SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. The direct-digital control system as indicated on the project documents, point list, points list, drawings and as described in these specifications shall be incorporated into the existing APOGEE Building Automation System. This scope of work shall include the interconnection of the new devices into the existing working system including all engineering, programming, controls, and installation materials, installation labor, start-up, final project documentation and warranty.

B. All work under this Section shall be provided by the following Controls Company:

1. Energy Control and Design Company; Contact Steve Marthaler at (920) 739-6885.

1. The Controls Contractor’s work shall include all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, Warranty, specified services and items required for complete and fully functional Controls Systems.

B. Some products are furnished but not installed by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the installation of the products. These products include the following:

1. Control valves.
2. Sensor wells and sockets in piping.
3. Terminal unit controllers.

C. Some products are installed but not furnished by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors

formal acknowledgements in writing prior to submission the procurement of the products. These products include the following:

1. Factory-furnished accessory thermostats and sensors furnished with unitary equipment.

D. Some products are not provided by, but are nevertheless integrated with the work executed by, the contractor administered by this Section of the technical specifications.

E. Responsibility Table:

Work/Item/System	**Furnish**	**Install**	**Low Voltage Wiring**	**Line Power**
Control system low voltage and communication wiring	23 09 23	23 09 23	23 09 23	N/A
Terminal units	23	23	N/A	26
Controllers for terminal units	23 09 23	23	23 09 23	16
LAN conduits and raceway	23 09 23	23 09 23	N/A	N/A
Automatic dampers (not furnished with equipment)	23 09 23	23	N/A	N/A
Automatic damper actuators	23 09 23	23 09 23	23 09 23	23 09 23
Manual valves	23	23	N/A	N/A
Automatic valves	23 09 23	23	23 09 23	23 09 23
Pipe insertion devices and taps, flow and pressure stations.	23	23	N/A	N/A
Thermowells	23 09 23	23	N/A	N/A
Current Switches	23 09 23	23 09 23	23 09 23	N/A
Control Relays	23 09 23	23 09 23	23 09 23	N/A
Power distribution system monitoring interfaces	23 09 23	23 09 23	23 09 23	26
All control system nodes, equipment, housings, enclosures and panels.	23 09 23	23 09 23	23 09 23	26

F. This facility’s existing direct-digital APOGEE control system is manufactured by Siemens, and its ECC is located in B088 A/C room. The existing system’s top-end communications is via Ethernet cabling over the site network. The existing system’s ECC and top-end controllers were installed 15 to 20 years ago. The contractor administered by this Section of the technical specifications shall observe the capabilities, communication network, services, spare capacity of the existing control system and its ECC prior to beginning work.

G. This campus has an existing standard ASHRAE Standard 135, BACnet/IP Control System supported by a preselected controls service company. This entity is referred to as the "Control System Integrator" in this Section of the technical specifications. The Control system integrator is responsible for ECC system graphics and expansion. It also prescribes control system-specific commissioning/ verification procedures to the contractor administered by this Section of the technical specification. It lastly provides limited assistance to the contractor administered by this Section of the technical specification in its verification work.

1. The contractor administered by this Section of the technical specifications shall be responsible for all device mounting and wiring.

2. Responsibility Table:

Item/Task	**Section 23 09 23 contactor**	**VA**
ECC expansion	X	
ECC programming	X	
Devices, controllers, control panels and equipment	X	
Point addressing: all hardware and software points including setpoint, calculated point, data point(analog/ binary), and reset schedule point	X	
Point mapping	X	
Network Programming	X	
ECC Graphics	X	
Controller programming and sequences	X	
Integrity of LAN communications	X	
Electrical wiring	X	
Operator system training	X	
LAN connections to devices	X	
LAN connections to ECC	X	
IP addresses		X
Overall system verification	X	
Controller and LAN system verification	X	

H. The direct-digital control system shall start and stop equipment, move (position) damper actuators and valve actuators, and vary speed of equipment to execute the mission of the control system. Use electricity as the motive force for all damper and valve actuators.

1.2 RELATED WORK

A. Section 21 05 11, Common Work Results for Fire Suppression.

B. Section 23 21 13, Hydronic Piping.

C. Section 23 22 13, Steam and Condensate Heating Piping.

D. Section 23 31 00, HVAC Ducts and Casings.
E. Section 23 36 00, Air Terminal Units.
F. Section 26 05 11, Requirements for Electrical Installations.
G. Section 26 05 26, Grounding and Bonding for Electrical Systems.
H. Section 26 05 33, Raceway and Boxes for Electrical Systems.
I. Section 26 27 26, Wiring Devices.
J. Section 27 15 00, Communications Horizontal Cabling.

