SECTION 23 09 23 - DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

WORK INCLUDED

Furnish a totally native BACnet-based system. 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 135-2001, BACnet. In other words, all workstations and controllers, including unitary controllers, shall be native BACnet devices. 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.

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.

All controls are to be provided and mounted and wired in the field. Factory supplied controls are not acceptable.

Coordinate with Electrical Contractor who is to furnish and install conduit, wire, branch circuit protection, etc. as required to bring 120 VAC power to control panel locations and equipment (actuators, sensors, control devices, etc.) as shown on the drawings and described in the specifications.

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.

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

Furnish all interconnecting cables between supplied cabinets, application controllers, and input/output devices.

Furnish all interconnecting cables between all operator's terminals and peripheral devices supplied under this section.

Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.

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

Provide a comprehensive operator and technician training program as described herein.

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 of which accurately represents the final system.

Furnish and install a complete sensor, actuator, wiring and piping system for all air handling and related equipment as shown on the plans and specified in this section. Install all necessary sensors and actuators as required by the plans and specifications and equipment schedules. No used components shall be used as any part of or piece of installed system, unless approved by Owner.

Commissioning according to commissioning specification, if required by Owner.

All line drivers, signal boosters, and signal conditioners etc. shall be provided as necessary for proper data communication.

Coordination as required with other sections of the specification for the proper and complete installation of the wiring and tubing system, control devices, dampers, valve, actuators, etc.

Furnish and install Direct Digital Control Equipment (DDC) as required by the point list, plans, and specifications including, control units, software, database development, check-out, and debugging. Provide points necessary for a complete and operable system.

Install the sequence of operations specified in the drawings and in this section.

Software testing requirements shall include testing in the field of all logic sequences including actual simulation of different processes and events and observing program response to the process or event. All deviations from the requirements of the sequence as specified on the drawings or this specification shall be corrected immediately at no additional cost to the Owner.

Provide documentation of software system testing before acceptance testing.

Provide staff for acceptance testing procedures. Modify hardware and software errors/problems at no additional cost to the Owner.

Setup trending data before and after system acceptance.

Attend a series of meetings with the Engineer and Owner to agree on system setup and operating parameters.

Provide detailed documentation of system configuration including control units and all control devices.

SYSTEM DESCRIPTION

A distributed logic control system complete with all software and hardware functions shall be furnished. System shall be completely based on ANSI/ASHRAE Standard 135-2001, BACnet. 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.

Operator's workstation software shall be current Microsoft Windows operating system. The Building Automation System (BAS) application program shall be written to communicate specifically utilizing BACnet protocols. Software shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, after-hours billing program, demand limiting, full suite of field engineering tools including graphical programming and applications. System using operating systems other than that described above are strictly prohibited.

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. Operators terminal software is to be used for access to field-based energy management functions only. Provide zone-by zone direct digital logic control and space temperature, scheduling, runtime accumulation, equipment alarm reporting and override timers for after-hours usage.

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 via BACnet LAN.

APPROVED MANUFACTURERS

The base bid shall be the BACtalk system from Alerton Technologies, Inc.

QUALITY ASSURANCE

Responsibility: The supplier of the BAS shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished.

Component Testing: Maximum reliability shall be achieved through extensive use of high- quality, pre-tested components. Every controller, sensor, and all other DDC components shall be individually tested by the manufacturer prior to shipment.

Tools, Testing, and Calibration Equipment: The BAS supplier shall provide all tools, testing, and calibration equipment necessary to ensure reliability and accuracy of the system.

The systems control Contractor shall have been in business of minimum of five years and be authorized installing Contractor for the manufacturer of the BACnet components.

Control system shall be engineered, programmed and supported completely by representative's local office that must be within 75 miles of project site.

REFERENCE STANDARDS

The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

ANSI/ASHRAE Standard 135-2001, BACnet

Uniform Building Code (UBC), including local amendments.

UL 91d Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.

National Electrical Coe (NEC).

FCC Part 15, Subpart J, Class A

EMC Directive 89/336/EEC (European CE Mark)

City, County, State, and Federal regulations and codes in effect as of contract date.

Except as otherwise indicated the system supplier shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.

SUBMITTALS

Drawings

The system supplier shall submit engineering Drawings, control sequence, and bill of materials for approval.

Drawings shall be submitted in the following standard sizes: 11" x 17" (ANSI B).

Four complete digital sets (or as determined by Owner) of submittal drawings shall be provided.

Drawings shall be available on CD-ROM.

System Documentation. Including the following in submittal package:

System configuration diagrams in simplified block format.

All input/output object listings and an alarm point summary listing.

Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.

Complete bill of materials and valve schedule.

Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.

Overall system operation and maintenance instructions- including preventive maintenance and troubleshooting instructions.

For all system elements- building controller(s), application controllers, routers, and repeaters, provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.

Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.

A list of all functions available and a sample of function block programming that shall be part of delivered system.

Project Management

The vendor shall provide a detailed project design and installation schedule integrated with the General Contractor's schedule. Provide coordination as required for all construction phases.

WARRANTY

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

Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday-Friday, 48 hours on Saturday and Sunday.

This warranty shall apply equally to both hardware and software.

RELATED WORK IN OTHER SECTION

Refer to Division 0 and Division 1 for related contractual requirements.

Refer to Section 23 05 00 for General Mechanical Provisions

Refer to Section 26 05 00 for General Electrical Provisions

PART 2 - PRODUCTS

OPERATOR'S WORKSTATION

The operator's workstation and printer shall be provided by the Owner.

Displays

Graphics displays are to be coordinated with Owner and to comply with the attached, approved displays from the Owner.

