SECTION 23 09 23

DIRECT DIGITAL CONTROL SYSTEM (DDCS)

PART 1 – GENERAL

1.01   WORK INCLUDED

A.   Furnish a totally native BACnet-based system, based on a distributed control system in accordance with this specification. 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 controllers, including unitary controllers, shall be native BACnet devices. The control system shall be Alerton BACtalk or equal.

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 detail, and software configuration from project design data.

D.   Prepare individual hardware layouts, interconnection detail, and software configuration from project design data.

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

F.   Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.

G.   Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

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

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

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

K.   Provide as-built documentation, 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.

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

1.02   SYSTEM DESCRIPTION

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 135-2001, BACnet. This system is to control all mechanical equipment, including all unitary equipment (VAV boxes, heat pumps, fan-coils, AC units, etc.), lighting control, and all air handlers, boilers, chillers, and any other listed equipment using BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

B.   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 Master Network. Local operator's terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of 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 and communicate on a peer-to-peer basis. Application controllers shall be mounted next to controlled equipment and communicate with building controller via BACnet LAN.

C.   Room sensors shall be provided with digital readout that allow the user to view room temperature, view outside air temperature, adjust the room setpoint within preset limits and set desired override time. User shall also be able to start and stop unit from the digital sensor. Include all necessary wiring and firmware such that room sensor includes field service mode. Field service mode shall allow technician to balance VAV zones and access any parameter in zone controller.

1.03   APPROVED MANUFACTURERS

A.   The following Manufacturers' products may be installed for this Section of work (listed alphabetically):

1.   Alerton Technologies, Inc.
2.   Johnson Controls
3.   Siemens Building Technologies
4.   Andover Controls
5.   Or equal BACnet System.

B.   Only BTL approved equipment furnished by the above listed manufacturers will be acceptable. Products that not BTL approved are not acceptable.

1.04   QUALITY ASSURANCE

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

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

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

D.   The systems control manufacturer shall have been an established manufacturer of BACnet protocol systems for a minimum of five years.

E.   Control system shall be engineered, programmed and supported completely by representative's local office that must be within 30 miles of project site. The control contractor shall be independent and standalone; and shall not be part of a Mechanical Contractor control division.

F.   All system levels shall be compliant with the BACnet Standard 135-2004. Upon completion of commissioning process and prior to acceptance, Developer Design/Builder shall provide a protocol analyzer and demonstrate that all system components that communicate within the system utilize the BACnet protocol. Contractor may at their expense hire a qualified, independent registered engineer to perform test. Any components that do not fully comply with the BACnet standard shall be replaced until entire system architecture is re-tested and compliant. Conflict resolution shall be submitted to BTL (www.bacnetassociation.org) at Contractor's expense and BTL determination shall be final.

G. Prior to receiving approval to proceed on this project the Developer Design/Builder must provide and demonstrate the following:

    1. Ten (10) customer references in Southern California with installed native BACnet systems as specified for this project.

    2. Five (5) large references in the Southwestern United States where the Developer Design/Builder has installed native BACnet systems in a building environment where the project is of similar size and complexity.

    3. Reference Information must include the following:

        a. Customer name
        b. Address
        c. Contact name
        d. Contact phone number
        e. System description
        f. Statement of BACnet compliance

1.05 PROJECT MANAGEMENT

A. Have present at the project site, a project manager who shall, as a part of their duties, be responsible for the following activities:

    1. Coordination between the Subcontractor and all other trades, County, Local Authorities, and design team.

    2. Coordination of all activities between his subcontractors.

    3. Attendance at subcontractor/Developer Design/Builder meetings.

    4. Scheduling of work progress, manpower loading, material delivery, equipment installation and checkout.

    5. Coordination of all submittals between consultants, engineers, other sub-trades and his subcontractors.

    6. Supervision of field technicians and interface with other trades.

1.06 REFERENCE STANDARDS

A. 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:

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

    2. ANSI/ASHRAE Standard 135-2001, BACnet.

    3. Uniform Building Code (UBC), including local amendments.

    4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.

