SECTION 230900 - BUILDING ENERGY MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish a totally native BACnet-based system, including the Microsoft compatible operator's workstation. The operator's workstation, all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135–2008, BACnet. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to existing systems or to systems installed under other sections.

B. Provide all necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.

C. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.

D. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

E. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.

F. Provide as-built documentation, operator's terminal software, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

G. Provide new sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.

H. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.

1.2 SYSTEM DESCRIPTION (OPERATORS WORKSTATION IS EXISTING)

A. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2008, BACnet and achieved listing under the BACnet Testing Laboratories BACnet - Advanced Workstation Software (B-AWS). This system is to control all mechanical equipment, including all unitary equipment such as VAV boxes, heat pumps, fan-coils, AC units, etc., and all air handlers, boilers, chillers, and any other listed equipment using native BACnet-compliant

components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

B. Operator's workstation software shall use Microsoft Windows 10 Professional or Windows 10 as the computer operating system. The Building Energy Management System application program shall be written to communicate specifically utilizing BACnet protocols. Software functions delivered on this project shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, after-hours billing program, demand limiting, and a full suite of field engineering tools including graphical programming and applications. All software required to program application specific controllers and all field level devices and controllers will be included. All software passwords required to program and make future changes to the system will also become the property of the owner. All software required to make any program changes anywhere in the system, along with scheduling and trending applications, will be provided. All software passwords required to program and make future changes to schedules, trends and related program changes will also become the property of the owner. All software required for all field engineering tools including graphical programming and applications will provide. All software passwords required to program and make future changes to field engineering tools, including graphical programming and applications will be left with the owner.

C. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator's terminal. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.

D. Room sensors shall be provided with digital readout (where shown on plans) that allow the user to view room temperature, view outside air temperature, adjust the room setpoint within preset limits and set desired override time. Include all necessary wiring and firmware such that room sensor includes field service mode. Field service mode shall allow a technician to balance VAV zones and access any parameter in zone controller directly from the room sensor. Field service mode shall have the ability to be locked out.

E. All application controllers for every terminal unit (VAV, HP, UV, etc.) air handler, all central plant equipment, and any other piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller through BACnet LAN.

1.3 APPROVED MANUFACTURERS

A. Acceptable BACnet manufactured system is Alerton Compass (No Substitution) to match owners existing Aerojet Camden Plant Control System.

1. Approved Control Manufacturers

a. Alerton Controls by L&H Airco (No Substitution)
b. Contact John Harris @ L&H Airco – 916-677-1000

1.4 BACNET MANUFACTURER QUALITY ASSURANCE

A. All BACnet application specific controllers submitted for use on this project must be certified as complaint with BACnet through the BACnet Manufacturers' Association (BMA) BACnet Testing Lab and must have a "BTL Mark". The temperature control system must be developed using existing proven equipment and must be readily available from inventory of the controls manufacturer or vendor at the time of bid.

B. Native BACnet System Manufacturer must have at a minimum 500 operating projects utilizing the proposed native BACnet System. All controllers used on project must be of regular manufacturer and be readily available from inventory of the BACnet System Manufacturer.

C. Provide standard components, of regular manufacture for this application for all materials and equipment. All systems and components shall have been thoroughly tested and proven in actual use.

D. Component Testing and Availability: Maximum reliability shall be achieved through extensive use of high-quality, pre-tested components. The manufacturer prior to shipment shall individually test each and every controller, sensor, and all other DDC components. EMS System Contractor or Manufacturer must certify that any DDC part can be replaced within 5 working days.

E. Operator workstation, if specified shall utilize Microsoft Windows 10 Professional or newer. All workstations and controllers shall be native BACnet devices and achieved listing under the BACnet Testing Laboratories BACnet - Advanced Workstation Software (B-AWS). No 3rd party gateways shall be used for communication to controllers installed under this section.

F. Provide all necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in the system.

G. Materials and equipment shall be manufacturer's latest standard design that complies with the specification requirements.

H. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.

I. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

1.5 BACNET SYSTEM PROVIDER QUALITY ASSURANCE

A. Responsibility: All work described in this section shall be engineered, and programmed by regularly employed control system engineers and technicians of the authorized temperature control system factory representative or branch office of the listed approved manufacturer. System Engineering, Programming and Startup support shall not be subcontracted. The supplier of the BACnet Temperature Control and Energy Management System shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished by him.

B. The Building Automation System (BAS) system shall be designed, installed, started up, and serviced by manufacturer authorized and trained personnel. System provider shall have an in-

place support facility with remote 8 hour response time with technical staff, spare parts inventory, and necessary test and diagnostic equipment.

C. Unacceptable Bids: Bids by wholesalers, parts distributors, contractors or franchised dealers or any firm whose principal business is not that of installing automatic temperature control systems shall not be acceptable.

D. Experience: BACnet System Provider (BSP) shall have been in business for a minimum of five continuous years prior to this project bid. BSP must have been a factory authorized representative for a minimum of five years of the contractors proposed manufacturer's products and systems.

E. BSP must have performed, at least 100 projects, each of which included the installation of not less than 500 hardware I/O points, using the contractors proposed manufacturer's products and systems. 20 of the 50 projects must have included the installation of not less than 1,500 hardware I/O points using the contractors proposed manufacturer's products and systems.

F. BSP shall have on staff a full time Mechanical Engineer that is a licensed Professional Engineer, having not less than five years' experience with the contractors proposed manufacturer's products and systems.

G. BSP shall have on staff four full time Applications Engineers and Control System Programmers, having not less than three years' experience with the contractors proposed manufacturer's products and systems.

H. BSP shall have on staff a minimum of three full time control technicians, Senior control technician shall have not less than three years' experience, junior technicians shall have not less than one years' experience with the contractors proposed manufacturer's products and systems.

I. BSP shall have a full time service department with service available 24 hours a day, seven days a week. Service department will have been established for a minimum of five years and be staffed with factory trained and authorized service technicians capable of servicing all aspects of the control systems depicted on these plans.

J. Service department shall have on staff a full time control system telephone support technician available during normal business hours dedicated to taking customer support calls and having the ability to call the project site and perform on-line diagnostics.

K. BSP shall assign an in-house project manager to provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents and shall indicate timing and dates for system installation, debugging, and commissioning.