1.3 DEFINITION

A. Algorithm: A logical procedure for solving a recurrent mathematical problem; A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.
B. ARCNET: ANSI/ATA 878.1 - Attached Resource Computer Network. ARCNET is a deterministic LAN technology; meaning it's possible to determine the maximum delay before a device is able to transmit a message.
C. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
D. Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).
E. Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.
F. BMP or bmp: Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.
G. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.
H. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls
I. Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22-25 degrees C (72-78 degrees F), as opposed to a single point change over or overlap).
J. Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.

K. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.

L. Distributed Control System: A system in which the processing of system data is decentralized and control decisions can and are made at the subsystem level. System operational programs and information are provided to the remote subsystems and status is reported back to the Engineering Control Center. Upon the loss of communication with the Engineering Control center, the subsystems shall be capable of operating in a stand-alone mode using the last best available data.

M. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.

N. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.

O. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.

P. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.

Q. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.

R. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.

S. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.

T. Gateway: Communication hardware connecting two or more different protocols. It translates one protocol into equivalent concepts for the

other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.

U. GIF: Abbreviation of Graphic interchange format.

V. Graphic Program (GP): Program used to produce images of air handler systems, fans, chillers, pumps, and building spaces. These images can be animated and/or color-coded to indicate operation of the equipment.

W. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.

X. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input (AI, digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc, whereas digital signals convert electronic signals to digital pulses (values), represent motor status, filter status, on-off equipment etc.

Y. I/P: a method for conveying and routing packets of information over LAN paths. User Datagram Protocol (UDP) conveys information to “sockets” without confirmation of receipt. Transmission Control Protocol (TCP) establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

Z. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.

AA. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.

BB. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

CC. MS/TP: Master-slave/token-passing (ISO/IEC 8802, Part 3). It is not an acceptable LAN option for VA health-care facilities. It uses twisted-pair wiring for relatively low speed and low cost communication.

DD. Operating system (OS): Software, which controls the execution of computer application programs.

EE. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.

FF. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.

GG. Peer-to-Peer: A networking architecture that treats all network stations as equal partners- any device can initiate and respond to communication with other devices.

HH. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.

II. Sensors: Devices measuring state points or flows, which are then transmitted, back to the DDC system.

JJ. Thermostats: devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

KK. UCU: Unitary Control Unit, digital controller, dedicated to a specific piece of equipment such as VAV boxes, etc.

1.4 QUALITY ASSURANCE

A. Criteria:

1. The controls subcontractor shall be responsible for the complete design and installation of the system.
2. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be manufacturer’s latest standard design and have been tested and proven in actual use.
3. Provide a competent and experienced Project Manager employed by the Controls Contractor. The Project Manager shall be supported as necessary by other Contractor employees in order to provide professional engineering, technical and management service for the work. The Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the Controls Contractor.

B. Codes and Standards:

1. All work shall conform to the applicable Codes and Standards.
2. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.
3. Peer-to peer controllers, unitary controllers shall conform to the requirements of UL 916, Category PAZX.

1.5 PERFORMANCE

A. The system shall conform to the following:

1. Graphic Display: The system shall be programmed for the new control points and shall display them on the workstation screen in accordance with established site standards.
2. Graphic Refresh: The system shall update all dynamic points with current data within (10) seconds. Data refresh shall be automatic, without operator intervention.
3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be (10) seconds. Analog objects shall start to adjust within (3) seconds.
4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior (10) seconds.
5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.
8. Performance: Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every one (1) second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
9. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.
10. Reporting Accuracy: Listed below are minimum acceptable reporting end-to-end accuracies for all values reported by the specified system:

Measured Variable	**Reported Accuracy**
Space temperature	±0.5°C (±1°F)
Ducted air temperature	±0.5°C [±1°F]

Outdoor air temperature	±1.0°C [±2°F]
Dew Point	±1.5°C [±3°F]
Water temperature	±0.5°C [±1°F]
Relative humidity	±2% RH
Water flow	±1% of reading
Air flow (terminal)	±10% of reading
Air flow (measuring stations)	±5% of reading
Air pressure (ducts)	±25 Pa [±0.1"w.c.]
Air pressure (space)	±0.3 Pa [±0.001"w.c.]
Water pressure	±2% of full scale *Note 1
Electrical Power	±0.5% of reading

Note 1: for both absolute and differential pressure

11. Extent of direct digital control: control design shall allow for at least the points indicated on the points lists on the drawings.