    5. National Electrical Code (NEC).

    6. FCC Part 15, Subpart J, Class A.

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

    8. City, county, state, and federal regulations and codes in effect as of contract date.

B. 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.

1.07 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: Include the following in submittal package:

1.   System configuration diagrams in simplified block format
2.   All input/output object listings and an alarm point summary listing.
3.   Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
4.   Complete bill of materials, valve schedule and damper schedule.
5.   Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
6.   Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
7.   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.
8.   A list of all functions available and a sample of function block programming that shall be part of delivered system.

C.   Project Management: The vendor 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.

1.08   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.   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 through Friday, 48 hours on Saturday and Sunday.

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

1.09   RELATED WORK IN OTHER SECTIONS

A.   Refer to Division 23 Facility Management and Control System.

B.   Refer to Section 15000 for BASIC HVAC REQUIREMENTS

C.   Refer to Section 16000 for BASIC ELECTRICAL REQUIREMENTS

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

PART 2 – PRODUCTS

2.01   BUILDING CONTROLLER

A.   General Requirements:

1.   Building Controller shall be of modular construction such that various modules may be selected to fit the specific requirements of a given project. Modules shall consist of a power supply module, a BACnet Ethernet-MS/TP module, a BACnet MS/TP only module and a modem module for telephone communication as a minimum. Those projects that require special interfaces may use Modbus modules as needed. However, all Ethernet communications and all controllers including

central plant controllers, advanced application controllers and unitary controllers supplied by BMS manufacturer shall utilize the BACnet protocol standard.

2. Modules shall be selected to fit the particular project application. Up to 7 modules shall be powered by a single power supply module. All modules shall be panel mounted on DIN rail for ease of addition and shall be interconnected via simple plug in cable. A module in the middle shall be replaceable without removing any other modules.

3. All modules 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. The software program implementing these 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, via a wide area network or downloaded via remote communications are not acceptable. Changing global strategies via firmware changes is also unacceptable.

4. 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 supplied and be resident on workstation. The same tool shall be used for all controllers.

5. 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.

6. Controller shall have a memory needed to ensure high performance and data reliability. Battery shall provide power for orderly shutdown of controller and storage of data in nonvolatile flash memory. Battery back up shall maintain real-time clock functions for a minimum of 20 days.

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

8. Schedules:
   a. Each building controller module shall support a minimum of 80 BACnet Schedule Objects and 80 BACnet Calendar Objects.
   b. Building controller modules shall provide normal 7 day scheduling, holiday scheduling and event scheduling.

9. Logging Capabilities:
   a. Each building controller shall log as minimum 320 values. 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 via WAN or remote communication.
   c. Building controller shall periodically upload trended data to networked operator's workstation for long term archiving if desired.
   d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

10. 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 via remote communications.
   d. Controller must be able to handle up to 320 alarm setups stored as BACnet event enrollment objects – system destination and actions individually configurable.

11. Demand Limiting:
   a. Demand limiting of energy shall be built a built in function that shall be user configurable. Each controller module shall support shedding of up to 200 loads using a minimum of two types of shed programs.
   b. Load shedding programs in Building Controller Modules shall operate as defined in section 2.1.J of this specification.

B.   Ethernet – MS/TP Module:

1.   Ethernet – MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following:

a.   All communication with operator workstation and all application controllers shall be via BACnet. Building controller Ethernet – MS/TP module shall incorporate as a minimum, the functions of a 2-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz) and master slave token passing (MS/TP) LAN. Ethernet – MS/TP module shall also route messages from all other Building Controller modules onto the BACnet Ethernet network.

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

c.   The RJ-45 Ethernet connection must accept either 10Base-T or 100Base-TX BACnet over twisted pair cable (UTP).

2.   BACnet Conformance:

a.   Ethernet – MS/TP module shall as a minimum support 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:

1)   Clock Functional Group

2)   Files Functional Group

3)   Reinitialize Functional Group

4)   Device Communications Functional Group

5)   Event Initiation Functional Group

b.   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.

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

d.   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).

C.   MS/TP Module:

1.   MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.

a.   Building Controller MS/TP module communications shall be via BACnet master slave token passing (MS/TP) LAN to all advanced application and application specific controllers. MS/TP module shall also route messages to Ethernet-MS/TP module for communication over WAN.

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

c.   Configuration shall be via RS-232 connection.