1.6 BACNET SYSTEM INSTALLER QUALITY ASSURANCE

A. Responsibility: All work described in this section shall be installed, wired, circuit tested and calibrated by electricians and technicians that have a minimum of 2 years experience of installing the specified control system.

B. The BACnet System Installer (BSI) shall have an in-place support facility within 8 hours response time of the site with technical staff, and necessary test and diagnostic equipment to support the project and the BSP.

C. Unacceptable Bids: Bids by wholesalers, parts distributors, contractors or franchised dealers or any firm whose principal business is not that of installing automatic temperature control systems shall not be acceptable.

D. Experience: BACnet System Installer (BSI) shall have been in business and licensed by the State of Arkansas for a minimum of five continuous years prior to this project bid.

E. BSI must have installed, from an office not more than 100 miles from project site at least 10 projects.

F. BSI shall have on staff a full time Control System Technician, having not less than one years' experience with the specified control system.

G. BSI shall field verify controls and equipment are compatible and match the design and shall notify the Owner immediately of any discrepancies between field conditions and Work shown in the Contract Documents.

1.7 SUBMITTALS

A. Drawings

1. The system supplier shall submit engineered drawings, control sequence, and bill of materials for approval.
2. Drawings shall be submitted in the following standard sizes: 11" x 17" (ANSI B).
3. Eight complete sets (copies) of submittal drawings shall be provided.
4. Drawings shall be available on CD-ROM.

B. System Documentation

1. Include the following in submittal package:

a. System configuration diagrams in simplified block format.
b. All input/output object listings and an alarm point summary listing.
c. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
d. Complete bill of materials, sequence of operations, valve schedule and complete system BACnet controller address list.
e. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
f. Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
g. For all system elements—operator's workstation(s), building controller(s), application controllers, routers, and repeaters—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2008.

h. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.
i. A list of all functions available and a sample of function block programming that shall be part of delivered system.
j. Upon completion of the work, provide a set of 'record drawings' including manufactures descriptive literature, operating instructions and maintenance and repair data all in accordance with the requirements of the general mechanical specification section. Provide electronic copies of all control system as-built AutoCAD drawings.

C. Project Management

1. The system provider shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents, and shall indicate timing and dates for system installation, debugging, and commissioning.

1.8 WARRANTY

A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.

B. This warranty shall apply equally to both hardware and software.

PART 2 - PRODUCTS

2.1 SYSTEM SERVER (EXISTING ON AEROJET NETWORK)

A. General structure of workstation interaction shall be a standard client/server relationship. Server shall be used to archive data and store system database. Clients shall access server for all archived data. Each client shall include flexibility to access graphics from server or local drive. Server shall support a minimum of 50 simultaneous clients.

B. BACnet Conformance

1. Operator Work Station shall be approved by the BTL as meeting the BACnet Advanced Work Station requirements.
2. Refer to Section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types accessed by the workstation shall include as a minimum: Analog Value, Analog Input, Analog Output, Binary Value, Binary Input, Binary Output, Calendar, Device, Event Enrollment, File, Notification Class, Program, and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

4. The operator's workstation shall comply with Annex J of the BACnet specification for IP connections. Must support remote connection to server using a thick client application. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs). Workstation shall support Foreign Device Registration to allow temporary workstation connection to IP network.

C. Displays

1. Operator's workstation shall display all data associated with project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator's workstation shall display all data using three-dimensional graphic representations of all mechanical equipment. System shall be capable of displaying graphic file, text, and dynamic object data together on each display and shall include animation. Information shall be labeled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user. Workstation shall allow user to change all field-resident EMCS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc., from any screen, no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.
2. All displays and programming shall be generated and customized by the local EMCS supplier and installer. Systems requiring factory development of graphics or programming of DDC logic are specifically prohibited.
3. Binary objects shall be displayed as ACTIVE/INACTIVE/NULL or with customized text such as Hand-Off-Auto. Text shall be justified left, right or center as selected by the user. Also, allow binary objects to be displayed as individual change-of-state graphic objects on the display screen such that they overlay the system graphic. Each binary object displayed in this manner shall be assigned up to three graphic files for display when the point is ON, OFF or in alarm. For binary outputs, toggle the object's commanded status when the graphic item is selected with the system mouse. Similarly, allow the workstation operator to toggle the binary object's status by selecting with the mouse, for example, a graphic of a switch or light, which then displays a different graphic (such as an "ON" switch or lighted lamp. Additionally, allow binary objects to be displayed as an animated graphic. Animated graphic objects shall be displayed as a sequence of multiple graphics to simulate motion. For example, when a pump is in the OFF condition, display a stationary graphic of the pump. When the operator selects the pump graphic with the mouse, the represented object's status is toggled and the graphic of the pump's impeller rotates in a time-based animation. The operator shall be able to click an animated graphical object or switch it from the OFF position to ON, or ON to OFF. Allow operator to change graphic file assignment and also create new and original graphics online. System shall be supplied with a library of standard graphics, which may be used unaltered or modified by the operator. Systems that do not allow customization or creation of new graphic objects by the operator (or with third-party software) shall not be allowed.
4. Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual graphic items on the display screen as an overlay to the system graphic. Each analog input object may be assigned a minimum of five graphic files, each with high/low limits for automatic selection and display of these graphics. As an example, a graphic representation of a thermometer would rise and fall in response to

either the room temperature or its deviation from the controlling setpoint. Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box. Selection for display type shall be individual for each object. Analog object values may be changed by selecting either the "increase" or "decrease" arrow in the analog object spinner box without using the keypad. Pressing the button on the right side of the analog object spinner box allows direct entry of an analog value and accesses various menus where the analog value may be used, such as trendlogs.

5. Analog objects may also be assigned to a system graphic, where the color of the defined object changes based on the analog object's value. For example, graphical thermostat device served by a single control zone would change color with respect to the temperature of the zone or its deviation from setpoint. All editing and area assignment shall be created or modified online using simple icon tools.
6. A customized menu label (push-button) shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu label pushbuttons may be mixed on the same display to allow sub-displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A security level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.
7. The BAS displays shall have the ability to link to content outside of the BAS system. Such content shall include but is not limited to: Launching external files in their native applications (for example, a Microsoft Word document) and launching a Web browser resolving to a specified Web address.
8. The BAS system shall have the ability to run multiple, concurrent displays windows showing continuously updated data.

