SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. A complete new stand-alone direct digital control system shall be provided under this project to serve the new equipment and renovated areas of this project. The system shall be a Direct Digital Control System utilizing electric actuation.

B. The Contractor administered by this section of the technical specifications must be in the business of installing direct digital controls for over three (3) years and must have installed and completed at least ten (10) direct digital temperature control jobs of similar design using the same model of equipment as specified. The Contractor administered by this section of the technical specifications must be a <u>Licensed Factory Representative and Installer</u> of the manufacturer's specified for the local area, and shall have a local engineering and service office within 90 miles of the job site.

C. The basic control system shall include all sensors, controllers, instruments, valves, actuators, devices, installation and service for a complete and functional control system. All control devices (valves, dampers, actuators, etc.) are included under the controls work unless specifically specified elsewhere in the Specifications. Control system shall be designed to allow easy field adjustment of all setpoints and parameters.

D. Cooperate with the HVAC Contractor and other Subcontractors in identifying active or inactive pneumatic tubing, control wiring, equipment, etc., and assist in the actual removal. Remove all pneumatic tubing, control wiring and control devices not required to accommodate the renovated areas and new control system.

E. Provide (a) direct-digital control system(s) as indicated on the project documents, point list, interoperability tables, drawings and as described in these specifications. Include a complete and working direct-digital control system. Include all engineering, programming, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.

1. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135 (BACNet), ANSI/EIA/CEA-709 (LONTalk), MODBUS Application Protocol V-

1.1b, OPC, and other open and proprietary communication protocols in one open, interoperable system.

2. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135, (BACnet) and ANSI/EIA/CEA-709 (LonMark) to assure interoperability between all system components is required. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP,) and/or RS-485 (BACnet MSTP) as specified.

3. The supplied system shall incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.

4. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

5. The work administered by this Section of the technical specifications 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.

6. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. The contractor administered by this Section of the technical specifications shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system

shall continue to operate independently. Failure of the ECC shall have no effect on the field controllers, including those involved with global strategies.

7. The control system shall accommodate one (1) Engineering Control Centerand the control system shall accommodate multiple web-based Users simultaneously, and the access to the system shall be limited only by operator password.

F. 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 but are not limited to the following:

1. Control valves.

2. Flow switches.

3. Flow meters.

4. Sensor wells and sockets in piping.

5. Terminal unit controllers.

G. 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 but are not limited to the following:

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

H. 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. 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 particulars of the products. These products include the following:

1. Chiller controls.

2. Terminal units' velocity sensors

3. Variable frequency drives.

I. 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, jack & cabling	Div 27	Div 27	Div 27	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
Interface with chiller controls	23 09 23	23 09 23	23 09 23	26
Chiller controls interface with control system	23	23	23 09 23	26
All control system nodes, equipment, housings, enclosures and panels.	23 09 23	23 09 23	23 09 23	26
Smoke detectors	28 31 00	28 31 00	28 31 00	28 31 00
Fire/Smoke Dampers	23	23	28 31 00	28 31 00
Smoke Dampers	23	23	28 31 00	28 31 00
Fire Dampers	23	23	N/A	N/A
Chiller/starter interlock wiring	N/A	N/A	26	26
Chiller Flow Switches	23	23	23	N/A
VFDs	26	26	23 09 23	26
Fire Alarm shutdown relay interlock wiring	28	28	28	26
Fan Coil Unit controls (not	23 09 23	23 09 23	23 09 23	26

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
furnished with equipment)				
Unit Heater controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Starters, HOA switches	26	26	N/A	26

J. Unitary standalone systems including Unit Heaters, Cabinet Unit Heaters, Fan Coil Units, Base Board Heaters, thermal comfort ventilation fans, and similar units for control of room environment conditions may be equipped with integral controls furnished and installed by the equipment manufacturer or field mounted. Refer to equipment specifications and as indicated in project documents. Application of standalone unitary controls is limited to at least those systems wherein remote monitoring, alarm and start-up are not necessary. Examples of such systems include:

1. Light-switch-operated toilet exhaust

2. Vestibule heater

3. Exterior stair heater

4. Attic heating and ventilation

5. Mechanical or electrical room heating and ventilation.

K. 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 23 21 13, Hydronic Piping.

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

C. Section 23 31 00, HVAC Ducts and Casings.

D. Section 23 73 00, Indoor Central-Station Air-Handling Units.

E. Section 26 05 11, Requirements for Electrical Installations.

F. Section 26 05 21, Low-Voltage Electrical Power Conductors and Cables (600 Volts and Below).

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 26 29 11, Motor Starters.