2.   BACnet Conformance:

a.   MS/TP module shall as a minimum support MS/TP BACnet LAN type. It shall communicate directly via this BACnet LAN as a native BACnet device and shall support simultaneous routing functions between all supported LAN types. Controller shall be a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:

1)   Clock Functional Group

2)   Files Functional Group

<table>
<tr><td></td><td>3)</td><td>Reinitialize Functional Group</td></tr>
<tr><td></td><td>4)</td><td>Device Communications Functional Group</td></tr>
<tr><td></td><td>5)</td><td>Event Initiation Functional Group</td></tr>
</table>

b. 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.

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

D. Power Supply Module:

1. Power supply module shall power up to 7 Building Controller Modules. Input for power shall accept between 17 and 30 VAC, 47 to 65 Hz.

2. Power supply module shall include rechargeable battery for orderly shutdown of controller modules including storage of all data in flash memory and for continuous operation of real time clocks for minimum of 20 days.

E. Modbus Module:

1. Modbus Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.

a. Building Controller Modbus module communications shall be via one of three types of ports: EIA-485, EIA-422 or RS-232 connection. Modbus module shall convert Modbus data into BACnet objects. Modbus module shall also route messages to Ethernet-MS/TP module for BACnet Ethernet communication over WAN.

b. Modbus Module shall support ASCII or RTU Modbus communication at 9600 or 4800 baud.

c. EIA-422 and EIA-232 connection shall support one connection of Modbus unit.

d. EIA-485 connection shall support connection of up to 247 Modbus units.

e. Configuration shall be via RS-232 connection.

2. BACnet Translation.

F. All Modbus data shall be translated into BACnet objects by the Modbus module. All configuration tools shall be supplied to assure data is translated as necessary to the correct format and value.

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

2.02 EXPANDABLE CENTRAL PLANT AND AIR HANDLING UNIT CONTROLLERS
(The following features are required for all central plant and air handling unit applications)

A. General:

1. Expandable application controller shall be capable of providing control strategies for the system based on information from any or all connected inputs. 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 via simple download are not acceptable. Changing global strategies via firmware charges is also unacceptable. Program execution of controller shall be a minimum of once per second.

2. Programming shall be object-oriented using control program blocks. Controller shall support a minimum of 500 Analog Values and 500 Binary Values. Each and every analog and binary value shall support standard BACnet priority arrays. Programming tool shall be provided with system and shall be the same tool that is used to program the Building Controller. All flowcharts shall be generated and automatically downloaded to controller. No re-entry of database information shall be necessary.

3. 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 terminal or field computer.

4. Controller shall have adequate data storage 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). Battery shall be a field-replaceable (non-rechargeable) lithium type. Unused battery life shall be 10 years.

5. The onboard, battery-backed real time clock must support schedule operations and trend logs.

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

7. Controller shall include both on-board 10BASE-T/100BASE-TX Ethernet BACnet communication over twisted pair cable (UTP) and shall include BACnet IP communication. In addition, controller shall include BACnet PTP connection port.

8. The base unit of the controller shall host up to 8 expansion modules with various I/O combinations. These inputs and outputs shall include universal 12-bit inputs, binary triac outputs, and 8-bit switch selectable analog outputs (0-10V or 0-20 mA). Inputs shall support 3K and 10K thermistors, 0-5VDC, 0-10VDC, 4-20mA, dry contacts and pulse inputs directly.

9. All outputs must have onboard Hand-Off-Auto switches and a status indicator light. HOA switch position shall be monitored. Each analog output shall include a potentiometer for manually adjusting the output when the HOA switch is in the Hand position.

10. The position of each and every HOA switch shall be available system wide as a BACnet object. Expandable Central Plant Controller shall provide up to 176 discreet inputs/outputs per base unit.

B. BACnet Conformance:

1. Central Plant/AHU 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. Building controller shall be a BACnet conformance class 3 device and support all BACnet services necessary to provide the following BACnet functional groups:
   a. Clock Functional Group
   b. Files Functional Group
   c. Reinitialize Functional Group
   d. Device Communications Functional Group
   e. Event Initiation 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 necessary tools shall be supplied for working with proprietary information.

3. Standard BACnet object types supported shall include as a minimum: Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program and Schedule object types. All necessary tools shall be supplied for working with proprietary information.