D. Password Protection

1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator's assigned functions when user is logged on. This includes displays as outlined above.
2. Each operator's terminal shall provide security for a minimum of 200 users. Each user shall have an individual User ID, User Name, and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID shall be 0–8 characters, User Name shall be 0–29 characters, and Password shall be 4–8 characters long. Each system user shall be allowed individual assignment of only those control functions, menu items, and user specific system start display, as well restricted access to discrete BACnet devices to which that user requires access. All passwords, user names, and access assignments shall be adjustable online at the operator's terminal. Users should have the capability to be assigned to specific user type "groups" that can share the same access levels to speed setup. Users who are members of multiple "groups" shall have the ability to activate/deactivate membership to those groups while using the BAS (without logout). Users shall also have a set security level, which defines access to displays and individual objects the user may control. System shall include 10 separate and distinct security levels for assignment to users.
3. System shall include an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.

4. The system shall permit the assignment of an effective date range, as well as an effective time of day, that the User IDs are permitted to authenticate.

E. Operator Activity Log

1. Operator Activity Log that tracks all operator changes and activities shall be included with system. System shall track what is changed in the system, who performed this change, date and time of system activity, and value of the change before and after operator activity. Operator shall be able to display all activity, sort the changes by user and also by operation. Operator shall be able to print the Operator Activity log display.
2. Log shall be gathered and archived to hard drive on operator's workstation as needed. Operator shall be able to export data for display and sorting in a spreadsheet.
3. Any displayed data that is changeable by the operator may be selected using the right mouse button and the operator activity log shall then be selectable on the screen. Selection of the operator activity log using this method shall show all operator changes of just that displayed data.

F. Scheduling

1. Operator's workstation shall show all information in easy-to-read daily format including calendar of this month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority. Priority for scheduling shall be events, holidays and daily, with events being the highest.
2. Holiday and special event schedules shall display data in calendar format. Operator shall be able to schedule holidays and special events directly from these calendars.
3. Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.
4. System shall include a Schedule Wizard for set up of schedules. Wizard shall walk user through all steps necessary for schedule generation. Wizard shall have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting Schedule.
5. Scheduling shall include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and history of previous starts. Each and every individual zone shall have optimum start time independently calculated based on all parameters listed. User shall input schedules to set time that occupied setpoint is to be attained. Optimum start feature shall calculate the startup time needed to match zone temperature to setpoint. User shall be able to set a limit for the maximum startup time allowed.
6. Any displayed data that is changeable by the operator may be selected using the right mouse button and the schedule shall then be selectable on the screen. Selection of the schedule using this method shall allow the viewing of the assigned schedule or launch the Schedule Wizard to allow the point to be scheduled.

G. Alarm Indication and Handling.

1. Operator's workstation shall provide audible, visual, printed, and email means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s) currently running. Printout of alarms shall be sent to the assigned terminal and port. Alarm notification can be filtered based on the User ID's authorization level.
2. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator's terminal. Each entry shall include a description of the event-

initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal, time and date of alarm acknowledgment, and identification of operator acknowledging alarm.

3. Alarm messages shall be in user-definable text (English or other specified language) and shall be delivered either to the operator's terminal, client or through remote communication using email (Authenticated SMTP supported).
4. System shall include an Alarm Wizard for set up of alarms. Wizard shall walk user through all steps necessary for alarm generation. Wizard shall have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting alarm setup.
5. Any displayed data that is changeable by the operator may be selected using the right mouse button and the alarm shall then be selectable on the screen. Selection of the alarm using this method shall allow the viewing of the alarm history or launch the Alarm Wizard to allow the creation of a new alarm.

H. Trendlog Information

1. System server shall periodically gather historically recorded data stored in the building controllers and store the information in the system database. Stored records shall be appended with new sample data, allowing records to be accumulated. Systems that write over stored records shall not be allowed unless limited file size is specified. System database shall be capable of storing up to 50 million records before needing to archive data. Samples may be viewed at the operator's workstation. Operator shall be able to view all trended records, both stored and archived. All trendlog records shall be displayed in standard engineering units.
2. Software that is capable of graphing the trend logged object data shall be included. Software shall be capable of creating two-axis (X, Y) graphs that display up to 10 object types at the same time in different colors. Graphs shall show object values relative to time. Each trendlog shall support a custom scale setting for the graph view that is to be stored continuously. System shall be capable of trending on an interval determined by a polling rate, or change-of-value.
3. Operator shall be able to change Trendlog setup information. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics on which object is displayed.
4. System shall include a Trend Wizard for setup of logs. Wizard shall walk user through all necessary steps. Wizard shall have its own pull-down selection for startup, or may be started by right-clicking on value displayed on graphic, and then selecting Trendlogs from the displayed menu.
5. System shall be capable of using Microsoft SQL as the system database.
6. Any displayed data that is changeable by the operator may be selected using the right mouse button and the trendlog shall then be selectable on the screen. Selection of the trendlog using this method shall allow the viewing of the trendlog view or launch the Trendlog wizard to allow the creation of a new trend.

I. Energy Log Information

1. System server shall be capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files shall be appended with new data,

allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.

2. All data shall be stored in database file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.
3. Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.
4. System shall display archived data in tabular format form for both consumption and peak values. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.

J. Demand Limiting

1. System shall include demand limiting program that includes two types of load shedding. One type of load shedding shall shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding shall adjust operator selected control setpoints in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to system.
2. Binary shedding shall include minimum of five (5) priority levels of equipment shedding. All loads in a given priority level shall be shed before any loads in a higher priority level are shed. Load shedding within a given priority level shall include two methods. In one, the loads shall be shed/restored in a “first off-first on” mode, and in the other the loads are just shed/restored in a “first off-last on” (linear) fashion.
3. Analog shed program shall generate a ramp that is independently used by each individual zone or individual control algorithm to raise the appropriate cooling setting and lower appropriate heating setting to reduce energy usage.
4. Status of each and every load shed program shall be capable of being displayed on every operator terminal connected to system. Status of each load assigned to an individual shed program shall be displayed along with English description of each load.