Operators 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 or field installation drawings and wiring diagrams from as-built drawings. Operators 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 BAS functions associated with the projects, 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/pneumonic indications.

AH displays, and programming shall be generated and customized by the local BAS supplier and installer. Systems requiring factory programming for graphics or DDC logic are specifically prohibited.

Binary objects shall be displayed as ACTIVE/INACTIVE/NULL or with customized text. 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 a graphic of a switch or light, for example, which then displays a different graphic (such as an "OFF" switch or lighted lamp). Additionally, allow binary objects to be displayed as 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 on an animated graphical objector to switch it from the OFF position to ON, or ON to OFF. Allow operator to change graphic file assignment and 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.

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 trend-logs.

Analog objects may also be assigned to an area of a system graphic, where the color of the defined area changes based on the analog object's value. For example, an area of a floor-plan graphic served by a single control zone would change color with respect to the temperature of the zone or it's deviation from setpoint. All editing and area assignment shall be creating or modified outline using simple icon tools.

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 push buttons 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.

A mouse shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.

Password Protection

Provide security system, according to district standard, 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.

Each operator's terminal shall provide security for 200 users minimum. 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 and menu items to which that user requires access. All passwords, user names, and access assignments shall be adjustable online at the operator's terminal. Each user 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.

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.

Operator Activity Log

Operator Activity Log shall be included with system that tracks all operator changes and activities. 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 by operation.

Log shall be gathered and archived to hard drive on operator workstation as needed. Operator shall be able to export data for display and sorting in a spreadsheet.

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.

Scheduling

Schedules shall be constructed according to district standard.

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 events being the highest.

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.

Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

System shall include a Schedule Wizard for setup of schedules. Wizard shall walk user through all steps necessary for schedule generation. Wizard shall have its own pull down selection for startup or maybe started by right clicking on value displayed on graphic and then selecting Schedule.

Scheduling shall include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and history of previous starts. Every individual zone shall have optimum start time independently calculated based on all parameters listed. User shall input schedules to set time that occurred 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.

Alarm Indication and Handling

Operator's workstation shall provide audible, visual, and printed 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.

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.

Alarm messages shall be in user definable text (English or other specified language) and shall be entered either at the operator's terminal or via remote communication.

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.

Provide email alarm for boiler failure only.

Trend-Log Information

System server shall periodically gather historically recorded data stored in the building controllers and archive the information. Archived file shall be appended with new sample data, allowing samples to be accumulated. Systems that write over archived data shall not be allowed, unless limited file size is specified. Samples may be viewed at the operator's workstation. Operator shall be able to scroll through all trended data. All trend-log information shall be displayed in standard engineering units.

Software shall be included that can graph the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to ten object types at the same time in different colors. Graphs shall show object values relative to time.

Operator shall be able to change trend log 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.

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 trend logs from the displayed menu.

Energy Log Information (When Specifically Required by Owner)

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.

All data shall be stored in data base file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.

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 sensor for BTU monitoring.

System shall display archived data in tabular format 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.

Demand Limiting (When Specifically Required by Owner)

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 every zone or piece of equipment connected to system.

Binary shedding shall include minimum of 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 linear fashion.

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.

Status of 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.

Configuration/SetUp

Provide means for operator to display and change system configuration. This shall include, but not 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.

Software

At the conclusion of project, Contractor shall leave with Owner a CD ROM that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This back up shall allow the Owner to completely restore the system in the case of computer malfunction.

BUILDING CONTROLLER

General

All communication with operator workstation and all application controllers shall be via BACnet. Building controller shall incorporate as a minimum, the functions of a 3-way BACnet router. Controller shall route BACnet messages between the high -speed LAN (Ethernet 10/100MHz), master slave token passing (MS/TP) LANs, a point-to-point (PTP-RS-232) connection and modem.

Each MS/TP LAN must be software configurable from 9.6 to 76.8Kbps.

The RJ-45 Ethernet connection must accept either I 0 Base-T or 100 Base-TX BACnet other twisted pair cable (UTP).

The direct access port must be a female DB-9 connector supporting BACnet temporary PTP connection of a portable BACnet operator terminal at 9.6 to 115.2 Kbps over RS-232 null modem cable.

Building 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 controller or by another controller. The program that implements these strategies shall be completely flexible and user definable. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site or downloaded via remote communications are not acceptable. Changing global strategies via firmware changes is also unacceptable.

Programming shall be object-oriented using control function blocks, supporting DDC functions, 1000 Analog Values and 1000 Binary Values. All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be resident on workstation and the same tool used for all controllers.

Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed via the operator's workstation or field computer.

Building controller shall provide battery-backed real-time (hardware) clock functions.

Controller shall have a memory needed to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1.5 years (cumulative).

Global control algorithms and automated control functions should execute via 32-bit processor.

Controller installation shall include memory-free gel-cell battery providing ongoing power conditioning and noise filtering for operation data integrity. It shall provide up to 5 minutes of powerless operation for orderly shutdown and data backup.

BACnet Conformance

Building Controller shall as a minimum support Point-to-Point (PTP), MS/TP and Ethernet BACnet LAN types. It shall communicate directly via these BACnet LANs as a native BACnet device and shall support simultaneous routing functions between all supported LAN types. Global controller shall be a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:

Clock Functional Group

Files Functional Group

Reinitialize Functional Group

Device Communications Functional Group

Event Initiation Functional Group

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.

Standard BACnet Object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notifications 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.

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 LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs) and function as a BACnet broadcast Management Device (BBMD).

Schedules

Each building controller shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.

Logging Capabilities

Each building controller shall log as a minimum 1000 trend-logs. Any object in the system (real or calculated) may be logged. Sample interval shall be adjustable at the operator's workstation.