4. The 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).

C. Schedules: Each Central Plant/AHU controller shall support a minimum of 50 BACnet Schedule Objects.

D. Logging Capabilities:

1. Each controller shall support a minimum of 200 trend logs. Any object in the system (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.
3. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs

E. Alarm Generation:

1. 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.
2. 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
3. Controller must be able to handle up to 200 alarm setups stored as BACnet event enrollment objects – system destination and actions individually configurable.

2.03   TERMINAL UNIT APPLICATION CONTROLLERS (Heat Pumps, AC Units, Fan Coils)

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 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.

B. BACnet Conformance:

1. 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:
   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, 0–5 VDC, 4–20 mA, 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 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 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.

2.04 TERMINAL BOX CONTROLLERS—SINGLE DUCT

A. Provide one native BACnet application controller for each terminal 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.

B. BACnet Conformance

1. 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:
      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, 0–5 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 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 the same programming tool as Building Controller and as described in operator 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 for specific display requirements for intelligent room sensor.

F.   On board flow sensor shall be microprocessor driven and precalibrated at the factory. Precalibration 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 terminal 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.

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

2.05   SENSORS and MISCELLANEOUS DEVICES

A.   Temperature Sensors: All temperature sensors to be solid state electronic, factory-calibrated to within 0.5°F, totally interchangeable with housing appropriate for application. Wall sensors to be installed as determined by Developer/Design Builder. Mount 48 inches about 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.   Sensor shall contain a backlit LCD digital display and user function keys along with temperature sensor. Controller shall function as room control unit, and shall allow occupant to raise and lower setpoint, and activate terminal unit for override use—all within limits as programmed by building operator. Sensor shall also allow service technician access to hidden functions as described in sequence of operation.
2.   The Intelligent Room Sensor shall simultaneously display room setpoint, room temperature, outside temperature, and fan status (if applicable) at each controller. This unit shall be programmable, allowing site developers the flexibility to configure the display to match their application. The site developer should be able to program the unit to display time-of-day, room humidity and outdoor humidity. Unit must have the capability to show temperatures in Fahrenheit or Centigrade.
3.   Override time may be set and viewed in half-hour increments. Override time count down shall be automatic, but may be reset to zero by occupant from the sensor. Time remaining shall be displayed. Display shall show the word "OFF" in unoccupied mode unless a function button is pressed.
4.   See sequence of operation for specific operation of LCD displays and function keys in field service mode and in normal occupant mode. Provide intelligent room sensors as specified in point list.
5.   Field service mode shall be customizable to fit different applications. If intelligent room sensor is connected to terminal controller, terminal box shall be balanced and all air flow parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.

C.   Wall Sensor: 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, warmer/cooler lever for set point adjustment and port for plug-in of Field Service Tool for field adjustments. 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. All programmable variables shall be available to Field Service Tool through wall sensor port.

D.   LCD Operator Terminal:

1.   The LCD operator terminal is a small wall- or panel-mounted operator terminal that connects directly to the BACnet LAN. The communication design and messaging structure shall comply with ANSI/ASHRAE Standard 135-2001, BACnet. Each operator terminal shall be able to display any BACnet object from anywhere in the BACnet network.

2. Each of these operator's terminals shall have a keypad and an adjustable backlit LCD, with a simple menu structure to give occupants and technicians intuitive access to system information. It shall have a minimum 4-line by 20-character display to allow an operator to query and adjust system values.
3. The system shall allow the connection of up to 16 LCD operator terminals to each Building Controller. The operator shall have the ability to connect to each of these operator terminals with a laptop computer via an RS-232 cable to gain system access, troubleshooting, and display programming.
4. Provide LCD operator terminals in the locations as determined by Developer/Design Builder.

E. Field Service Tool:

1. Field service tool shall allow technician to view and modify all setpoints and tuning parameters stored in application controller. In addition, technician shall be able to view status of all inputs and outputs on digital readout. Each piece of data shall have a data code associated with it that is customizable.
2. Field service tool shall plug into wall sensor and provide all the functionality specified. Operator workstation shall include the capability to disable operation of the field service tool.
3. Provide XX Field Service Tools for this project.

