAS Control System.

<u>Any necessary workstation or web server</u> shall include a computer. The computer shall be industry-standard hardware that meets or exceeds the DDC system manufacturer's recommended

specifications and response times specified elsewhere in this document. The following hardware requirements also apply:

a. The hard disk shall have sufficient memory to store:

i. All required operator workstation software.

ii. A DDC database at least twice the size of the delivered system database.

iii. One year of trend data based on the points specified to be trended at their specified trend intervals.

b. Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.

c. Minimum hardware configuration shall include the following:

i. Dual or Quad Core Processor

ii. 6 GB RAM

iii. 500 GB hard disk providing data at 3.0 Gb/sec

iv. 16x DVD-RW drive

v. Serial, parallel, and network communication ports and cables as required for proper DDC system operation

SYSTEM SOFTWARE

1. Operating System. Web server or workstation shall have an industry-standard professional-grade operating system. Operating system shall meet or exceed the DDC System manufacturer's minimum requirements for their software. Acceptable systems include Microsoft Windows 7 or 8, Windows Server 2003 or 2008, Red Hat Enterprise Linux, or Ubuntu Desktop 10.04.

2. System Graphics. The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

   a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.

   b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.

   c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

   d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Adobe Flash).

3. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses a mouse to create and modify graphics that are saved in the same formats as are used for system graphics.

4. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

SYSTEM APPLICATIONS

1. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

2. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.

3. Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.

4. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection.

5. Online Help. Provide a context-sensitive, online help system to assist the operator in operating and editing the system. Online help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

6. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data.

    i. Operator Access. The user name and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users.

    ii. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time period shall be user-adjustable.

    iii. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

7. System Diagnostics. The system shall automatically monitor the operation of building management panels and controllers. The failure of any device shall be annunciated to the operator.

8. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Section 23 09 93 (Sequences of Operation). Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

9. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms.

10. Alarm Reactions. Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.

11. Alarm and Event log. Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms, and archive closed alarms to the workstation or web server hard disk.

12. Trend Logs. The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Section 23 09 93 (Sequences of Operation). Trends shall be BACnet trend objects.

13. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.

14. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

15. Standard Reports. Furnish the following standard system reports:

    a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.

    b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.

    c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:

        1. Alarm History.

        2. Trend Data. Operator shall be able to select trends to be logged.

        3. Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

16. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.

<u>WORKSTATION APPLICATION EDITORS</u>

1. Each PC or browser workstation shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.

2. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.

3. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.

4. Custom Application Programming. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

    a. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.

    b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.

    c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

    d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

    e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

    f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

    g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

    h. Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

    i. System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

<u>CONTROLLER SOFTWARE</u>

1. Furnish the following applications for building and energy management. All software applications shall reside and operate in the system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

2. Scheduling. Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:

a. Weekly Schedule. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).

b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.

c. Holiday Schedules. Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.

3. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

4. Binary Alarms. Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

5. Analog Alarms. Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.

6. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.

7. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

8. Maintenance Management. The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms per the equipment manufacturer's recommendations.

9. Sequencing. Application software shall sequence chillers, boilers, and pumps as specified in the sequences, if applicable.

10. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.

11. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

12. Energy Calculations.

a. The system shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data, where applicable.

b. The system shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

13. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

14. On and Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-acting.

15. Runtime Totalization. Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in the sequences, where applicable.

CONTROLLERS

1. General. Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified herein. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

2. Provide BACnet controllers that comply with the following:

   a. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.

   b. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.

   c. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.

   d. Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.

   e. Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.

   f. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.

   g. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.

   h. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

   i. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

   j. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

   k. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

l. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

m. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

n. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.

o. Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

p. Environment. Controller hardware shall be suitable for anticipated ambient conditions.

   i. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).

   ii. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

q. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

r. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

s. Memory.

   i. Controller memory shall support operating system, database, and programming requirements.

   ii. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.

   iii. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

2. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. 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. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

INPUT AND OUTPUT INTERFACE

1. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

2. Protection. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.

3. Binary Inputs. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

4. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.

5. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

6. Binary Outputs. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

7. Analog Outputs. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0-10 Vdc or a 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

8. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

9. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

10. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

<u>AUXILIARY CONTROL DEVICES</u>

1. Electric Damper and Valve Actuators shall conform the following:

    a) Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.

    b) Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).

    c) Signal and Range. Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.

    d) Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.