K. Tenant Activity

1. System shall include program that monitors after-hours overrides by tenants, logs that data, and generates a bill based on usage and rate charged for each tenant space. Tenant Activity program shall be able to assign multiple zones, from a list of every zone connected to system, to a particular tenant. Every zone is monitored for after-hour override usage and that data logged in server. Operator may then generate a bill based on the usage for each tenant and the rate charged for any overtime use.
2. Configuration shall include entry of the following information for use in logging and billing:

    a. Tenant’s contact name and address
    b. One or multiple tenant zones that make up a total tenant space, including a separate billing rate for each separate zone
    c. Minimum and maximum values an event duration and event limit
    d. Property management information
    e. Overall billing rate
    f. Seasonal adjustments or surcharge to billing rate

g. Billing notification type such including, but not limited to printer, file and email
h. Billing form template

3. Logging shall include recording the following information for each and every tenant event:

a. Zone description
b. Time the event begins
c. Total override time
d. Limits shall be applied to override time

4. A tenant bill shall be generated for a specific period using all the entered configuration data and the logged data. User with appropriate security level shall be able to view and override billing information. User shall be able to select a billing period to view and be able to delete events from billing and edit a selected tenant activity event's override time.

L. Reports

1. System server shall be capable of periodically producing reports of trendlogs, alarm history, tenant activities, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.
2. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.

M. Configuration/Setup

1. Provide means for operator to display and change system configuration. This shall include, but not be limited to, system time, day of the week, date of daylight savings set forward/set back, printer termination, port addresses, modem port and speed, etc. Items shall be modified using understandable terminology with simple mouse/cursor key movements.

N. Field Engineering Tools

1. Operator's workstation software shall include all field engineering tools for programming all controllers supplied. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from other types of blocks. Graphical programming that uses simple rectangles and squares is not acceptable.
2. User shall be able to select a graphical function block from menu and place on screen. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.
3. Programming tools shall include a real-time operation mode. Function blocks shall display real-time data and be animated to show status of data inputs and outputs when in real-time operation. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.
4. Field engineering tools shall also include a database manager of applications that include logic files for controllers and associated graphics. Operator shall be able to select unit type, input/output configuration and other items that define unit to be controlled. Supply minimum of 250 applications as part of workstation software.

5. Field engineering tool shall include Device Manager for detection of devices connected anywhere on the BACnet network by scanning of the entire network. This function shall display device instance, network identification, model number, and description of connected devices. It shall record and display software file loaded into each controller. A copy of each file shall be stored on the computer's hard drive. If needed, this file shall be downloaded to the appropriate controller using the mouse.
6. System shall automatically notify the user when a device that is not in the database is added to the network.
7. System shall include backup/restore function that will back up entire system to selected medium and then restore system from that media. The system shall be capable of creating a backup for the purpose of instantiating a new client PC.
8. The system shall provide a means to scan, detect, interrogate, and edit 3rd party BACnet devices and BACnet objects within those devices.

2.2 BUILDING CONTROLLER

A. General Requirements

1. BACnet Conformance

   a. Please refer to paragraph BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

2. Building controller shall be of scalable design such that the number of trunks and protocols may be selected to fit the specific requirements of a given project.
3. The controller shall be capable of panel-mounted on DIN rail and/or mounting screws.
4. The controller shall be capable of providing global control strategies for the system based on information from any objects in the system, regardless if the object is directly monitored by the building controller module or by another controller.
5. The controller shall be capable of running up to six (6) independent control strategies simultaneously. The modification of one control strategy does not interrupt the function or runtime others.
6. The software program implementing the DDC strategies shall be completely flexible and user-definable. All software tools necessary for programming shall be provided as part of project software. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site, using a wide area network (WAN) or downloaded through remote communications are not acceptable. Changing global strategies using firmware changes is also unacceptable.
7. Programming shall be object-oriented using control function blocks and support DDC functions. All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be supplied and be resident on workstation. The same tool shall be used for all controllers.
8. The programming tool shall provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed using the operator's workstation or field computer.
9. Controller shall have 6,000 Analog Values and 6,000 Binary Values.

10. Controller IP configuration can be done via a direct USB connect with an operator's workstation or field computer.
11. Controller shall have at a minimum a Quad Core 996Ghz processor to ensure fast processing speeds.
12. Global control algorithms and automated control functions shall execute using a 64-bit processor.
13. Controller shall have a minimum of 1 GB of DDR3 SDRAM on a 533Mhz bus to ensure high speed data recording, large data storage capacity and reliability.
14. Controller shall support two (2) on-board EIA-485 ports capable of supporting various EIA-485 protocols including, but not limited to BACnet MS/TP and Modbus.

    a. Ports are capable of supporting various EIA-485 protocols including, but not limited to BACnet MS/TP and Modbus.

15. Controller shall support two (2) ports—each of gigabit speed—Ethernet (10/100/1000) ports.

    a. Ports are capable of supporting various Ethernet protocols including, but not limited to BACnet IP, FOX, and Modbus.

16. All ports shall be capable of having protocol(s) assigned to utilize the port's physical connection.
17. The controller shall have at a minimum four (4) onboard inputs, two (2) universal inputs and two (2) binary inputs.
18. Schedules

    a. Building controller modules shall provide normal seven-day scheduling, holiday scheduling and event scheduling.
    b. Each building controller shall support a minimum of 380 BACnet Schedule Objects and 380 BACnet Calendar Objects.

19. Logging Capabilities

    a. Each building controller shall log as minimum 2,000 objects at 15-minute intervals. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
    b. Logs may be viewed both on-site or off-site using WAN or remote communication.
    c. Building controller shall periodically upload trended data to networked operator's workstation for long-term archiving if desired.

        1) Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

20. Alarm Generation

    a. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
    b. Each alarm may be dialed out as noted elsewhere.
    c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.

d. Controller must be able to handle up to 2,000 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

21. Demand Limiting

a. Demand limiting of energy shall be a built-in, user-configurable function. Each controller module shall support shedding of up to 1,200 loads using a minimum of two types of shed programs.
b. Load shedding programs in building controller modules shall operate as defined in this section.

22. Tenant Activity Logging

a. Tenant Activity logging shall be supported by a building controller module. Each independent module shall support a minimum of 380 zones.
b. Tenant Activity logging shall function as defined in section 2.1.K of this specification.