Logs may be viewed both on-site or off-site via remote communication.

Building controller shall periodically upload trended data to networked operator's workstation for long term archiving if desired.

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

Alarm Generation

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.

Each alarm may be dialed out as noted in paragraph 2 above.

Alarm log shall be provided for alarm viewing. Log may be viewed on site at the operator's terminal or off-site via remote communications.

Controller must be able to handle up to 1500 alarm setups stored as BACnet event enrollment objects- system destination and actions individually configurable.

CENTRAL PLANT AND AIR HANDLER APPLICATION CONTROLLERS

BACnet Application Controllers

Provide one or more native Banet 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 via 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 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.

BACnet Conformance

Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4, 7d.8 Kbps, as native BACnet devices. Application controllers shall be of BACnet conformance class 3 support all BACnet services necessary to provide the following BACnet functional groups:

Files Functional Group

Reinitialize Functional Group

Device Communications Functional Group

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.

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.

BACnet Inputs

Application controllers shall include universal inputs with 10-bit resolution that accept 3K and 10K thermistors, 0-10 VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of 3 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 shall be switch selectable as either 0-10 VDC, or 0-20 mA. Software shall include scaling features for analog outputs. Application controller shall include 24 VDC voltage supply for use as power supply to external sensors.

BACnet Sequences

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 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. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via 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.

BACnet Intelligent Room Sensors

Application controller shall include support for intelligent room sensor (see section 2.9.B). Display on intelligent rooms sensor shall be programmable at application controller and include an operating mode and field service mode. All button functions and display data shall be programmable to how 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.

TERMINAL UNIT APPLICATION CONTROLLERS (HEAT PUMPS, AS UNITS, FAN COILS)

BACnet Application Controller

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 via 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.

BACnet Conformance

Application controllers shall as a minimum support MSTP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4, and 76.85 Kbps, as a native BACnet device. Application controller's shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:

Files Functional Group

Reinitialize Functional Group

Device Communications Functional Group

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.

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.

BACnet Universal Inputs

Application controllers shall include universal inputs with 10-bit resolution that accept 3K and 10K thermistors, 0-10 VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of 3 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 shall be switch selectable as either 0-10 VDC or 0-20 mA. Software shall include scaling features for analog outputs. Application controller shall include 24 VDC voltage supply for use as power supply to external sensors.

BACnet Board Controller

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 via 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 furnished as part of system.

BACnet Intelligent Room Sensors

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.

VAV BOX CONTROLLERS- SINGLE DUCT

BACnet Application Controller - VAV Box

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 via 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.

BACnet Conformance

Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4, and 76.8 Kbps, as a native BACnet device. Application controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:

Files Functional Group

Reinitialize Functional Group

Device Communications Functional Group

BACnet Functional Groups

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.

BACnet Object Types

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.

BACnet Universal Inputs

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 outs 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).

BACnet Board Application Controller

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 ID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and typing blocks together on screen. Application controller shall be programmed using the same programming tool as Building Controller and as described in Operator workstation section. All programming tools shall be provided as part of the system.

BACnet Intelligent Room Sensor

Application controller shall include support for intelligent room sensor (see Section 2.09B). Display on room sensor shall be programmable at application controller and include an operating mode and 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 for specific display requirements for intelligent room sensor.

Flow Sensor

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 EEPROM. 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 workstation, portable computers and special hand-held field tools shall not be needed for field calibration.

Duct Temperature Sensor

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

SENSORS

All sensing inputs shall be provided industry standard signals.

Temperatures, humidity's, differential pressure signals, and all other signal inputs shall be industry standard variable voltage or amperage.

All signal inputs shall be compatible with controllers used and with requirement for readout of variables as specified.

If sensors are not linear, then software will linearize sensor output.

Controls and sensor for NAV boxes to be provided to VAV manufacturer for installation at the factory.

TEMPERATURE SENSORS/THERMOSTATS

All sensors shall be completely electronic.

Duct / Air Handling Unit Type Temperature Sensor (mixed, discharge / supply, and return air).

The probe of the duct sensor shall be 12" in length and be made of stainless steel. Applications where the smallest dimension of the duct is less than 24", the probe shall be sized to reach the center of the duct.

Large systems above 9 square feet may require an averaging probe if sufficient mixing of the air stream is not possible.

Mount the sensor far enough downstream to allow mixing of the air stream, this is most important on Hot and Cold Deck applications where the coil is placed after the fan.

Sensors for mounting on insulated ducts or casings are to be equipped with brackets for mounting clear of the isolation.

Do not locate sensors in dead air spaces or in positions with obstructed air flow.

Provide separate duct flange for each sensing element.

Temperature sensing elements shall be thermally isolated from brackets and supports.

Securely seal ducts where elements or connections penetrate duct.

Mount sensor enclosures to allow for easy removal and servicing without disturbance or removal of duct insulation.

Immersion Type Temperature Sensor

The probe of the sensor shall be constructed of stainless steel and pressure rating consistent with system pressure and velocity.

The well shall be constructed of stainless steel and sized to reach into the center of the pipe. Pipes with small diameters shall have the well mounted at a 90-degree elbow to allow sufficient contact with the fluid.

Locate wells to sense continuous flow conditions.

Do not install wells using extension couplings.

Wells shall not restrict flow area to less than 70 percent of line size pipe normal flow area. Increase piping size as required to avoid restriction.

Provide thermal transmission material within the well.

Provide wells with sealing nuts to contain the thermal transmission material and allow for easy removal.

Room Type Temperature Sensor

All thermostat locations shall be submitted for approval before installation.