1.6 WARRANTY

A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in FAR clause 52.246-21.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.

C. The on-line support service shall allow the Controls supplier to Internet (VPN)to monitor and control the facility's building automation system.

D. Controls and Instrumentation subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA.

1.7 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer's literature and data for all components including the following:

1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as

well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.

2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated point names.
3. Control dampers and control valves schedule, including the size and pressure drop.
4. Catalog cut sheets of all equipment used. This includes, but is not limited to DDC controllers, panels, peripherals, airflow measuring stations and associated components, and auxiliary control devices such as sensors, actuators, and control dampers. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent.
5. Sequence of operations for each HVAC system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.
6. Color prints of proposed graphics with a list of points for display.

C. Product Certificates: Compliance with Article, QUALITY ASSURANCE.

D. As Built Control Drawings:

1. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.
2. Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.

E. Operation and Maintenance (O/M) Manuals):

1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS.
2. Include the following documentation:
   a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.

b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.
c. Complete troubleshooting procedures and guidelines for all systems.
d. Complete operating instructions for all systems.
e. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.
f. Licenses, guaranty, and other pertaining documents for all equipment and systems.

F. Submit Performance Report to Contracting Officer Representative (COR) prior to final inspection.

1.8 INSTRUCTIONS

A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below.
1. Provide on the job training during start-up, checkout period, and performance test period. VA facilities personnel will work with the Contractor's installation and test personnel on a daily basis during start-up and checkout period. During the performance test period, controls contactor will provide for a total of 2 hours, during the performance test period of the control system, at a time mutually agreeable to the Contractor and the VA.
2. The O/M Manuals shall contain approved submittals as outlined in Article 1.7, SUBMITTALS. The Controls subcontractor will review the manual contents with VA facilities personnel during second phase of training.
3. Training shall be given by direct employees of the EC&D.

1.9 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

A. The ECC and peripheral devices and system support equipment shall be designed to operate in ambient condition of 0 to 55°C (32 to 122°F) at a relative humidity of 10 to 90% non-condensing.
B. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.
C. Sensors and controlling devices shall be designed to operate in the environment, which they are sensing or controlling.

1.10 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

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

Standard 135-10.....BACNET Building Automation and Control Networks

C. American Society of Mechanical Engineers (ASME):

B16.18-01.....Cast Copper Alloy Solder Joint Pressure Fittings.
B16.22-01.....Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

D. American Society of Testing Materials (ASTM):

B32-08.....Standard Specification for Solder Metal
B88-09.....Standard Specifications for Seamless Copper Water Tube
B88M-09.....Standard Specification for Seamless Copper Water Tube (Metric)
B280-08.....Standard Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service
D2737-03.....Standard Specification for Polyethylene (PE) Plastic Tubing

E. Federal Communication Commission (FCC):

Rules and Regulations Title 47 Chapter 1-2001 Part 15: Radio Frequency Devices.

F. Institute of Electrical and Electronic Engineers (IEEE):

802.3-11.....Information Technology-Telecommunications and Information Exchange between Systems-Local and Metropolitan Area Networks- Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access method and Physical Layer Specifications

G. National Fire Protection Association (NFPA):

70-11.....National Electric Code
90A-09.....Standard for Installation of Air-Conditioning and Ventilation Systems

H. Underwriter Laboratories Inc (UL):

94-10.....Tests for Flammability of Plastic Materials for Parts and Devices and Appliances
294-10.....Access Control System Units
486A/486B-10.....Wire Connectors
555S-11.....Standard for Smoke Dampers
916-10.....Energy Management Equipment
1076-10.....Proprietary Burglar Alarm Units and Systems

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Spare parts shall be available for at least five years after completion of this contract.

2.2 CONTROLS SYSTEM ARCHITECTURE

A. General

1. The Controls Systems shall consist of multiple Nodes and associated equipment connected by industry standard digital and communication network arrangements.
2. The networks shall, at minimum, comprise, as necessary, the following:
   a. Existing network computer processing, data storage and communication equipment including Servers and digital data processors.
   b. Existing routers, bridges, switches, hubs, modems, gateways, interfaces and similar communication equipment.
   c. Active processing network area controllers together with their power supplies and associated equipment.
   d. Addressable elements, sensors, transducers and end devices.
   e. Third-party equipment interfaces as required by the Contract Documents.
   f. Other components required for a complete and working Control Systems as specified.

