SECTION 27.51.24
HVAC – BUILDING AUTOMATION SYSTEM

PART 1 – GENERAL

1.01 OVERVIEW
A. Each building system shall provide the Direct Digital Control (DDC), Energy Management and Building Automation System (BAS) for the air conditioning, heating and ventilating systems.

1.02 MANUFACTURERS
A. Johnson Controls

1.03 SCOPE OF WORK
A. Contractor's Responsibilities
   1. The Contractor shall furnish and install all necessary software and hardware, wiring, and computing equipment in compliance with this specification.

B. System Requirements
   1. Standard Material/Products. All material and equipment used shall be standard components, regularly manufactured and available, and not custom designed especially for this project. The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware. The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

C. Equipment
   1. System Hardware
      The Contractor shall provide the following:
      PC’s, PDA’s, server(s), routers, modems and control modules as specified. All sensing devices, relays, switches, indicating devices, and transducers required to perform the functions as listed in I/O Summary Tables. All monitoring and control wiring and air tubing.
   2. System Software
      The Controls Contractor shall provide all software identified in Part 2 of this specification, including the BAS Server, fully configured database, graphics, reports, alarm/events. The Graphical User Interface (GUI) shall be completely Web based as specified herein.
   3. Input/Output Point Summary Schedule
      The system as specified shall monitor, control, and calculate all of the points and perform all the functions required for this project including those shown on drawings and listed in other specification sections.

1.04 WARRANTY
A. The Contractor shall warrant, from the date of final acceptance by Owner, that all systems, subsystems, component parts, and software are fully free from defective design, materials, and workmanship for a period of one year.

1.05 GENERAL
A. The system shall continuously perform Direct Digital Control (DDC) functions at the local control module in a stand-alone mode. Using Graphical Programming, the operator shall be able to design and modify control sequence of operation and all tuning parameters. All software application algorithms described below MUST reside at the local Multi-Application or Single-Application Controller level. Systems that rely on a workstation PC, server or router to perform these functions are NOT acceptable.
PART 2 – PRODUCTS

2.01 SYSTEM OVERVIEW

A. The BAS contractor shall provide system software based on a server/thin-client architecture, designed around the open standards of web technology. The BAS server and Network Controllers shall communicate using ASHRAE’s BACnet/IP protocol, and in addition, both shall offer concurrent support of the following protocols: LonWorks, MODBUS, and SNMP. The Network Controllers and Server shall be accessible using a web browser over intranet and remotely over the Internet.

B. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft and Netscape Navigator browsers (latest versions), and Windows as well as non-Window operating systems. No special software, (active-x components or fat java clients) shall be required to be installed on the PC’s / PDA’s used to access the BAS via a web browser.

C. The BAS server software must support at least the following server platforms (Windows, Sun Solaris and Linux). The BAS server software shall be developed and tested by the manufacturer of the system Network controllers shall be available for purchase through at least 3 different manufacturers of BAS systems. BAS software that is only available through manufacturer’s branch offices or manufacturer’s independent contractor channel is not acceptable.

D. As-Builts, Operation and Maintenance Manuals developed specifically for the project shall be delivered on a CD-ROM and loaded on the BAS server by contractor. Contractor shall provide a link for each HVAC system controller (standalone or unitary) on browser graphics to the appropriate technical documents for troubleshooting and maintenance.

E. The web browser GUI shall provide a completely interactive user interface and must offer the following features as a minimum:

- Trending
- Scheduling
- Downloading Memory to field devices
- Real time ‘live’ Graphic Programs
- Tree Navigation
- Parameter change of properties
- Setpoint Adjustments
- Alarm / Event information
- Configuration of operators
- Execution of global commands

2.02 WEB BROWSER GRAPHICAL USER INTERFACE

A. Action Pane

The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

1. Graphics: Using animated gifs or other graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content, and other valid HTML elements. The data on each graphic page shall automatically refresh at a rate defined by the operator.

2. Properties: Shall include graphic controls and text for the following: Locking or overriding BACnet objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress a ‘accept/cancel’ button.

3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree) and in compliance with section 2.2.G
4. Events: Shall be used to view alarm event information geographically (using the navigation tree), acknowledge events, sort events by category, actions and verify reporting actions.

5. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling.

6. Logic - Live Graphic Programs: Shall be used to display a ‘live’ graphic programs of the control algorithm for the mechanical/electrical system selected in the navigation tree. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

7. The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated .gif’s or .jpg, active setpoint graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:

   a. Display Size: The GUI workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color.
   b. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
   c. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone’s actual comfort condition changes.
   d. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.
   e. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
      - Each piece of equipment monitored or controlled including each terminal unit
      - Each building
      - Each floor and zone controlled

8. Zone Setpoint Adjustments
Color floor plans displayed via a web browser shall utilize a contiguous band of colors, each corresponding to actual zone temperatures relative to the desired heating and cooling setpoints. Utilizing a mouse, it shall be possible to select occupied or unoccupied setpoints (corresponding to the floor plan colors) and drag the slide bar(s) to increase or decrease heating and cooling setpoints. In addition to the slide bars, an operator may type the numeric value of the heating and cooling setpoints. The floor plan graphic shall then change colors on a zone-by-zone basis to reflect the actual temperature in each zone relative to the changed heating or cooling setpoint.

9. Hierarchical Schedules
Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day ‘Holiday’ for every level in the system would be created by clicking on a master schedule object on the “home” web page. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the ‘Independence Day’ Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and webpage.
10. Trends
   Trends shall conform to the BACnet Trend Log Object specification. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log’s properties shall be editable using the Navigation Tree and Graphic Panel. All log data shall be available to the end user in the following formats: XML, HTML, CSV. Plain text.

11. Security Access
   Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility. Each user of the BAS shall be provided a “home page” upon login and shall have limited access to other pages based on role.

2.03 GRAPHICAL PROGRAMMING
   A. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in standalone control modules. Any system that does not use a drag and drop method of graphical icon programming as described herein is NOT acceptable. GPL is a method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors, etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

   B. Graphical programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

   C. The Graphic Programming software must support a ‘live’ mode, where all input/output data, calculated data, and setpoints shall be displayed in a ‘live’ real-time mode.

   D. For each piece of HVAC equipment, the entire graphic program shall be displayed through the Web Browser GUI. The operator must have the ability to scroll through the entire ‘live’ graphic program as necessary. Piecemeal graphic programs that only show one part of HVAC equipment program at any one time are NOT acceptable. For example, when viewing an AHU live graphic program, the operator shall see the entire AHU graphic program, not just the Heating Coil control. The Graphic Programming software shall allow the end user to program the Network Controllers and configure the unitary controllers in real time using the browser.

2.04 PRODUCTS HARDWARE
   A. BAS SERVER HARDWARE
      Computer Configuration (Hardware Independent)
      1. Central Server. The BAS Contractor shall provide a server configuration that includes the following components as a minimum:
         8GHz or higher CPU (or non-Intel platform equivalent to this) – (Dual Processor)
         5 GB RAM preferred.
         40 gigabyte hard disk, SVGA Card with 1024 x 768, 24-bit True Color, 24X CDRW Rom Drive, 17” SVGA Color Monitor, Keyboard and mouse, 56Kbps EIA-232C Modem with automatic answer/originate capability
         Operating system for the computer operator workstation server shall be Microsoft Windows, Linux or Sun Solaris (latest versions).
         Internet Explorer
         10Base-T Ethernet Port
Printer capable of providing letter quality print (a color printer is preferred). Note: For reporting alarms, a printer capable of handling fanfold paper is desirable. The thin-client Web Browser BAS GUI shall be Microsoft Internet Explorer (latest version). No special software, (active-x components or fat java clients) shall be required to be installed on the PC’s / PDA’s used to access the BAS via a web browser.

**B. NETWORK CONTROLLERS**

The controller network shall use BACnet as its native communication protocol. Network controllers must be of a modular design to ensure reliability, distributed control and system performance. If the BAS server fails or loses connectivity to the network for a period of time, the end user shall be able to connect with a browser to the Network Controller via the Intranet/Internet and at a local jack. The end user shall have the exact same browser interface and capabilities without the server in place (except for global summary/control that is located in Server). BACnet bridges or routers shall not be used.

The central system shall use the building Local Area Network (LAN) for communication. The communication between the central server and the Network controllers shall be BACnet/IP. Proprietary protocols are NOT acceptable.