Provide all sensors with blank stainless-steel wall plate.

Coordinate sensor location with light switches. Mount blank plate wall sensors 60"above the floor. Mount any sensors with adjustments or readouts at 48" above floor. Verify location before installation, so that no direct sunlight or influences from heat and cooling sources will be imposed on the sensor.

Unless otherwise indicated or specified, provide one discharge and one space temperature sensor for each VAV Terminal Control Unit.

Metal guards shall be provided as shown on drawings.

Insulation shall be installed between the temperature sensor and open conduit to eliminate false temperature readings due to cold drafts.

AIR PRESSURE SENSORS

Static Pressure and Velocity Controllers

Static Pressure sensors shall be of either the diaphragm or rigid element bellows, electronic type, photo helic.

Each sensor shall be provided with connections, i.e., stop cock tubing, for attaching a portable pressure gauge.

Sensors for mounting on insulated ducts or casings are to be equipped with brackets for mounting clear of the insulation.

The transmitter shall be a two-wire type and provide a 4-20 mA signal which is proportional and linear over the calibrated pressure range.

The transmitter shall be capable of operating from an unregulated 18-30 VDC power supply.

The device housing shall provide 1/4" barbed brass fitting for the connection of the pressure lines. Pressure ranges shall suit the application so that normal operation will occur at midrange of the sensor span.

The location of the indoor measurement shall be remote from doors and openings to the outside, away from elevator lobbies, and shielded from air velocity effects. See Drawings for location.

WATER PRESSURE SENSORS

The device shall be capable of withstanding an over pressure of two times its calibrated span without any damage to the sensing element.

Typical ranges: 0-150 psig.

The device enclosure shall be NEMA 4 type and provide rugged mounting feet. All wetted parts shall be stainless steel so that a wide variety of fluids may be measured.

The transmitter shall be capable of operating from an unregulated 18-30 VDC power supply.

Pressure sensors for liquid or pressurized applications shall be installed with shut off valve to that the system must not be shut down or drain to install or service the sensor.

WATER FLOW SENSOR

Sensing Method: Electronic impedance sensing with single turbine.

Accuracy: +/- 0.5% of reading at calibrated velocity. +/- 2% of reading from 0.4 to 20 ft/s.

Pressure drop: Less than 1 psi at 20 ft/s in 1-1/2" pipe, decreasing in larger pipes and lower velocities.

Maximum operating pressure: 400 psi.

Maximum Liquid Operating Temperature: Standard is 180° F continuous, 200° F. Optional is 280° F continuous, 300° F peak. Onicon F-1100 Series with analog output.

Please see individual specification sheets for detailed information.

WATER FLOW SWITCH

316L stainless steel bellows.

Provide with blade to match pipe size.

Contacts rated for 15A at 240V.

Caleffi, Kele or approved.

DIFFERENTIAL PRESSURE TRANDSDUCER

A-10V output signal. Rated for temperature and pressure of fluid to be maintained. Setra or approved.

FREEZE PROTECTION THERMOSTAT

Length: One linear foot of sensing element per square foot of coil or duct area.

Low temperature cutout control, snap acting, normally closed contacts.

Sensing element contacts will open when any 16-inch portion of the element sensing at or lower than setpoint.

Auto Reset.

Temperature sensing elements shall be thermally isolated from brackets and supports.

Resent temperature 5° F above setpoint.

TRANSFORMERS

Transformers selected and sized for appropriate VA capacity and installed and fused according to applicable codes.

CO2 SENSORS

Sensor output shall communicate via BACnet MS/TP protocol.

The transmitter shall be capable of operating from an unregulated 18-30 VDC power supply.

Sensors shall be self-calibrating. Service life of device shall be 15 years with stability of 2% or less variation.

CURRENT SWITCHES

The status of all non-VFD fan and pump motors and all VFD fan and pump motors less than 20 HP shall ONLY be detected using current switches.

The current switch shall be provided for electrical equipment status applications only.

Switch should attach directly to the conductor and have a mounting bracket for installation flexibility.

The current switch shall be 100% solid state electronics.

The current switch shall be induce powered from the monitored load.

RELAYS

Coil voltage draw shall not exceed secondary controller output current generation. 24V coil with contacts rated for up to 277V. Controls shall be rated for 20 amps.

CURRENT SENSORS / TRANSFORMERS

The status and amperage of all VFD motors for fan and pumps greater than 20 HP shall be detected using current sensors ONLY.

The amp signal shall be provided on operator screen.

The scale used must be selected in order to obtain normal operating readings at the mid-point of the scale.

The scale used must be selected in order to detect changes in current flow resulting from motor belt or coupling loss. Belt slippage, and other mechanical failures and should be able to distinguish low load conditions.

BOILER SYSTEM SHUT-OFF SWITCH

Switch to be lockable type, Square D XALK 194 or equal.

SURGE PROTECTION (GLOBAL PANEL ONLY)

All equipment shall be protected from power surges and voltage transients. If failure occurs from surges and transients during the warranty period, then the Contractor shall repair surge protection equipment and other equipment damaged by the failure at no cost to the Owner.

Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients and shall be consistent with IEEE standards 587-1980.

ELECTRONIC ACTUATORS AND VALVES

Quality Assurance for Actuators and Valves

UL Listed Standard 873 and C.S.A. Class 4813 02 certified.

NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.

Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.

Execution Details for Actuators and Valves

Spring actuators are not acceptable by Owner.

Only as specifically required by Owner shall each DDC analog output point shall have an actuator feedback signal, independent of control signal, wired and terminated in the control panel for true position information and troubleshooting. Or the actuator feedback signal may be wired to the DDC as an analog input for true actuator position status. This may apply to chilled heating water plants.