B. BACnet MS/TP

1. BACnet MS/TP LAN must be software-configurable from 9.6 to 115.4Kbps

a. Each BACnet MS/TP LAN shall support 64 BACnet devices at a minimum.
b. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. BACnet IP

1. The building controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the local area network (LAN).
2. Must support interoperability on WANs and campus area networks (CANs), and function as a BACnet Broadcast Management Device (BBMD).
3. Each controller shall support at a minimum 128 BBMD entries.
4. BBMD management architecture shall support 3,000 subnets at a minimum.
5. Shall support BACnet Network Address Translation.
6. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

D. Expansion Ports

1. Controller shall support two (2) expansion ports.

a. Combining the two on-board EIA-458 ports with fully loaded expansion ports, the controller shall support six (6) EIA-485 trunks simultaneously.

2. Expansion cards that mate to the expansion ports shall include:

a. Dual port EIA-485 card.
b. LON network card.

E. Power Supply

1. Input for power shall accept between 17 and 30VAC, 47 and 63Hz.
2. Optional rechargeable battery for shutdown of controller including storage of all data in flash memory.
3. On-board capacitor will ensure continuous operation of real-time clocks for minimum of 14 days.

F. Controller shall be in compliance with the following:

1. UL 916 for open energy management
2. FCC Class B
3. ROHS
4. IEC 60703
5. C-Tick Listed

G. Controller shall operate in the following environmental conditions:

1. -4 to 149 degrees F without optional battery, or 32 to 122 degrees F with optional battery.
2. 0 to 95% relative humidity (RH), non-condensing.

2.3 CENTRAL PLANT AND AIR HANDLER APPLICATION CONTROLLERS

A. Provide one or more native BACnet application controllers for each air handler and provide native BACnet application controllers as needed for central plant control that adequately cover all objects listed in object list. All controllers shall interface to building controller through either MS/TP LAN using BACnet protocol, or Ethernet LAN using BACnet over Ethernet or BACnet TCP/IP. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-BACnet controllers shall be used.

B. BACnet Conformance

1. Application controllers shall be approved by the BTL as meeting the BACnet Application Controller requirements.
2. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Multi-state Values, Device, File, and Program object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 12-bit resolution that accept 3K and 10K thermistors, 0–10VDC, Platinum 1000 ohm RTD, 0–5VDC, 4–20mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of three inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs with 12-bit resolution shall support either 0–10VDC or 0–20mA. Binary outputs shall have LED indication of status. Software shall include scaling features for analog outputs. Application controller shall include 20VDC voltage supply for use as power supply to external sensors.

D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller up to 20 times per second (minimum of 10 times per second) and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator's terminal.

1. The following control blocks shall be supported:

    a. Natural Log
    b. Exponential
    c. Log base 10
    d. X to the power of Y
    e. Nth square root of X
    f. 5th Order Polynomial Equations
    g. Astronomical Clock (sunrise/sunset calculation)
    h. Time based schedules

E. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator's terminal section.

F. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode, based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

G. Schedules

1. The controller shall support a minimum of 3 BACnet Schedule Objects and have a real time clock on board with battery backup to maintain time through a power loss.

H. Logging Capabilities

1. Controller shall support a minimum of 50 trendlogs. Any object in the controller (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.

2. Controller shall periodically upload trended data to system server for long-term archiving if desired. Archived data stored in (MS Jet Database or SQL) database form and shall be available for use in third-party spreadsheet or database programs.

I. Alarm Generation

1. Alarms may be generated within the controller for any object change of value or state (either real or calculated). This includes things such as analog object value changes, and binary object state changes.
2. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
3. Controller must be able to handle up to 25 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

J. The controller processor shall be a 32-bit processor.

K. The packaging of the controller shall provide operable doors to cover the terminals once installation is complete. The housing of the controller shall provide for DIN rail mounting and also fully enclose circuit board.

2.4 TERMINAL UNIT APPLICATION CONTROLLERS (HEAT PUMPS, AC UNITS, FAN-COILS) - VLC

A. Provide one native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

B. BACnet Conformance

1. Application controllers shall, as a minimum, support MS/TP BACnet LAN types. They shall communicate directly using this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device and must be hardwired (wireless communication is not acceptable). Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements and support all BACnet services necessary to provide the following BACnet functional groups:

    a. Files Functional Group
    b. Reinitialize Functional Group
    c. Device Communications Functional Group

2. Please refer to Section 22.2, BACnet Functional Groups in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be

thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

D. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.

E. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

F. Controller must provide Economizer Fault Detection and Diagnostics (FDD) as required by Building Energy Efficiency Standards - Title 24 2013. Controller must be approved and listed on California Energy Commission (CEC) website under Fault Detection Diagnostic System Declaration List (no exception).

2.5 VAV BOX CONTROLLERS - SINGLE DUCT

A. Provide one native BACnet application controller for each VAV box that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include on board CFM flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.

B. BACnet Conformance

1. Application controllers shall, at a minimum, support MS/TP BACnet LAN types. They shall communicate directly through this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device and must be hardwired (wireless communication is not acceptable). Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements.
2. Please refer to Section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller shall include microprocessor driven flow sensor for use in pressure independent control logic. All boxes shall be controlled using pressure-independent control algorithms and all flow readings shall be in CFM (LPS if metric).

D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using the same programming tool as Building Controller and as described in operator's workstation section. All programming tools shall be provided as part of system.

E. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operations for specific display requirements for intelligent room sensor.

F. On board flow sensor shall be microprocessor-driven and pre-calibrated at the factory. Pre-calibration shall be at 16 flow points as a minimum. All factory calibration data shall be stored in non-volatile memory. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. All calibration parameters shall be adjustable through intelligent room sensor. Operator's workstation, portable computers, and special hand-held field tools shall not be needed for field calibration.

G. Provide duct temperature sensor at discharge of each VAV box that is connected to controller for reporting back to operator's workstation.

H. VAV controller shall not require reset and synchronization of actual damper position. An automatically initiated function to reset volume regulator damper to fully closed position is not allowed.

2.6 AUXILIARY CONTROL DEVICES

A. Temperature Sensors

1. All temperature sensors to be solid-state electronic, interchangeable with housing appropriate for application. Wall sensors to be installed as indicated on drawings. Mount 42 inches above finished floor. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells provided by control contractor, but installed by mechanical contractor. Immersion wells shall be filled with thermal compound before installation of immersion sensors. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake, and in a location that is in the shade most of the day.