2) Water and control valves shall conform to the following:

a) Control valves shall be two-way or three-way type for two-position or modulating service as shown.

b) Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

i) Water Valves:

(1) Two-way: 150% of total system (pump) head.

(2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

c) Water Valves.

i) Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

ii) Sizing Criteria:

(1) Two-position service: Line size.

(2) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 3.0 psi, whichever is greater.

(3) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.

(4) Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.

(5) Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.

3) Water valves shall fail normally open or closed, as scheduled on plans, or as follows:

a. Water zone valves - normally open preferred.

b. Heating coils in air handlers - normally open.

c. Chilled water control valves - normally closed.

4) Other applications - as scheduled or as required by sequences of operation

5) Temperature Sensors.

a) Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

b) Wireless Zone Sensors

i. Battery life shall be 15 years or greater to minimize the need for battery replacement in typical operating conditions. If the life of the battery is expected to be shorter than 15 years, include in your proposal the cost for labor and material to replace the batteries as required for a 15 year period at no additional cost to the owner or their representatives.

ii. To check for proper operation, wireless space temperature sensors shall include a signal strength on the space sensor display.

iii. To allow local troubleshooting without specialized tools, error codes shall be displayed on the digital display. Error codes shall include: not associated, address to 000, improper software configuration, input voltage too high, or general sensor failure. Codes shall be indicated on inside of sensor back cover.

iv. To support use by the physically impaired, the wireless space sensor shall be a minimum font size of 12 points, and the LCD model shall be readable in low light conditions.

v. An optional 2% relative humidity sensors module shall be available for humidity control applications to minimize the need for wired sensors, and shall not shorten typical battery life to less than 15 years.

vi. An optional CO2 sensor module shall also be available to add to the space temperature sensor for space demand ventilation control applications.

6) Duct Sensors.

a) Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m^2(10 ft^2) of duct cross-section.

7) Sensors Shown on Piping. Provide immersion sensors with a separable stainless steel well for all pipe-mounted sensors. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.

8) Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.

9) Differential Sensors. Provide matched sensors for differential temperature measurement.

a) Humidity Sensors.

i. Duct and room sensors shall have a sensing range of 20%-80%.

ii. Duct sensors shall have a sampling chamber.

iii. Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°C-75°C (40°F-170°F).

iv. Humidity sensors shall not drift more than 1% of full scale annually.

10) Current Transformers.

a. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

b. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.

c. Unit shall be split-core type for clamp-on installation on existing wiring.

LOCAL CONTROL PANELS

All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.

Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

PART 3 EXECUTION

General: The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started. The control equipment and connecting wiring shall be installed in a neat and professional manner by trained mechanics under direct supervision of the control contractor, conforming to all applicable state and local codes.

WIRING - GENERAL REQUIREMENTS

All control wiring that is not concealed above accessible ceilings shall be installed in raceways. Wiring in walls shall be in EMT conduit. Raceway installation shall conform to Division 16 requirements. Control's junction boxes and covers shall be painted green.

All enhanced Category 5 copper cabling runs will be tested and follow the industry standards for enhanced Category 5 installation, testing and acceptance.

The Vendor will fire caulk all sleeves and penetrations required for cable installation. Vendor will provide sleeves with end bushings for project if needed. All penetrations shall be sleeved. Size of sleeves shall be determined based on quantity of cables need for serviced area.

WIRING - QUALIFICATIONS AND MATERIALS

The station wiring components, including all necessary appurtenances and required accessories shall be the standard product of a manufacturer regularly engaged in the production of this type of equipment. The materials to be furnished shall be of proven ability and shall be designed, constructed, and installed in accordance with best practices and methods.

The equipment must be of such physical dimensions to be suitable for installation according to the methods described here and in the space allotted.

All materials and parts shall be new and unused, of current manufacture, and of the highest grade, free from all defects or imperfections. Workmanship shall conform to the best modern practices.

The supplier shall furnish all installation and testing necessary for final approval and acceptance.

Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with installations similar to that required for this project.

WIRING - MATERIALS

All IP communication network wiring shall be of the unshielded twisted pair enhanced Category 5 plenum rated, 24 gauge, solid bare annealed copper conductors, Cable will be intended for high-speed local area network (LAN) applications through data rates of 100 Mb/s. No manufacturer seconds will be accepted for installation. Vendors shall provide certification from manufacturers that intended purchased cable is not manufacturer seconds.