VAV box damper actuation shall be Floating Type or Analog (2-10 VDC, 4-20mA).

Booster-heat valve actuation shall be Floating type or Analog (2-10 VDC, 4-20mA).

Primary valve control shall be analog (2-10 VDC, 4-20mA).

Actuators for Damper and Control Valves 1/2" to 6" shall be Electric unless otherwise specified, Provide actuators as follows:

UL Listed standard 873 and Canadian Standards association Class 481302 shall certify actuators.

NEMA 2 rated actuator enclosures. Use additional weather shield to protect actuator when mounted outside.

5-year Manufacturer's Warranty. Two-year unconditional, plus three-year product defect from date of installation.

No spring return actuators, unless approved by the Owner.

Position indicator device shall be installed and made visible to the exposed side of the Actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the actuator.

Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out dur to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for Butterfly Valve actuators.

A push button gearbox release shall be provided for all non-spring actuators.

Modulating actuators shall be 24VAC and consume 10 VA power or less.

Conduit connectors are required when specified and when code requires it.

Damper Actuators

No spring return actuators, unless approved by the Owner.

Economizer Actuators shall utilize Analog control 2-10 VDC, Floating control is not acceptable.

Electric damper actuators (including VAV box actuators) shall be direct shaft mounted and use a V-bolt and toothed V-Clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.

Once electronic actuator shall be direct shaft mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one actuator has enough torque to drive both and damper drive shafts are both horizontal installed.

Multi -section dampers with electric actuators shall be arranged so that each damper section operates individually. Once electronic actuator shall be direct shaft mounted per damper section (see below execution section for more installation details).

Valve Actuators: 1/2" to 6"

No spring return actuators, unless approved by the Owner.

The valve actuator shall be capable of providing the minimum torque required for proper valve close off for the required application.

All control valves actuators shall have an attached 3-foot cable for easy installation to a junction box.

Override handle and gearbox release shall be provided for all non-spring return valve actuators.

Control Valves 1/2" to 6"

The BAS Contractor shall furnish all specified motorized control valves and actuators. BAS Contractor shall furnish all control wiring to actuators. The plumbing Contractor shall install all valves. Equal Percentage control characteristic shall be provided for all water coil control valves. Linear valve characteristic is acceptable for 3-way valves 2 1/2" inch and above.

Characterized Control Valves shall be used for hydronic heating or cooling applications and small to medium AHU water coil applications to 100 GPM.

Leakage is Zero Percent, Close-off is 200 psi, Maximum Differential is 30 psi. Rangeability is 500:1.

Valves ½ inch through 2 inches shall be nickel- plated forged brass body, NPT screw type connections.

Valves ½ inch through 1 ¼ inches shall be rated for ANSI Class 600 working pressure. Valves 1 ½ inch and 2 inches shall be rated for ANSI Class 400 working pressure.

The operating temperature range shall be 0° to 250° F.

Stainless steel ball & stem shall be furnished on all modulating valves.

Seats shall be fiberglass reinforced Teflon.

Two-way and three-way valves shall have an equal percentage control port. Full stem rotation is required for maximum flow to insure stable BTU control of the coil.

Three-way valve shall be applicable for both mixing and diverting.

The characterizing disc is made of TEFZEL and shall be keyed and held secure by a retaining ring.

The valves shall have a blowout proof stem design.

The stem packing shall consist of 2 lubricated O-rings designed for on-off or modulating service and require no maintenance.

The valves shall have an ISO type, 4-bolt flange, for mounting actuator in any orientation parallel or perpendicular to the pipe.

A non-metallic thermal isolation adapter shall separate valve flange from actuator.

One fastening screw shall secure the direct coupling of the thermal isolation adapter between the actuator and the valve. This will prevent all lateral or rotational forces from affecting the steam and it's packing O-rings.

Globe vales 1/2" to 2" shall be used for steam control or water flow applications.

Valves shall be bronze body, NPT screw type, and shall be rated for ANSI Class 250 working pressure.

Valves ½ inch (DC 15) through 2 inches (DNSO) shall close off against 50 psi pressure differential with Class III leakage (0.1%).

The operating temperature range shall be 20° to 280°F.

Spring loaded TFE packing shall protect against leakage at the stem.

Two-way valves shall have an equal percentage control port.

Three-way valves shall have a linear control and bypass port.

Mixing and diverting valves must be installed specific to the valve design.

Globe Valve 2 1/2" to 6".

Valves 2 ½ inch (DN 65) through 6 inches (DNSO) shall be iron body, 125 lb. flanged with Class III (0.1%) close-off leakage at 50 psi differential.

Valves shall close off against 50 psi pressure differential with Class III leakage (0.1%).

Flow type for two-way valves shall be equal percentage. Flow type for three-way valves shall be linear.

Mixing and diverting valves must be installed specific to the valve design.

Butterfly Valves

Butterfly valves shall be sized for modulating service at 60-70-degree stem rotation. Isolation valves shall be line-size. Design velocity shall be less than 12 feet per second when used with standard EPDM seats.

Body is Cast Iron.

Disc is Aluminum Bronze standard.

Seat is EPDM standard.

Body Pressure is 200 psi, -30°F to 275°F.

Flange is ANSI 125/250.

Media Temperature Range is -22°F to 240°F.

Maximum Differential Pressure is 200 psi for 2" to 6" size.

Actuator Mounting for Damper and Valve arrangements shall comply to the following:

Damper Actuators shall not be installed in the air stream

A weather shield shall be used if actuators are located outside. For Damper Actuators use clear plastic enclosure.