B. Intelligent Room Sensor with LCD Readout

1. Hardware

a. Room sensor shall include:

1) Backlit touchscreen digital display (If Specified)
2) Setpoint Control (If Specified)
3) Programmable Override Button (If Specified)
4) Temperature sensor
5) Humidity sensor (If Specified)
6) Programmable Status Light indicator (If Specified)
7) CO2 sensor (If Specified)
8) BACnet MS/TP communication up to 115.2kbps (If Specified)

b. Temperature sensor shall be a Uni-Curve Type II thermistor with an accuracy of +/- 0.36 degrees F at calibration point over the range of 32 to 116 degrees F or better.
c. Humidity sensor shall have an accuracy of +/-3% from 10 to 90% relative humidity (RH) or better, non-condensing.
d. The intelligent room sensor's Status Light indicator shall have a minimum of four (4) colors (blue, red, amber and green) that will cast a glow onto the wall below the sensor to be used as visual indicator to the occupants of the condition of the system. The color and on/off state of the Status Light indicator shall be fully programmable.

1) Red LED shall be used to locally identify Economizer Fault Detection and Diagnostics (FDD) fault as required by Building Energy Efficiency Standards - Title 24 2013.

e. CO2 sensor shall have an accuracy of +/- 30 ppm over the range of 0–5000 ppm or better.
f. CO2 sensor shall utilize Automatic Baseline Correction to maintain sensor calibration without the need for manual calibration.
g. The user shall interact with the smart sensor using a touchscreen, with no buttons allowed.
h. The intelligent room sensor shall have provisions for a tamper proof installation requiring tools to be removed from the wall.
i. The touchscreen shall have a surface hardness of Mohs 7 or greater to prevent being easily scratched.
j. Controller shall function as room control unit, and allow occupant to raise and lower setpoint, and activate terminal unit for override use—all within limits as programmed by building operator.

k. The sensor must be hardwired to a DDC controller (wireless communication is not acceptable).

2. Display Content

a. The intelligent room sensor shall simultaneously display room setpoint, room temperature, and outside temperature at each controller.
b. The intelligent room sensor shall have the ability to add or remove from the display time-of-day, room humidity, and indoor air temperature to customize the view for the customer.
c. The intelligent room sensor must have the capability to show temperatures in degrees Fahrenheit or degrees Celsius.
d. A communication loss or improper communications wiring shall be displayed on the LCD screen to aid in trouble shooting.
e. Information about the version of firmware shall be displayable on the LCD screen.
f. A cleaning mode will be provided to allow for the touchscreen to be cleaned without inadvertently making changes to system parameters.
g. The intelligent room sensor shall have the ability to display the status of a lighting zone and control the on/off state of the zone from the touchscreen using a tenant-accessible display page.
h. The intelligent room sensor shall have the ability to display the status of a window zone (e.g., blinds) and control the on/off state of the zone from the touchscreen using a tenant-accessible display page.
i. After Hours Override shall:

1) Override time may be set and viewed in 30-minute increments.
2) Override time countdown shall be automatic, but may be reset to zero by occupant from the sensor.
3) Time remaining shall be displayed.
4) Display shall show the word “OFF” in unoccupied mode unless a function button is pressed.

3. Other Modes

a. The intelligent room sensor shall also allow service technician access to hidden functions for advanced system configuration. This functionality shall be accessed-protected with a configurable PIN number.
b. Field Service Mode shall allow access to common parameters as dictated by the application’s sequence of operations. The parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.
c. If the intelligent room sensor is connected to VAV controller, Balance Mode shall allow a VAV box to be balanced and all air flow parameters viewed. The balancing parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.

4. Intelligent Room Sensor shall be in compliance of the following:

a. UL Standard for Safety 916
b. FCC Part 15.107 & 109, Class B, CFR47-15
c. EMC Directive 89/336/EEC (European CE Mark)

C. Wall Sensor (Non-Hazardous Area)

1. Standard wall sensor shall use solid-state sensor identical to intelligent room sensor and shall be packaged in aesthetically pleasing enclosure. Sensor shall provide override function (if specified), warmer/cooler lever for set point adjustment (if specified). Override time shall be stored in controller and be adjustable on a zone-by-zone basis. Adjustment range for warmer/cooler lever shall also be stored in EEPROM on controller. Provide with NIST Certificates. (If specified)

D. D.Combo Temperature & Humidity Duct Sensor (NEMA 4X)

1. Provide NEMA 4X Combination Room or Duct 10K, Type 2 Thermistor Temperature Sensor with +/- 2% Humidity Sensor with NIST Certificates where specified on drawings.

E. Hazardous Explosion Proof Sensor

1. Provide Hazardous location Room, Duct or Immersion 10K, Type 2 Thermistor temperature sensor with heavy duty Feraloy Iron or Aluminum as required per room environmental conditions. Provide with NIST Certificates.

F. Intrinsically Safe Temperature & Humidity Transmitter Sensor

1. Provide Vaisala HMT370EX sensor for operation in up to Zone 0 / 20. Temperature Range -94 to +356 F. Provide with graphical LCD display and traceable calibration certificate. See plans for locations.

2.7 2.7 MISCELLANEOUS CONTROL DEVICES

A. General:

1. Provide sensors and control devices, as specified, indicated on mechanical plans, control flow diagrams and as required to meet specified performance. Where performance specifications exceed capabilities of hardware specified, performance governs.
2. Equip analog sensors with thermistors or 4 to 20 milliamp transmitters with built-in circuit protection against reverse polarity and supply voltage transients. The thermistors and transmitters shall be compatible with the DDC System.
3. All sensor wiring, analog or digital, input or output shall be capable of sharing single conduit runs without affecting signal performance.
4. The sensor range and type shall be suitable to the application.
5. Minimum contact rating of relays and switches shall be 10 amperes, 110 volts resistive.
6. Devices shall be UL listed for electrical safety where applicable.
7. All components of sensors exposed to process shall be rated to withstand 150 percent of maximum process temperature and pressure.
8. Thermowells shall have extension for pipe insulation and threaded connection to pipe. Threaded connection shall be a minimum of ½-inch nominal pipe thread. Maximum insertion length shall be 6 inches or 75 percent of the pipe diameter whichever is smaller.