B. The Specifications for the individual elements and component subsystems shall be minimum requirements and shall be augmented as necessary by the Contractor to achieve both compliance with all applicable codes, standards and to meet all requirements of the Contract Documents.

C. Existing Network Architecture

1. The Controls system Application network shall utilize an open architecture capable of each and all of the following: Utilize standard Ethernet communications and operate at a minimum speed of 10/100 MB/sec.
2. The networks shall utilize only copper communication media as appropriate and shall comply with applicable codes, ordinances and regulations.

3. All necessary telephone lines, ISDN lines and internet Service Provider services and connections will be provided by the VA.

D. Third Party Interfaces:

1. The Other manufacturers and contractors supplying other associated systems and equipment shall provide their necessary hardware, software and start-up at their cost and shall cooperate fully with the contractor administered by this Section of the technical specifications in a timely manner and at their cost to ensure complete functional integration.

E. Servers:

1. Utilize existing Controls System Application Server(s) to archive historical data including trends, alarm and event histories and transaction logs.

2.3 COMMUNICATION (RESERVED)

2.4 ENGINEERING CONTROL CENTER (ECC) (RESERVED)

2.5 PORTABLE OPERATOR'S TERMINAL (POT) (RESERVED)

2.6 BACNET PROTOCOL ANALYZER (RESERVED)

2.7 NETWORK AND DEVICE NAMING CONVENTION (RESERVED)

2.8 BACNET DEVICES (RESERVED)

2.9 CONTROLLERS

1. Contractor shall utilize existing controllers where necessary and provide new if required for the functioning of the controls to the new VAV boxes within the space.

2.10 SPECIAL CONTROLLERS (RESERVED)

2.11 SENSORS (AIR, WATER AND STEAM)

A. Sensors' measurements shall be read back to the existing APOGEE system, and shall be visible by the computers.

B. Temperature and Humidity Sensors shall be electronic, vibration and corrosion resistant for wall, immersion, and/or duct mounting. Provide all remote sensors as required for the systems.

1. Temperature Sensors: thermistor type for terminal units and Resistance Temperature Device (RTD) with an integral transmitter type for all other sensors.

a. Duct sensors shall be rigid or averaging type as shown on drawings. Averaging sensor shall be a minimum of 1 linear ft of sensing element for each sq ft of cooling coil face area.

b. Immersion sensors shall be provided with a separable well made of stainless steel, bronze or monel material. Pressure rating of

well is to be consistent with the system pressure in which it is to be installed.

c. Space sensors shall be equipped with in-space set-point adjustment, override switch, numerical temperature display on sensor cover, and communication port a shown on the drawings. Match room thermostats.

1) Public space sensor: setpoint adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Do not provide in-space User set-point adjustment. Provide an opaque keyed-entry cover if needed to restrict in-space User set-point adjustment.

d. Wire: Twisted, shielded-pair cable.

e. Output Signal: 4-20 ma.

2. Humidity Sensors: (reserved)

C. Static Pressure Sensors: Non-directional, temperature compensated.

1. 4-20 ma output signal.

2. 0 to 5 inches wg for duct static pressure range.

3. 0 to 0.25 inch wg for Building static pressure range.

D. Water flow sensors: (Reserved)

E. Water Flow Sensors: (reserved)

F. Steam Flow Sensor/Transmitter: (reserved)

G. Flow switches:

1. Shall be either paddle or differential pressure type.

a. Paddle-type switches (liquid service only) shall be UL Listed, SPDT snap-acting, adjustable sensitivity with NEMA 4 enclosure.

b. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap acting, NEMA 4 enclosure, with scale range and differential suitable for specified application.

H. Current Switches: Current operated switches shall be self powered, solid state with adjustable trip current as well as status, power, and relay command status LED indication. The switches shall be selected to match the current of the application and output requirements of the DDC systems.

2.12 CONTROL CABLES

A. EC&D shall furnish and install all necessary control cables for the existing Siemens APOGEE system as required in the drawings.

2.13 THERMOSTATS AND HUMIDISTATS

A. Room thermostats shall be furnished and installed by EC&D as required in the drawings.

2.14 FINAL CONTROL ELEMENTS AND OPERATORS

A. Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.