F. Network Connection Tool:

1. Network connection tool shall allow technician to connect a laptop to any MS/TP network or at any MS/TP device and view and modify all information throughout the entire BACnet network. Laptop connection to tool shall be via Ethernet or PTP.
2. Provide quick connect to MS/TP LAN at each controller. Tool shall be able to adjust to all MS/TP baud rates specified in the BACnet standard.
3. Proved XX Network Connection Tools for this project.

2.06 ELECTRONIC ACTUATORS AND VALVES

A. Quality Assurance for Actuators and Valves:

1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
3. Five-year manufacturers warranty. Two-year unconditional and three-year product defect from date of installation.

B. Execution Details for Actuators and Valves:

1. Furnish a Freeze-stat and install "Hard Wire" interlock to disconnect the mechanical spring return actuator power circuit for fail-safe operation. Use of the control signal to drive the actuators closed is not acceptable.
2. 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.
3. Terminal box damper actuation shall be Floating type or Analog (2-10vdc, 4-20ma).
4. Booster-heat valve actuation shall be Floating type or Analog (2-10vdc, 4-20ma).
5. Primary valve control shall be Analog (2-10vdc, 4-20ma).

C. Actuators for Damper and Control Valves ½" to 6" shall be Electric unless otherwise specified, provide actuators as follows:

1. UL Listed Standard 873 shall certify Actuators.
2. NEMA 2 rated actuator enclosures are. Use additional weather shield to protect actuator when mounted outside.

3. 5 year Manufacturers Warranty. Two-year unconditional + Three year product defect from date of installation.
4. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
5. 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.
6. 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 due 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.
7. A push button gearbox release shall be provided for all non-spring actuators.
8. Modulating actuators shall be 24Vac and consume 10VA power or less.
9. Conduit connectors are required when specified and when code requires it.

D. Damper Actuators:

1. Outside Air and Exhaust Air Damper Actuators shall be Mechanical Spring Return. Capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
2. Economizer Actuators shall utilize Analog control 2-10 VDC, Floating control is not acceptable.
3. Electric damper actuators (including terminal 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.
4. One 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 sufficient torque to drive both and damper drive shafts are both horizontal installed.
5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section. (See below execution section for more installation details.)

E. Valve Actuators ½" to 6":
1. All zone service actuators shall be non-spring return unless otherwise specified.
2. The valve actuator shall be capable of providing the minimum torque required for proper valve close off for the required application.
3. All control valves actuators shall have an attached 3-foot cable for easy installation to a junction box.
4. Override handle and gearbox release shall be provided for all non-spring return valve actuators.

F. Control Valves ½″ 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 2½ inch and above.

1. Characterized Control Valves shall be used for hydronic heating or cooling applications and small to medium AHU water coil applications to 100GPM. Actuators are non-spring return for terminal unit coil control unless otherwise noted.
   a. Leakage is Zero percent, Close-off is 200psi, Maximum differential is 30psi. Rangeablity is 500:1.
   b. Valves 1/2 inch through 2 inches shall be nickel-plated forged brass body, NPT screw type connections.
   c. Valves 1/2 inch through 1-1/4 inches shall be rated for ANSI Class 600 working pressure. Valves 1-1/2 inch and 2 inches shall be rated for ANSI Class 400 working pressure.
   d. The operating temperature range shall be 0° to 250° F.
   e. Stainless steel ball & stem shall be furnished on all modulating valves.

f.   Seats shall be fiberglass reinforced Teflon.

g.   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.

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

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

j.   The valves shall have a blow out proof stem design.

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

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

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

n.   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 stem and it's packing O-rings.

2.   Globe valves ½" to 2" shall be used for steam control or water flow applications.

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

b.   Valves 1/2 inch (DN15) through 2 inches (DN50) with spring return actuators shall close off against 50 psi pressure differential with Class III leakage (.1%).

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

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

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

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

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

3.   Globe Valve 2 ½ to 6":

a.   Valves 2-1/2 inch (DN65) through 6 inches (DN50) shall be iron body, 125 lb. flanged with Class III (.1%) close-off leakage at 50 psi differential.

b.   Valves with spring return actuators shall close off against 50 psi pressure differential with Class III leakage (.1%).