Network Controllers must use BACnet as the native communication protocol and must, as a minimum, support the following BIBBS:

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Firmware Updates. The Network Controller utilize FLASH memory to allow firmware updates to be performed remotely.

The Network Controller shall support a minimum of 32 simultaneous browser users.

**C. STANDALONE CONTROLLERS**

1. General Purpose Application Controllers

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

<table>
<thead>
<tr>
<th>Data Sharing</th>
<th>Alarm Event</th>
<th>Schedule</th>
<th>Trend</th>
<th>Device Man.</th>
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<td>DM-UTC-B</td>
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2. Communication Speed

**CONSTRUCTION DOCUMENTS PACKAGE**

**ISSUED 30-DEC-15**
Controllers shall communicate at the minimum speed of the Intranet using BACnet IP. Standalone controllers shall be used to integrate electrical switchgear and metering via Modbus RTU/ASC/TCPIP. Provide necessary software drivers to integrate these devices to Standalone Controllers. Convert Modbus to BACnet for communication with the BAS Server.

3. General Specification
Each General Purpose Application Controller must be capable of standalone direct digital operation utilizing its own 32 bit processor, non-volatile flash memory, input/output, 12 bit A to D conversion, hardware clock/calendar and voltage transient and lightning protection devices. A separate co-processor shall be used for communications to the controller network. All non-volatile flash memory shall have a battery backup of at least five years. Firmware revisions to the module shall be made from the BAS server or remotely over the Intranet or Internet. Controllers that require component changes to implement firmware revisions are NOT acceptable.

4. Point Programming
All point data, algorithms and application software within a controller shall be custom programmable from the operator workstation.

5. Program Execution
Each General Purpose Application Controller shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/writeable nonvolatile flash memory within the controller and will be able to upload/download to/from the BAS Server.

6. Input-Output Processing
Digital Outputs shall be relays, 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed using jumpers and provide dry contacts. Each output shall have a manual Hand-Off-Auto switch for local override and an LED to indicate the operating mode. Triac outputs are NOT acceptable. Universal Inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77°F (25°C), 0-5VDC, 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, dry contact - 0.5mA maximum current. Analog Output shall be electronic, voltage mode 0-10VDC or current mode 4-20mA.

7. Unitary Controller Network

a. Unitary Controllers
The Unitary Controllers shall use BACnet MSTPor LONworks as the native communications protocol between controllers on the unitary controller network and must, as a minimum support the following BIBBS (if BACNet MSTP):

Data Sharing  Device Man.

DS-RP-B  DM-RD-B
DS-WP-B  DM-PT-B

The communication between unitary controllers shall be 38.4 Kbps minimum over EIA-485 using an BACnet MS/TP architecture or 78kbps minimum using a LONworks Network. Each Unitary Controller and Unitary Controller Interface shall have LED indication for visual status of communication, power, and all outputs. In the event of a loss of communication, each Unitary Controller shall control from a standalone algorithm, which maintains the assigned space temperature until communication with the Unitary Control Router is restored. Digital outputs shall be relays, 24 Volts AC or DC maximum, having a 1 Amp maximum current. Each relay shall be configured as normally open or normally closed, and provide a dry contact. Triac outputs are NOT acceptable. Universal inputs shall be Thermistor Precon Type II, dry contacts or 0-5VDC with 0-10K Ohm input impedance. Enhanced Zone Sensor Input. The input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED.
D. FIELD HARDWARE/INSTRUMENTATION

1. Type & Accuracy
   Temperature sensors shall be of the type and accuracy indicated for the application. Sensors shall have an accuracy rating within 1% of the intended use temperature range.

2. Water Sensors
   Water sensors shall have an accuracy of +0.25°F (0.15°C) in their range of application.

3. Valve and Damper Actuators
   Electronic Direct-Coupled. Electronic direct-coupled actuation shall be provided. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft. The fastening clamp assembly shall be of a 'V' bolt design with associated 'V' shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a 'V' clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or screw type fasteners are not acceptable.

4. Electronic Overload Sensing
   The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.

5. Power Failure/Safety Applications
   For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.

PART 3 – EXECUTION – NOT USED

END OF SECTION