B. Humidity Sensors:

1. Humidity sensor assemblies shall consist of a capacitive or bulk polymer type sensor and a solid state four to twenty milliamp transmitter protected in a housing suitable for the environment where it is installed.
2. Provide low profile sensor housing 1-inch diameter by 0.35-inch thick.
3. Provide cable to transmitter as required. Locate transmitter in an accessible location.
4. Humidity Sensor shall have a digital display.
5. Acceptable manufacturers: ACI, Veris, Senva.

C. Flow Transmitter Assembly – Water (Insertion Electromagnetic):

1. Meter device shall be Insertion Electromagnetic element flow station set supplied by one manufacturer. Measuring station shall be stainless steel complete with full port shutoff ball valves and quick coupling connections and a permanent metal tag showing designated flow rates, meter readings for designed flow rates, metered fluid, line size and tag, station or location number.
2. Stations shall be either nipple section or weld insert type and be rated to 400 psi at 280 degrees F. Sensing elements shall be able to be rotated.
3. Output: Meter shall have (2) outputs; 4 to 20 milliamps or 0 to 10 volts DC. Provide 10 feet of plenum rated cable.
4. Supply Voltage: 24-volt AC/DC at 100 milliamps.
5. Pressure Drop: Maximum 1 psi for 2-1/2-inch pipe size, and decreasing for larger pipe sizes.
6. Repeatability: 0.2 percent.
7. Accuracy: +/- 1.0% of reading
8. Acceptable Manufacturers: Onicon F-3400

D. Pressure Transmitter Assembly – Air Streams:

1. The assembly shall consist of a pressure sensor and a solid-state, 2-wire, 4- to 20-milliamp transmitter contained in a housing suitable for duct mounting.
2. The assembly shall be factory calibrated and field installed to an accuracy of plus or minus 0.05 inches water gauge over a range of 0 to 4 inches water gauge.
3. Probe: 6-inch pitot tube, brass.
4. Pressure Transmitter shall have a digital display.
5. Acceptable Manufacturers: ACI, Veris, Senva

E. Differential Pressure Transmitter Assembly – Water:

1. Assembly shall consist of a differential pressure sensor and an electronic 2-wire, 4 to 20-milliamp transmitter assembly enclosed in a gasketed, dust and watertight case. All body cavities open to the process fluid shall be provided with drain ports at the cavity bottom and vent ports at the top of the cavity. Both drain and vent ports shall be minimum ¼-inch nominal pipe thread.
2. The transmitter shall be 24-volt DC powered and capable of sustaining up to 50 psig differential pressures in either direction, up to the body rating without damage of the instrument, loss of accuracy, or zero shift. Minimum pressure rating: 200 psig.
3. The transmitter shall be fully compensated for both process and ambient temperature variations. The transmitter shall be furnished complete with input gauges and factory mounted 3-valve manifold.
4. Accuracy: plus or minus 1 percent of full range.
5. Repeatability: 0.5 percent.

6. Pressure Transmitter shall have a digital display.
7. Acceptable Manufacturers: ACI, Veris, Senva

F. Demand Control Ventilation Sensor

1. CO2 Sensors and Transmitters: Provide a self-compensating, CO2 transmitter with an industry standard, 4-20 ma output signal. Measurement range to be 0 to 2000 ppm with an accuracy of □ 20ppm + 1 percent of reading and a stability of <5 percent in 5 years. Locate the sensors to be as shown on the drawings.
2. CO2 Sensor to have digital display.
3. Acceptable Manufacturers: ACI, Veris, Senva

G. Current Sensing Switches:

1. Current switches shall be utilized for monitoring motor operation. Switch set point shall be fixed so that a contact closure is made any time the motor is operating within a range of .15-200 amps. Induced current from the motor power feed shall power current switch. Current switch shall be a self-gripping split-core type with optional mounting bracket; shall be isolated to 600 VAC rms, shall have an adjustable mounting bracket for installation flexibility. Output shall be N.O. Solid State, 1.0A @ 30VAC/DC with a minimum aperture of 0.5”x0.6” for motor power feed.
2. Acceptable Manufacturers: ACI, Veris, Senva

H. Differential Pressure Switch – Air:

1. Provide diaphragm operator to actuate a single-pole double-throw snap-acting switch. Operating point shall be adjustable. Range shall suit application.
2. High and low sensing ports shall be 1/8-inch nominal pipe thread connected to angle type tips designed to sense pressure.
3. Switches used for fan shutdown shall be manual reset type.
4. Acceptable Manufacturers: Cleveland Controls or acceptable equal.

I. Low Limit Thermostat:

1. Shall have a minimum 12-foot flexible vapor charged element.
2. When temperature sensed by any 12-inch segment of the element falls below setpoint (usually 35 degrees F), thermostat shall operate double-pole double-throw manual reset contacts.

J. Automatic Dampers:

1. Provide automatic dampers where indicated on Drawings and not included with equipment.
2. Dampers shall be low leakage type, with published AMCA certified leakage data. Leakage through a 48-inch by 48-inch damper at 4 inches water gauge pressure difference shall be less than 6.2 cubic feet per minute per square foot of damper.
3. Damper blades and frames shall be fabricated from extruded aluminum, reinforced for rigidity. Blades shall be of airfoil design with full-length edge seals with inflatable pockets to enable air pressure from either direction to assist in blade seal off. Edge seals shall be mechanically locked to the blades locked without the use of cement but easily replaceable in the field. Edge seal material shall meet all local codes and requirements of city officials. Bearings shall be non-corrosive and axles shall provide positive locking connection to

blades and linkage. Blades mounted vertically shall be supported by thrust bearings. Jamb seals shall be aluminum, flexible compression type.

4. Dampers used for modulating control application shall be of opposed blade configuration and dampers used for open/closed applications shall be parallel blade type.
5. Dampers shall have a maximum blade length of 48 inches and a maximum blade width of 8 inches. The maximum height of each damper section shall be 72 inches. Where greater length or height is required, provide an assembly of multiple damper sections.
6. Install damper actuators of sufficient quantity and size to limit leakage to specified rate. Damper assemblies consisting of multiple damper sections shall be provided with a minimum of one damper actuator per section or be connected with an approved jack-shafting arrangement.
7. Acceptable Manufacturers: Ruskin, Honeywell, Greenheck.