Damper or valve actuator ambient temperature shall not exceed 122°F through any combination of medium temperature or surrounding air. Appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation shall be provided as necessary.

Actuator cords or conduit shall incorporate a drip leg if condensation is possible. Water shall not be allowed to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point shall be avoided to prevent water from condensing in conduit and running into actuator.

Valve Sizing for Water Coil.

On/Off Control Valves shall be line size.

Modulating Control Valve Body Size may be reduced at most two pipe sizes form the line size or not less than half the pipe size. The BAS Contractor shall size all water coil control valves for the application as follows.

Booster-heat valves shall be sized not to exceed 4-9 psi differential pressure. Size valve for 50% Valve Authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.

Primary valves shall be sized not to exceed 5-15 psi differential pressure. Size valve for 50% Valve Authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.

Butterfly valves shall be sized for modulating service at 60-70-degree rotation. Design velocity shall be 12 feet per second or less when used with standard EPDM seats.

Valve Mounting Arrangements Shall Comply to the following:

Unions shall be provided on all ports of two-way and three-way valves.

Install three-way equal percentage Characterized Control Valves in a mixing configuration with the “A” port piped to the coil.

Install 2 1/2" inch and above, Three-way Globe Valves, as manufactured for mixing or diverting service to the coil.

Two-way Valve shall be piped in the return side of the coil in order to minimize ambient heat at the coil.

All valves and actuators to be Belimo unless directed otherwise by Owner.

ENCLOSURES

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

Enclosures may be NEMA I when located in a clean, dry indoor environment. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.

Enclosures shall have hinged, locking doors.

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 1/8" thick sized appropriately to make label easy to read.

PART 3 - EXECUTION

EXAMINATION

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.

Notify the Owners representative in writing of conditions detrimental to the proper and timely completion of the work.

Do not begin work until all unsatisfactory conditions are resolved.

INSTALLATION (GENERAL)

Install in accordance with manufacturer's instructions.

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.

LOCATION AND INSTALLATION OF COMPONENTS

Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum 3'-0" clear access space in front of units. Obtain approval on locations from Owner's representative prior to installation.

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

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

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

INTERLOCKING AND CONTROL WIRING

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.

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.

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.

Provide auxiliary pilot duty relays on motor starters as required for control function.

Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings. Coordinate with electrical Contractor.

All control wiring to be installed neatly and consistently per local code requirements. If local code allows, control wiring above accessible ceiling spaces may be run with plenum rated cable (without conduit).

WIRING, CONDUIT, AND HANGERS

All wiring and fiber optic cable in the central plant, tunnels, and plenums to be supported by B-line Bridle rings or equal. All wiring and fiber optic cable in the hallways, rooms and other public areas shall be in conduit.

All wires in Bridle Rings or conduit shall follow building lines and shall run within several inches of the wall as much as possible.

Wire and cable of the sizes and types shown on the plans and/or hereinafter specified shall be furnished and installed by the Control Contractor. All wire and cable shall be new soft drawn copper and shall conform to all the latest requirements of the National Electrical Code, IPCEA, and shall meet the specifications of the ASTM.

Input/output wiring: Wiring serving inputs and outputs from the BAS shall be cables consisting of single or multiple twisted individually shielded pairs. Each pair shall have an independent shield with drain wire. Cables installed without Condit shall be plenum rated and comply with NEC article 725. Where automation input/output wiring is run in cable tray furnish and install conductors or multiconductor cable rated for use in cable trays per NEC article 340 and/or 725.

Power Conductors shall provide power to controls furnished under this section, unless power to controllers is noted on the electrical drawings. Contractor shall coordinate with electrical Contractor to identify dedicated controls circuits. All feeder and branch circuit wire shall be 600 V insulated of THHN type unless shown or specified to be otherwise. No wire less than No. wire less than No. 12 gauge shall be used except for control circuits or low voltage wiring. Wire sizes No. 14 to No. 10 shall be solid except where otherwise indicated. Wire sizes No. 8 and larger shall be stranded. All wire sizes shown are American Wire Gauge sizes. Where power conductors are run in cable tray, furnish and install conductors or multiconductor cable rated for use in cable trays per NEC articles 340 and/or 725.

All the conductors used for signals from the controllers and field sensors must be shielded two wire, 18 AWG, with a drain wire.

All power wiring to be copper stranded RW 90 type, with appropriate gauge in accordance with the codes. The following color code must be applied:

Line voltage to be black and/or white

Ground to be green

Wiring Installation

All wires shall be continuous from outlet to outlet and there shall be no unnecessary slack in the conductors.

All drain wires must be grounded at the source end. The other end must be protected with a dielectric material (tape).

Pull-Box and Junction Box

Pull boxes and junction boxes shall be installed where indicated on the drawings or where required to facilitate wire installation. Locate in conjunction with other trades to install without conflict with other materials or equipment.

A pull-box will be located at every 50’.

All switch, pull, junction boxes etc., shall be hot dipped galvanized or sherardized, concrete tight, with interlocking ring or multiple point locking devices. Connectors shall be three pieces. Indentation fittings are not acceptable.

In suspended ceilings, all boxes must be installed on the structure.

Boxes shall be attached by fasteners designed for the purpose and shall provide adequate mechanical strength for future maintenance.

Junction and pull boxes not dimensioned shall be minimum 4-inches square.

Care shall be used to avoid proximity to heat ducts and/or steam lines. Where crossings are unavoidable, conduit shall clear cover of line by at least six inches.