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

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

4.   All pressure independent valves for individual constant volume reheat coil control shall be provided as part of Hydronic Coil Piping / Hose Kit Package as specified in section 23 21 13. Control valve actuators will be supplied by the control contractors and shipped to the pressure independent valve manufacturer for factory installation. The control contractor is responsible for wiring and testing the valve actuators. Manufacturer shall confirm all GPM required for each valve.

G.   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

1.   Body is Cast Iron.

2.   Disc is Aluminum Bronze standard.

3.   Seat is EPDM Standard.

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

5.   Flange is ANSI 125/250.

6.   Media Temperature Range is –22F to 240F

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

H.   Butterfly Valve Industrial Actuators:

1.   Actuators shall be approved under Nationally Recognized Testing Laboratory to UL standards. CSA Class 4813 02 or equal. Enclosure shall be NEMA 4 (weatherproof) enclosure and will have an industrial quality coating.

   a.   Actuator shall have a motor rated for continuous duty. The motor shall be fractional horsepower; permanent split capacitor type designed to operate on a 120 VAC, 1 pH, 60 Hz supply. Two adjustable cam actuated end travel limit switches shall be provided to control direction of travel. A self-resetting thermal switch shall be imbedded in the motor for overload protection.

   b.   Reduction gearing shall be designed to withstand the actual motor stall torque. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.

   c.   Actuator shall have a 6 ft wiring harness provided for ease in field wiring (above 1500 in-lbs). Two adjustable SPDT cam-actuated auxiliary switches, rated at 250 VAC shall be provided for indication of open and closed position. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.

   d.   Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator and when in manual operation electrical power to the actuator will be permanently interrupted. The hand wheel will not rotate while the actuator is electrically driven.

   e.   The actuator shall be Analog, floating, or two position as called out in the control sequence of operation. All Analog valves shall be positive positioning, and respond to a 2-10 VDC, 4-20 mA, or adjustable signal as required. Analog actuators shall have a digital control card allowing any voltage input for control and any DC voltage feedback signal for position indication.

2.   Performance Verification Test:

   a.   Control loops shall cause productive actuation with each movement of the actuator and actuators shall modulate at a rate which is stable and responsive. Actuator movement shall not occur before the effects of previous movement have affected the sensor.

   b.   Actuator shall have capability of signaling a trouble alarm when the actuator Stop-Go Ratio exceeds 30%.

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

   a.   Damper Actuators: Shall not be installed in the air stream.

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

   c.   Damper or valve actuator ambient temperature shall not exceed 122 degrees 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

   d.   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.

   e.   Damper mounting arrangements shall comply to the following:

      1)   The ventilation subcontractor shall furnish and install damper channel supports and sheet metal collars.

      2)   No jack shafting of damper sections shall be allowed.

      3)   Multi-section dampers shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per section.

   f.   Size damper sections based on actuator manufacturers specific recommendations for face velocity, differential pressure and damper type. In general:

      1)   Damper section shall not exceed 24 sq ft. with face velocity @ 1500 FPM.

      2)   Damper section shall not exceed 18 sq ft. with face velocity @ 2500 FPM.

      3)   Damper section shall not exceed 13 sq ft. with face velocity @ 3000 FPM.

   g.   Multiple section dampers of two or more shall be arranged to allow actuators to be direct shaft mounted on the outside of the duct.

        h.   Multiple section dampers of three or more sections wide shall be arranged with a 3-sided vertical channel (8″ wide by 6″ deep) within the duct or fan housing and between adjacent damper sections. Vertical channel shall be anchored at the top and bottom to the fan housing or building structure for support. The sides of each damper frame shall be connected to the channels. Holes in the channel shall allow damper drive blade shafts to pass through channel for direct shaft mounting of actuators. Open side of channel shall be faced down stream of the airflow, except for exhaust air dampers.

        i.   Multiple section dampers to be mounted flush within a wall or housing opening shall receive either vertical channel supports as descried above or sheet metal standout collars. Sheet metal collars (12″ minimum) shall bring each damper section out of the wall to allow direct shaft mounting of the actuator on the side of the collar.

    4.   Valve Sizing for Water Coil

        a.   On/Off Control Valves shall be line size.

        b.   Modulating Control Valve Body Size may be reduced at most two pipe sizes from the line size or not less than ½ the pipe size. The BAS contractor shall size all water coil control valves for the application as follows:

            1)   Booster-heat valves shall be sized not to exceed 4-9psi 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.