B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.

C. Control Valves:

1. The modulating control vales shall be pressure independent. The flow through the valve shall not vary more than +/- 3% due to system pressure fluctuations across the valve in the selected operating range. The control valves shall accurately control the flow from 0 to 100% full rated flow. A flow performance curve shall be furnished with each valve. The flow performance curve hall list flows at all the valve positions in 10-degree rotation increments. A maximum of 5 PSI shall be required to operate the valve pressure independently through the complete operating range.
2. The rangeability of the control valves shall be 100:1 minimum. This rangeability and turndown shall be at full differential pressure provided by the pump serving the hydronic loop where that particular control valve is located. The close off pressure of all control valves shall be the full body rating of the valves.
3. The valve bodies shall be of cast iron, steel or bronze and rated at 150 PSI working pressure. All internal parts shall be stainless steel, steel, Teflon, brass, or bronze. Plastic internal parts are not acceptable. Valve flow characteristics shall be able to be changed without removing the valve from the piping system in all valves 8” or smaller.
4. Balancing valves shall not be required where pressure independent control valves are installed. Balancing valves and balancing are required if modulating pressure independent flow control valves are not installed.
5. The valve actuators shall be mounted on the valves at the factory. Where DDC proportional actuators are utilized, the end stroke of the actuator shall be set with the software (limit control signal) at full design flow from data off the performance curves.

6. The control actuator for all valves shall modulate the control valve from 0 to 100% design flow while rotating the valve stem a maximum of 90 degrees.
7. The control valve flow adjustment stem shall extend up from the control valve. The control valve shall have mounting holes tapped into it for mounting the control actuator bracket. This valve stem is rotated by the actuator to provide the required flow. Please contact the valve manufacturer for torque requirements.
8. Three pressure / temperature ports (Pete's Plugs) shall be installed at the factory in each valve. Two ports shall be used to measure inlet and outlet pressure to the valve. The third port is used to measure internal pressure within the valve.
9. Flow rate through the valve shall be determined by the valve stem position.
10. Valves 50 mm (2 inches) and smaller shall be bronze body with threaded or flare connections.
11. Valves 60 mm (2 1/2 inches) and larger shall be bronze or iron body with flanged connections.

2.15 AIR FLOW CONTROL (RESERVED)

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to Resident Engineer for resolution before proceeding for installation.
2. Work Coordination: Section 01 00 00, GENERAL REQUIREMENTS.
3. Install equipment, piping, wiring /conduit parallel to or at right angles to building lines.
4. Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.
5. Mount control devices, tubing and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
6. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

7. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
8. Install equipment level and plum.
9. Provide all sensors and wiring to monitor unit status, valve status, hot water supply and return temperatures, and all other points listed in the specifications or on the drawings.

A. Electrical Wiring Installation:

1. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section. All wiring shall be installed in conduit.
2. Install all system components in accordance with local Building Code and National Electric Code.
   a. Splices: Splices in shielded cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties within cabinets and run in conduit outside of cabinets.
   b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Cables shall be supported for minimum sag.
   c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board.
   d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.
3. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.
4. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
5. Grounding: ground electrical systems per manufacturer’s written requirements for proper and safe operation.

C. Install Sensors and Controls:

1. Temperature Sensors:
   a. Install all sensors and instrumentation according to manufacturer’s written instructions. Temperature sensor locations

shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.

b. Calibrate sensors to accuracy specified, if not factory calibrated.

c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.

d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor.

e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors form contact with metal casings and coils using insulated standoffs.

f. All pipe mounted temperature sensors shall be installed in wells.

h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.

i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Pressure Sensors:

a. Install duct static pressure sensor tips facing directly downstream of airflow.

b. Install high-pressure side of the differential switch between the pump discharge and the check valve.

c. Install snubbers and isolation valves on steam pressure sensing devices.

3. Actuators:

a. Mount and link damper and valve actuators according to manufacturer’s written instructions.

b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.

c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

4. Flow Switches:

a. Install flow switch according to manufacturer's written instructions.
b. Mount flow switch a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 600 mm (2 feet) whichever is greater, from fittings and other obstructions.
c. Assure correct flow direction and alignment.
d. Mount in horizontal piping-flow switch on top of the pipe.