All splices, taps, and terminations shall be made at outlet, junction, or pull boxes. Wire to No. 6 gauge shall be spliced using Scotch Lok wire nuts. No Bakelite wire nuts shall be used. Wire No. 6 and larger shall be spliced using soldemess connectors as manufactured by Penn Union Company. Splices No. 6 and larger shall be insulated by taping with plastic vinyl tape as manufactured by Minnesota Mining and Manufacturing Company. Splices shall not be permitted in automation input and output wiring without specific written authorization from the Engineer. If such splice is approved, the location of the splice shall be clearly documented on the "As Built" drawings. Splices in automation wiring, if necessary shall be made using Thomas & Betts STA-KON connectors installed per the manufacturer's directions to maintain NEMA specified voltage drops and wire retention forces.

Grounding

The Contractor shall extend existing equipment grounding systems. The Contractor shall use only approved grounding clamps and connectors as manufactured by Penn Union, Bumdy or O-Z Mfg. Company.

The conduit system of the 480/277 and 208Y/120-volt systems shall be continuous and shall be used as the static grounding conductor, except for circuits installed in flexible conduit. Install a green grounding conductor inside all flexible conduits and extend to the nearest outlet or junction box. Install a green grounding conductor inside all non-metallic conduits or raceways.

Conduit Material

All wiring to be E.M.T. type conduits unless in plenum or above the 8' level in mechanical rooms and attics.

All conduits to be a minimum of 1/2 ".

All flexible conduits will not exceed 6' in length and are to be used only in areas where vibrations and/or expansion joints are present.

Flexible conduit to be used for connecting any element to its conduit. The length of this flexible conduit will not exceed 24".

Flexible steel conduit shall be used where flexible conduit connections are required and at connections to all motorized equipment and motors. If located outside seal-tight shall be used.

In damp areas, the conduit and related equipment must be suitable for the application.

Electrometalic tubing shall be installed for all exposed work and for all concealed work in applications where conduit is required.

Conduit shall be by Allied, Triangle, Republic, Youngstown, Canon, Rob Roy, or approved equal.

For exposed finished area where the conduit cannot be run in ceiling spaces, wall cavities or attics, surface-mounted powdered coated conduit is acceptable. Provide samples for size and color selection. Wiremold may be used only with Owner's approval.

Conduit Installation

All wiring in mechanical rooms at heights below 8 feet must be run in conduit. Otherwise, wiring in all other open areas (areas with no ceiling or cloud ceiling) must be routed in conduit. Wiring above accessible ceilings or drops in walls to single control devices need not be in conduit.

All conduits to be installed in a concealed manner where possible and shall be installed parallel to the lines of the building.

All exposed conduits in finished areas shall be white powder coated and installed parallel or at right angles to be the building walls or floors. Wiremold is to be used only as directed by Owner.

Conduit bends shall be made with standard hickeys of proper size. Radius of bends to be at least 6 times the diameter of the conduit. Runs between outlets shall not contain more than the equivalent of three-quarter bends. Conduit runs shall be continuous from outlet to outlet, outlet to cabinet, etc.

Conduits shall be installed with pitch toward outlet box wherever possible. All heavy wall conduits shall have two locknuts and a bushing at each termination outlet box, junction box, etc., except where terminated in a threaded hub.

A bushing shall be used where conduit enters a panel box. Bushing for No. 4 AWG or larger shall be insulated type with provisions for grounding as type “BL” made by O-Z Electric Company or approved equal.

Expansion fittings shall be provided at all conduits across the building expansion joints. Fittings shall be Type “AX” or “TX” as made by O-Z Electric Company or approved equal. Provide copper bonding jumper at each expansion fitting.

All I” conduit to be supported every 6’, the supports will be located at the connector end of the conduit.

Exposed conduit shall be securely fastened in place on maximum 5 ft. intervals for 3/4 " through 2 1/2 " nominal sizes. Supports may be one-hole malleable straps or other approved devices. No perforated metal straps will be permitted.

In mechanical attics, conduit to be run vertically up to the 8’ level and run in plenum rated cable after that.

Wireway

Furnish and install at all control panel locations a NEMA 1 lay-in wireway system to bring cable into and out of the panel as detailed on the drawings and specified in this section. Furnish 3-way wireways at each panel location; one for Class 1 wiring, 1 for Class 2, and Class 3 wiring. Panels at units to be NEMA 3R or better.

Wireway systems at locations where cables are to be run without conduit or in a cable tray shall consist of a connection to the control panel with a vertical extension to 8’-0" or the pipe rack or cable tray level, whichever is higher. The vertical section shall terminate in a 90° fitting with a closure plate. The closure plate shall be provided with a conduit nipple with locknuts and bushings as a wire entry point into the square duct. The conduit nipple shall be one size smaller than the wireway it is associated with.

Wireway systems at locations where cables are to be run in conduit shall consist of a horizontal section of wireway with a length equal to the control panel width and located above the control panel and connected to the control panel with three conduit nipples, locknuts, and bushings; ne for tubing, one for Class 1 wiring and one for Class 2 and 3 wiring. Conduits for cable runs shall terminate on the wireway.

The intent of the wireway configurations outlined above is to provide a method for adding input and output wiring to the control panel without having to drill directly into the electronics enclosure after the system is on line and running and to provide sufficient area to land field conduits while maintaining appropriate circuit segregation for wire entry into the controller enclosure. The installation of wireway shall be made with this consideration in mind.

Hangers and Anchors

Where control system tubing is run on trapezes and/or hangers used by and or installed by other trades, supports for trapezes shall be coordinated by all trades using the trapeze to assure that the anchor system is not overloaded and is sufficient for the load imposed including a margin of safety and seismic considerations. Under no circumstances shall a trapeze or hanger system installed by the electrical trades be used to support work by any other trade, nor shall the electrical trades use the trapezes installed by any of the other trades for the support of electrical equipment, all as required by the National Electric Code. Similarly, under no circumstances shall a trapeze or hanger system installed by the sprinkler trades be used to support work by any other trade, nor shall the sprinkler trades use the trapezes installed by any of the other trades for the support of sprinkler systems or equipment, all as required by NFPA 13, standard for The Installation of sprinkler Systems.