            2)   Primary valves shall be sized not to exceed 5-15psi 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.

            3)   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.

        c.   Valve Mounting arrangements shall comply to the following:

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

            2)   Install three-way equal percentage Characterized Control valves in a mixing configuration with the "A" port piped to the coil.

            3)   Install 2½ inch and above, Three-Way globe valves, as manufactured for mixing or diverting service to the coil.

2.07   MISCELLANEOUS SENSORS AND DEVICES

A.   Temperature and relative humidity transmitters shall be Hycal, Model HT2 and designed for accurate, reliable HVAC control. Transmitters shall be supplied for duct and wall mounted applications. Transmitters shall be two-wire, 4-20ma with 0 to 100% RH and the selected temperature range; temperature compensated; 10-35 VDC input power; single point calibration.

B.   Averaging duct and central plant immersion temperature sensors shall be Hycal, Model CT-809; 2-wire; 4-20ma output with the ranges selected to provide the most accurate, consistent temperature control.

C.   Water flow transmitters shall be ONICON series 1200, dual turbine type; 4-20ma at 24VDC. Transmitters shall be selected based on pipe size and material (schedule). Transmitters to be installed for proper reading by following manufacturers instructions.

D.   Current switches shall be Veris, Model H908, or approved equal.

E.   Differential pressure transducer for shall be Setra, Model 264 for air and Model 230 for water, or approved equal.

F.   Filter differential pressure switches shall be Dwyer, Model 1910, or approved equal.

G.   Water differential pressure switches shall be Delta Pro, Model 24-014, or approved equal.

H.   High/low static pressure air sensing switch shall be a Model AFS-460, or approved equal.

I.   C02 sensors shall be Veris CWE, or approved equal.

2.08   ENCLOSURES

A.   All controllers, power supplies and relays shall be mounted in enclosures. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures shall be NEMA 4 when installed in other than a clean environment.

B.   Enclosures shall have hinged, locking doors.

C.   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

3.01   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 Countys' 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.

3.02   INSTALLATION (GENERAL)

A.   Install in accordance with manufacturer's instructions.

B.   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.

3.03   LOCATION AND INSTALLATION OF COMPONENTS

A.   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 County'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—sized to suit pipe diameter without restricting flow.

3.04   INTERLOCKING AND CONTROL WIRING

A.   Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 26. All wiring to be installed in conduit.

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 County's representative prior to rough-in.

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

E. Provide power for all control components from nearest electrical control panel—coordinate with Developer/Design Builder's electrical contractor.

F. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways.

G. All wiring to be installed in conduit.

H. Control power supply shall be from emergency power source for all equipment connected to emergency power.

3.05 TRADE RESPONSIBILITY MATRIX

	Item	Furnish By	Install By	Power By	Control Wiring By
1	Equipment Motors	M	M	E	N/A
2	Magnetic Motor Starters				
	a. Automatically controlled, with or without HOA switches.	E	E	E	HDCS
	b. Manually controlled.	E	E	E	N/A
	c. Manually controlled, and which are furnished as part of factory wired equipment.	M	M	E	E
	d. Special duty type (part winding, multi-speed, etc.	M	Note 1	E	Note 1
	e. Variable frequency drives with manual bypass	M	E	E	HDCS Note 2
3	General equipment disconnect switches, thermal overload switches, manual operating switches.	E	E	E	N/A
4	Sprinkler system water flow and tamper switches	M	M	E	E
5	Line voltage contactors.	E	E	E	E
6	Control relay transformers (other than starters)	HDCS	HDCS	E	HDCS
7	Main fuel oil tank alarms (high and low level), remote indication lights and HDCS monitoring.	M	M	E	HDCS
8	Day fuel tank oil alarms (high and low level), remote indication lights and FMCS monitoring.	M	M	E	HDCS
9	Line voltage control items such as line voltage thermostats not connected to HDCS	E	E	E	E
10	Loose controls and instruments furnished as part of the packaged mechanical equipment or required for operation, such as pumping systems, float controls, etc.	M	M	M	M
11	HDCS control and instrumentation panels	HDCS	HDCS	E	HDCS
12	Automatic control valves, and sensor wells for HDCS	HDCS	M	E	HDCS
13	Duct smoke detectors, smoke/fire dampers (secondary monitoring)	M	M	E	HDCS
14	Control interlock wiring or software integration wiring for pumps, VFD's, and other HDCS connected equipment	HDCS	HDCS	E	HDCS
15	Airflow control devices and transmitters	M	M	E	HDCS
16	Air terminal devices (VAV's, CAV's, etc.)	M	M	E	HDCS
17	Intelligent devices and control units furnished with packaged mechanical equipment such as air conditioning units, split system fan coils, heat pumps, etc.	M	M	E	HDCS