K. Automatic Valves:

1. Automatic control valves shall be ball or globe valve type with modulating plug, throttling guides, replaceable seats and discs, and stainless steel stems as required.
2. Valves 2-inch and smaller shall have bronze bodies with screwed ends. Valves 2½-inch and larger shall have iron bodies with flanged ends.
3. Valve body rating shall be equal or greater than the piping in which it is installed and the valve shall be rated for operation against the minimum system differential pressure.
4. Chilled Water Service: Equal percentage flow characteristics, single seated type.
5. Isolation Service: Linear flow characteristics. Single or double seated.
6. Cooling valves normally closed. Or as noted or specified.
7. Size valves to meet the coil loads as specified and as follows:
8. 2-Position Valves: Line size unless noted.
9. Water Service: Maximum pressure drop shall be equal to the pressure drop of the associated coil or exchanger, or 5 pounds per square inch whichever is greater.
10. Cooling Tower Bypass Valves: Sized according to pressure available.

L. Acceptable Manufacturers: Belimo.

1. Automatic Electric Damper/Valve Actuators
2. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
3. Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing.
4. All rotary spring-return actuators shall be capable of both clockwise and counter-clockwise spring-return operation. Linear actuators shall spring-return to the retracted position.
5. Proportional actuators shall accept a 0- to 10-volt DC or 0- to 20-milliamp control signal and provide a 2- to 10-volt DC or 4- to 20-milliamp operating range.
6. All 24-volt AC/VDC actuators shall operate on NEC Class 2 wiring and shall not require more than 10 volt-amps for AC or more than 8 watts for DC applications. Actuators operating on 120 volts AC or 230 volts AC shall not require more than 11-volt-amps.
7. All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 60 inch-pounds torque capacities shall have a manual crank for this purpose.
8. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

9. Actuators shall be provided with a raceway fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
10. Actuators shall be UL Standard 873 Listed and CSA Class 4813 02 Certified as meeting correct safety requirements and recognized industry standards.
11. Actuators shall be designed for a minimum of 60,000 full-stroke cycles at the actuator's rated torque.
12. Actuators shall have visual mechanical position indication, showing output shaft and valve position. The actuator shall be capable of operating the valve from the fully closed to the fully open position and vice versa in less than 60 seconds.
13. Acceptable Manufacturers: Belimo.

2.8 Butterfly Valves

1. All butterfly valves shall be of the full lug body style with lugs drilled and tapped and have drip tight shutoff capabilities in either direction up to and including maximum system working pressure. Butterfly valves shall be capable of closing tight after long periods of inactivity.
2. All valves shall be suitable for use with ANSI Standards flanges. Bodies shall be semi-steel or cast iron.
3. Valves shall provide tight shutoff up to the full valve rating on dead end or isolation service without the use of downstream flanges.
4. All valves shall be furnished with self-lubricated bronze bearings. Shafts seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion.
5. Discs shall be semi-steel with welded nickel edge. The disc-to-shaft connections shall be type 316 stainless steel. Pins, shaft and disc of all valves shall be individually machined and completely interchangeable.
6. Valves shall be line size unless otherwise noted on Drawings.
7. Acceptable Manufacturers: Belimo.

2.9 ENCLOSURES

A. All controllers, power supplies and relays shall be mounted in enclosures.

B. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment.

C. Enclosures shall be NEMA 3R when installed in outdoor locations.

D. Enclosures shall have hinged, locking doors.

E. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 0.125 inches thick and appropriately sized to make label easy to read. Identify each item of control equipment with stamped tape firmly attached to equipment and each panel with nameplate of 1/16 inch laminated plastic with black background and white letters 1/4 inch high.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the owner's representative in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 INSTALLATION (GENERAL)

A. All panel fabrication and panel control wiring for temperature control panels shall be done by authorized representative of the controls manufacturer whose primary business is BACnet System Provider (BSP).

B. All field control wiring and conduit for temperature control and indicating systems shall be done by BACnet System Installer (BSI) in coordination with BSP. Wiring shall conform to National Electric Code.

C. Provide all miscellaneous devices, hardware, software, interconnections, installation, and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

D. The installation and supervision of this project shall be carried out experienced temperature control personnel who are directly employed by the BSI Contractor.

3.3 LOCATION AND INSTALLATION OF COMPONENTS (BSI)

A. Locate and install components for easy accessibility; in general, mount 42 inches above floor with minimum 3 feet of clear access space in front of units. Obtain approval on locations from owner's representative prior to installation.

B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture, and high or low temperatures.

C. Identify all equipment and panels. Provide permanently mounted tags for all panels.

D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections, and sized to suit pipe diameter without restricting flow.

3.4 INTERLOCKING AND CONTROL WIRING (BSI)

A. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 26 and all national, state and local electrical codes.

B. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for all communications trunks.

C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the owner's representative prior to rough-in.

D. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings; coordinate with electrical contractor.

E. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways. All other wiring to be installed neatly and inconspicuously per local code requirements. If local code allows, control wiring above accessible ceiling spaces may be run with plenum-rated cable (without conduit) including proper cable supports.

3.5 DDC OBJECT TYPE SUMMARY (BSP)

A. Provide all database generation.

B. Displays

1. System displays shall show all analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.

C. Run Time Totalization

1. At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for each point shall be entered for alarm and or maintenance purposes.

D. Trendlog

1. All binary and analog object types (including zones) shall have the capability to be automatically trended.

E. Alarm

1. All analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.

F. Database Save

1. Provide backup database for all standalone application controllers on disk.

3.6 FIELD SERVICES

A. Prepare and start logic control system under provisions of this section.

B. Start-up all BACnet DDC Control System components provided under this section. Allow sufficient time for startup and pre-functional testing (if specified) prior to placing control systems in permanent operation.

C. Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line or Remote Desktop connection for this service for one year or as specified.

3.7 AS-BUILT DOCUMENTATION REQUIRED

A. Provide all as-built documentation specified in this section and the general conditions.

3.8 TRAINING

A. Initial Training – Provide 16 hours of on-site customer training to familiarize owner personnel with new controlled equipment on existing Alerton System.

3.9 DEMONSTRATION

A. Demonstrate complete operating system to owner's representative.

B. Provide certificate stating that control system has been tested and adjusted for proper operation.

END OF SECTION 230900