Anchors to be loaded in tension for use in existing concrete structure and anchors loaded in tension and not cast in place shall be epoxy resin set anchors installed per the manufacturer's recommendations for technique, size, loading, embedment, etc. Where anchors are loaded in shear at these locations, suitably sized and installed wedge type anchors may be used.

In all cases anchor loading shall be based on hanger spacing, weight of the pipe to be supported when full and insulated, weight of any additional loads imposed upon the anchor, wind loading, seismic loading, quality of the material that the anchor is being installed in, etc. The control contractor shall verify in the field that the anchors used and the materials that they are being installed in are suitable for the load imposed and shall bring any problems to the attention of the Engineer in writing immediately and not proceed without direction from the Engineer.

Wedge type anchors shall be Hilti Kwik Bolt II. Adhesive anchors shall be Hilti HVA.

UNIT CONTROL PANELS INSTALLATION AND FABRICATION

Enclosed cabinet type with hinged door for mounting all relays, switches, thermometers, and miscellaneous controls not requiring direct mounting on equipment such as sensing elements, valves, and damper motors. Provide cabinet for each control unit adjacent to each system.

Control panels shall be fabricated to match the approved shop drawings submitted by the Control Contractor. Fabrication shall be in a neat and workmanlike manner and shall facilitate repair, maintenance, and adjustment of the equipment contained therein.

Control panels shall be fabricated and laid out to incorporate the following features:

Identification of all internally and cover mounted devices. Cover mounted labels shall be engraved labels as specified in Section 2.22 D. Labels shall be mounted adjacent to the device they are associated with so that replacement of the device does not eliminate the label. Provide laminated control diagram at each panel.

Electrical wiring shall enter the panel from the top, bottom, and/or side of the left side of the panel or as required by the panel supplier to meet NEC requirements.

All wires entering or leaving the panel shall pass through a rail terminal trip. Where the wires are part of a current loop transmission circuit, the terminals shall be the disconnecting link type. Terminals shall be identified with a number that corresponds to the terminal number on the job wiring diagram. Rail terminal trip specifications include:

Terminal rail assemblies shall be fabricated from components selected from the product line of one manufacturer.

Sizes (heights, widths, and profiles) of each terminal shall be selected to be compatible with the other terminals on the rail.

Terminal units located at the end of a rail or adjacent to terminals with a different profile (for example, where disconnecting terminals are located next to resistor terminals) shall be provided with end caps to completely close off the terminal unit interior components from the local environment.

End stops shall be provided for on all rails to secure the terminals located on the rail in place.

All internal wiring and tubing shall be run inside plastic wiring/tubing duct as manufactured by Tyton. Wire duct shall be sized to hold the required number of wires and tubes without crimping the tubes and with enough space to allow wiring and tubing to be traced during troubleshooting operation.

Wires that pass from the panel interior to cover mounted devices shall be provided with a flex loop that is anchored on both sides of the hinge. Wiring running to cover mounted devices shall be bundled using cable ties.

Provide strain relief type cord and cable connectors for all cables that leave the panel as individual cables not in conduit.

All control panels shall be provided with removable sub panels to allow the panel enclosures to be installed at the job site during rough in while the panels are fabricated off-site for later installation.

In areas of low light, provide one under cabinet type fluorescent light with switch mounted internally in the control panel. Panels with external light hoods will also be acceptable if the light will illuminate the panel interior with the door open.

Provide one duplex outlet mounted inside the global controller panel only and separately fuse it with a non-time delay fuse at 15 A at any panel location containing electronic or electrical control components. This receptacle may be served from the control panel 120 VAC power source.

Each control panel shall be provided with a control power disconnect switch located and wired to disconnect all control power in the panel. The leaving side of this switch shall be wired to the panel and field components through a fuse or fuses sized and applied to protect both the components of the system as well as the wire and as required for code compliance.

Power to the following equipment will have a fuse rated for applicable current and voltage. Fuses will be on rail terminal strips. Equipment includes:

Each control unit

Control devices

Panel light

Receptacle loads (i.e. modems, laptops)

All control panels containing electrical equipment shall be NEMA rated for the location in which they are installed. Cover mounted components, tubing penetration, and conduit penetrations shall be made in a manner consistent with the NEMA rating.

All wiring leaving the panel shall be separated by classification; i.e., Class 1 circuits shall not be run with Class 2 circuits, etc. Segregation shall be maintained inside the panel to the fullest extent possible. Where low voltage wires carrying low level ac and dc signals cross wires containing power and high-level ac signals, the wires shall cross at a 90° angle.

Control panels shall be shop fabricated and tested prior to installation in the field. The Engineer shall be given the opportunity to witness the testing of the panels.

Panel Location

Each control panel is to be located for convenient servicing.

FIELD SERVICES

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

Start-up and functional test of control systems. Allow enough time for start-up and functional test prior to placing control systems in permanent operation.

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.

Provide Owner's representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

TRAINING

Provide application Engineer to instruct Owner in operation of systems and equipment.

Provide system operator's training to include, but not limited to, such items as the following:

Modification of data displays

Alarm and status descriptors

Requesting data

Execution of commands

Request of logs

Provide on-site training above as required for up to 12 hours in 2 to 4 hour sessions (travel hours are included as part of the 12 hours) as part of this contract.

END OF SECTION 23 09 23