	Abbreviations
M	Mechanical Contractor, Division 23
E	Electrical Contractor, Division 26
HDCS	Direct Digital Control System, Division 27
N/A	Not applicable
	Notes
1	Magnetic motor starters (special duty type) shall be set in place under Electrical division except when part of factory wired equipment, in which Case set in place under Mechanical divisions
2	Where a remote motor disconnect is required in addition to the one provided integral to a Variable Frequency Drive (VFD), the HDCS Contractor shall provide the necessary control interlock between the disconnects.

3.06   DDC OBJECT TYPE SUMMARY

A.   Provide all database generation.

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

C.   Run Time Totalization: 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: All binary and analog object types (including zones) shall have the capability to be automatically trended.

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

F.   Database Save: Provide back-up database for all stand-alone application controllers on disk.

3.07   FIELD SERVICES

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

B.   Start-up and commission systems. Allow sufficient time for start-up and commissioning 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. County shall provide phone line for this service for 1 year or as specified.

D.   Provide County's Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

3.08   AS BUILT DOCUMENTATION

A.   After completion of the project, insert final approved shop drawings include the following information:

    1.   An operator's manual including detailed man-machine interface.
    2.   An operator's reference table listing the addresses of all connected input points and output points. Show settings where applicable.
    3.   A programmer's manual including all information necessary to perform the programming function.
    4.   A language manual including a detailed description of the language used and all routines, modules, etc., used by the system.

5. Flow charts of the software programs utilized in the system.
6. Complete program listing file, and parameter listing file for all programs.

B. Provide two (2) AutoCad (latest version) CD and one (1) full size reproducible of each control diagram and equipment schedule reflecting the "as-built" condition.

3.09 TRAINING

A. Provide application engineer to instruct County in operation of systems and equipment.

B. 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 and request of logs. Provide this training to a minimum of 3 persons.

C. Provide on-site training above as required, up to 32 hours as part of this contract.

D. Provide tuition for at least two individuals for a one-week factory training class. If applicable, costs for travel, lodging and meals will be the responsibility of the County.

3.10 DEMONSTRATION

A. Provide systems demonstration under provisions of Section 23 05 01.

B. Upon completion of the installation, start up the system and perform all necessary testing, debugging and calibration of each component in the entire system. Perform an acceptance test in the presence of the County's Representative. When the system performance is deemed satisfactory in whole or in part of the by the County's Representative, the part(s) of the system will be accepted.

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

D. Final system acceptance shall be contingent upon completion of final review and correction of all deficiencies. Satisfactory completion of the operational tests which shall demonstrate compliance with all performance and requirements of the Contract Documents.

PART 4 - SEQUENCE OF OPERATIONS

4.1 GENERAL

A. Provide a complete and operational temperature control and building automation system based on the following points and sequence of operation. The system shall be complete as to sequences and standard control practices. The determined point list is the minimum amount of points that are to be provided. If additional points are required to meet the sequence of operation, they will be provided.

B. BACnet Object List: The following points as defined for each piece of equipment are designated as follows:

1. Binary Out (BO) - Defined as any two-state output (start/stop) (enable/disable), etc.
2. Binary In (BI) - Defined as any two-state input (alarm, status), etc.
3. Analog In (AI) - Defined as any variable input (temperature) (position), etc.
4. Analog Out (AO) - Defined as any electrical variable output. 0–20mA, 4–20mA and 0–10VDC are the only acceptable analog outputs. The driver for analog outputs must come from both hardware and software resident in the controllers. Transducers will not be acceptable under any circumstance.

END OF SECTION