Insulation shall be Fluorinated ethylene propylene (FEP) on all pairs. 3X1 or 2X2 construction is not permitted. Submit proof of compliance.

All BACnet MS/TP communication network wiring shall be single shielded twisted pair, low capacitance, CL2P, 22 or 24 AWG, TC Foam FEP, plenum-rated wire, colored green.

Data wiring shall be sheathed with green sheathing.

Acceptable manufacture: Berk-Tek LANmark 350. Equivalent products by AT&T, Mohawk, or General Cable are acceptable.

TERMINATIONS

All connections shall be insulation displacement connections without exception.

MODULAR WALL JACK ASSEMBLY

Station cable runs shall be terminated in the mechanical room on a quadruplex modular wall jack assembly using an 8 position, 8 contact type wired TIA 586A, color green.

WIRING - INSTALLATION

Cables shall be terminated in the jack assembly wired standard TIA 568A 10BaseT configuration for data and standard color configuration for voice.

Station wire shall be home run from the jack location to the nearest designated telecommunications closet location (see the description below). There shall be two (2) feet of slack in the cable at the jack location. Slack cable may be pulled into the ceiling when installing the wall jack assembly.

Install station cabling using bridle hangers or Caddy CableCat 5 support clips. Hangers shall not exceed four feet separation. Station cable shall not have more than twelve inches of sagging at mid-span. Station cabling shall not criss-cross in interior of building. Station cable shall be installed running length way of major hallways. Utilize cable tray system where available. Installation of station cable runs must either above all obstruction in bridle hangers or below obstructions with one foot clearance of ceiling in suspended bridle hangers. Proper engineering practices for installation will be used. Wire ties must be plenum rated for cable bundling.

All data lines will terminate standard TIA 568A configuration on patch panels in the designated LAN equipment room.

Terminations shall be made in such a manner as to not remove any more of the sheath (jacket) than is necessary to allow terminations without untwisting individual pairs more than one-half inch. Every effort shall be made not to unnecessarily disturb the lay of pairs at terminating points (TC's and WAO's).

Cable shall be installed with a bend radius of at least four times the cable diameter and not less than 1 inch (UTP).

Extreme care shall be taken not to exceed the recommended pulling tension of the cable installed. In no case shall cable be subjected to pulling tensions greater than 25 pounds. When placing cables in conduit, use anti-friction cable pulling lubricant that is compatible with the jacketing compound. Conduit runs in excess of 100 feet shall have intermediate pull boxes or likewise any conduit have the equivalent of two 90 degree bends. Pull boxes shall not be used to change direction and shall be straight through.

Telecommunications wiring shall not share conduits or pathways with power wiring. Isolate telecommunications wiring from other cabling that may induce unwanted signals. Avoid routing telecommunications cabling in proximity of sources of electromagnetic interference or radio frequency interference, motors, generators, fluorescent ballasts, etc.

Cable installed without conduit in ceiling spaces serving as a return air plenum shall be UL listed as Type CMP, or UL classified as having adequate fire resistance and low smoke producing characteristics per NEC Article 800-3(b)(2).

All cables placed in the ceiling will be placed in a rack or tray, if provided. Otherwise they will be bundled and secured off the ceiling tiles and any and all lighting or electrical fixtures.

All wall penetrations shall be made utilizing a metal raceway sleeve, with bushings installed on each side. Secure raceway to wall studs or other rigid structure. Vendor is responsible for all fire wall penetrations. All fire wall penetrations shall be in metal sleeve with fire caulking. Any locations that vendor will be using existing penetrations must be brought to existing code requirements for wall penetrations.

WIRING - TESTING AND ACCEPTANCE

Testing: provide printed results of tests for crosstalk, resistance, and dB loss for each data line. The results of each test will meet standard industry requirements for data wiring. Ensure that cabling supports all data requirements for the intended service. All cabling shall be tested with a TSB67 Level II compliant tester.

Acceptance Period: an acceptance period of thirty (30) consecutive days of successful operation after system installation and testing shall constitute a successful acceptance period.