D. Installation of network: Program the existing network for the new points.
1. Ethernet:
a. The network shall employ Ethernet LAN architecture, as defined by IEEE 802.3. The Network Interface shall be fully Internet Protocol (IP) compliant allowing connection to currently installed IEEE 802.3, Compliant Ethernet Networks.
b. The network shall directly support connectivity to a variety of cabling types. As a minimum provide the following connectivity: 100 Base TX (Category 5e cabling) for the communications between the ECC and the controllers.
2. Third party interfaces: Contractor shall integrate real-time data from building systems by other trades and databases originating from other manufacturers as specified and required to make the system work as one system.

E. Installation of digital controllers and programming:
1. System point names shall be modular in design, permitting easy operator interface without the use of a written point index.
2. Provide software programming for the applications intended for the systems specified, and adhere to the strategy algorithms provided.
3. Provide graphics for each piece of equipment and floor plan as shown on the drawings. This includes each terminal unit, etc. These graphics shall show all points dynamically as specified in the point list.

3.2 SYSTEM VALIDATION AND DEMONSTRATION

A. As part of final system acceptance, a system demonstration is required (see below). Prior to start of this demonstration, the contractor is to perform a complete validation of the new controls and instrumentation system as shown on the drawings.

B. Validation

1. Prepare and submit for approval a validation test plan including test procedures for the performance verification tests. Test Plan shall address all specified functions of the ECC and all specified sequences of operation. Explain in detail actions and expected results used to demonstrate compliance with the requirements of this specification. Explain the method for simulating the necessary conditions of operation used to demonstrate performance of the system. Test plan shall include a test check list to be used by the Installer’s agent to check and initial that each test has been successfully completed. Deliver test plan documentation for the performance verification tests to the owner’s representative 30 days prior to start of performance verification tests. Provide draft copy of operation and maintenance manual with performance verification test.
2. After approval of the validation test plan, installer shall carry out all tests and procedures therein. Installer shall completely check out, calibrate, and test all connected hardware and software to insure that system performs in accordance with approved specifications and sequences of operation submitted. Installer shall complete and submit Test Check List.

C. Demonstration

1. System operation and calibration to be demonstrated by the Installer in the presence of the Architect or Owner's representative on random samples of equipment as dictated by the Owner’s representative. Should random sampling indicate improper commissioning, the owner reserves the right to subsequently witness complete calibration of the system at no addition cost to the owner.
2. Demonstrate to authorities that all required safeties and life safety functions are fully functional and complete.
3. Make accessible personnel to provide necessary adjustments and corrections to systems as directed by balancing agency.
4. General:
   a. Engage a factory-authorized representative and furnish personnel, instrumentation, and equipment necessary to perform complete testing of the installed HVAC systems, including piping and electrical connections. Field test will demonstrate proper calibration of input and output devices, and the operation of specific equipment.

b. Calibrate electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
d. Observe HVAC systems in shut down condition. Check dampers and valves for normal position.
e. Contractor shall schedule the performance verification test with the COTR.
f. During and after completion of the field tests, contractor shall determine causes, calibrate, repair, or replace equipment that fails to meet contract requirements, and subsequently deliver a written report to the VA. Provide COR graphics of installed unit performance through Insight.

5. Field Performance Tests:
   a. Perform tests in accordance with Articles-Quality Assurance and Performance.
   b. Test and adjust controls and safeties.
   c. Test application software for its ability to communicate with digital controllers, operator workstation, and uploading and downloading of control programs.
   d. Demonstrate the software ability to edit the control program off-line.
   e. Demonstrate reporting of alarm conditions for each alarm and ensure that these alarms receive at the assigned location, including operator workstations.
   f. Demonstrate ability of software program that it functions for the intended applications-trend reports, change in status etc.
   g. Demonstrate via graphed trends to show the sequence of operation is executed in correct manner, and that the HVAC systems operate properly through the complete sequence of operation, e.g., seasonal change, occupied/unoccupied mode, and warm-up condition.
   h. Demonstrate hardware interlocks and safeties functions, and that the control systems perform the correct sequence of operation after power loss and resumption of power loss.
   i. Demonstrate to the VA graphed trends of control loops to demonstrate that the control loop is stable and the set points are maintained.

j. Control loop shall respond to set points and stabilize in one (1) minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.

6. Performance Verification Test:

a. The contractor shall verify the performance of the control systems by running a continuous test, after the system has been completely tested and debugged, for 80 hours and submit the report to the VA.

----- END -----

INTENTIONALLY LEFT BLANK