After completion of the installation and testing, the acceptance test period will be started. The system will be accepted upon the completion of a successful acceptance period. A successful acceptance period shall demonstrate total system availability during the acceptance period. The Contractor shall be responsible for completing any required repairs, connections, replacements, and associated testing and documentation until the successful completion of the acceptance period.

WIRING - PROJECT CLOSEOUT

Wiring Diagrams: provide two (2) complete sets of reproducible drawings indicating wiring schematics after completion.

Test Results: provide two (2) sets of print-outs in 8.5”x11” format, neatly bound. Include cover page and index.

Identification: All points, devices, panels, etc. shall be permanently tagged and labeled. Raceways shall be spot painted with green paint. Box covers shall be painted green. Control cabling shall be color identified.

HARDWARE INSTALLATION

Install panels, sensors, devices, etc. to facilitate access and preferably at approximately 5’ above finish floor. Coordinate installation of all duct mounted devices with the mechanical contractor and before insulation is installed.

PROGRAMMING:

Provide sufficient internal memory for the specified sequences of operation and trend logging

Point Naming. Name points as shown on the equipment points list and plans. If character limitations or space restrictions make it advisable to shorten the name, coordinate the abbreviations with the Engineer. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

Provide software programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

a. Text-based:

    i. Must provide actions for all possible situations

    ii. Must be modular and structured

    iii. Must be commented

b. Graphic-based:

    i. Must provide actions for all possible situations

    ii. Must be documented

c. Parameter-based:

    i. Must provide actions for all possible situations

    ii. Must be documented.

Operator Interface Graphics: Provide graphics for all new mechanical systems and floor plans included in the construction documents. This includes each air handler, sensors, duct configuration, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as setpoints. As a minimum, show on each equipment graphic the input and output points and relevant calculated points as indicated on the applicable Points List

System Verification, Startup and Checkout: The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

Trend Data and Setup. The contractor shall program trends, alarms, data storage/archiving, reporting requirements, etc. Coordinate trend data setup, storage, and reporting with the Owner. Initiate trending at least seven days prior to substantial completion.

CONTROL SYSTEM VERIFICATION, DEMONSTRATION AND ACCEPTANCE

System verification shall be performed by the contractor and all known discrepancies resolved prior to demonstrating operability of the system. Contractor shall provide onsite demonstration of system operability including review of sequences, setpoints, alarms, trend data setups, etc. to the Owner and Engineer in order to achieve substantial completion level of acceptance. The contractor shall resolve all punchlist items issued by the Engineer/Owner.

TRAINING

1. Provide training for designated number of staff (up to 5) of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

2. Training shall enable students to accomplish the following objectives.

   A. Day-to-day Operators:

      a. Proficiently operate the system

      b. Understand control system architecture and configuration

      c. Understand DDC system components

      d. Understand system operation, including DDC system control and optimizing routines (algorithms)

      e. Operate the workstation and peripherals

      f. Log on and off the system

      g. Access graphics, point reports, and logs

      h. Adjust and change system set points, time schedules, and holiday schedules

      i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals

      j. Understand system drawings and Operation and Maintenance manual

      k. Understand the job layout and location of control components

      l. Access data from DDC controllers and ASCs

CONTROL SCHEME & SEQUENCE

<u>See drawings for specific controls and sequences.</u>

COORDINATION WITH TEST ADJUST AND BALANCE (TAB) CONTRACTOR

The contractor shall coordinate with the mechanical contractor to ensure all operating discrepancies are resolved and the system is operating in accordance with the design intent. Only then shall the go ahead for Test Adjust and Balance operations be initiated. The control contractor shall participate in the TAB operations to facilitate their work.

FINAL COMPLETION

<u>Final Completion</u>: To achieve final completion, the control contractor shall:

1. Completely adjust or calibrate, ready for use, all thermostats, sensors, damper operators, relays, etc., provided under this section.

2. Complete the labeling of all control devices, panels, wiring, etc.

3. Test all connected devices so that the displayed controlled variable is within the limits/tolerances of the specific equipment.

4. Test all smoke detectors and associated controls.

5. Test all other controls indicated or specified by the contract documents.

6. Provide trend data reports to substantiate consistent (7 day minimum) operations and systems' control in accordance with the design intent and performance requirements specified herein.

7. Complete all punchlist items to the satisfaction of the Engineer.

8. Provide training and asbuilt documents as described herein to the Owner.

END OF SECTION