1.3 DEFINITIONS

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. BACnet: A Data Communication Protocol for Building Automation and Control Networks , ANSI/ASHRAE Standard 135. This communications protocol allows diverse building automation devices to communicate data over and services over a network.

E. BACnet/IP: Annex J of Standard 135. It defines and allows for using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP sub-networks that share the same BACnet network number.

F. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may sue different LAN technologies.

G. BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.

H. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.

I. BACnet Broadcast Management Device (BBMD): A communications device which broadcasts BACnet messages to all BACnet/IP devices and other BBMDs connected to the same BACnet/IP network.

J. BACnet Interoperability Building Blocks (BIBBs): BACnet Interoperability Building Blocks (BIBBs) are collections of one or more BACnet services. These are prescribed in terms of an "A" and a "B" device. Both of these devices are nodes on a BACnet internetwork.

K. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.

L. 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).

M. 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.

N. 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.

O. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.

P. 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

Q. 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).

R. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.

S. Device Object: Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.

T. Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135-2008, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.

U. 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.

V. 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.

W. 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.

X. 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.

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

Z. 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.

AA. 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.

BB. 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.

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

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

EE. 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.

FF. GIF: Abbreviation of Graphic interchange format.

GG. 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.

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

II. 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.

JJ. 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.

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

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

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

NN. 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.

OO. Native BACnet Device: A device that uses BACnet as its primary method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.

PP. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.

QQ. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

RR. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

SS. Object Properties: Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

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

UU. 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.

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

WW. 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.

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

YY. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.

ZZ. Repeater: A network component that connects two or more physical segments at the physical layer.

AAA. Router: a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.

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

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

1.4 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: The Contractor shall obtain hardware and software supplied under this Section and delegate the responsibility to a single source controls installation subcontractor. The controls subcontractor shall be responsible for the complete design, installation, and commissioning of the system. The controls subcontractor shall be in the business of design, installation and service of such building automation control systems similar in size and complexity.

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. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this Section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative would observe the control systems in full operation.

4. The controls subcontractor shall have in-place facility within 90 miles with technical staff, spare parts inventory for the next five (5) years, and necessary test and diagnostic equipment to support the control systems.

5. The controls subcontractor shall have minimum of three years experience in design and installation of building automation systems similar in performance to those specified in this Section. Provide evidence of experience by submitting resumes of the project manager, the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the

supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.

6. 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 attend scheduled Project Meetings as required and 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.

1.5 PERFORMANCE

A. The system shall conform to the following:

1. Graphic Display: The system shall display up to four (4) graphics on a single screen with a minimum of twenty (20) dynamic points per graphic. All current data shall be displayed within ten (10) seconds of the request.

2. Graphic Refresh: The system shall update all dynamic points with current data within eight (8) 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 two(2) seconds. Analog objects shall start to adjust within two (2) 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 six (6) 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. 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]
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

10. Control stability and accuracy: Control sequences shall maintain measured variable at setpoint within the following tolerances:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.)	0–1.5 kPa (0–6 in. w.g.)
Air Pressure	±3 Pa (±0.01 in. w.g.)	-25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi)	0–1 MPa (1–150 psi)
Fluid Pressure	±250 Pa (±1.0 in. w.g.)	0–12.5 kPa (0–50 in. w.g.) differential

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 government. 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 connect via (through password-limited access) VPN through the internet monitor and control the facility's building automation system. This remote connection to the facility shall be within two (2) hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekend and holidays. If the problem cannot be resolved with on-line support services, the Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 24 hours after the problem is reported.

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 software (by manufacturer and by third parties), 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 shall 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.

7. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.

8. Schematic wiring diagrams for all control, communication and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.

9.   An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.

10. Riser diagrams of wiring between central control unit and all control panels.

11. Scaled plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.

12. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.

13. Quantities of submitted items may be reviewed but are the responsibility of the contractor administered by this Section of the technical specifications.

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

D.   Licenses: Provide open licenses for all software residing on and used by the Controls Systems and transfer these open licenses to the VA prior to completion.

E.   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) stick set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.

3.   Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.

F.   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. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.

    d. Complete troubleshooting procedures and guidelines for all systems.

    e. Complete operating instructions for all systems.

    f. 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.

    g. Training Manuals: Submit the course outline and training material to the COTR for approval three (3) weeks prior to the training of VA facility personnel. These persons will be responsible for maintaining and the operation of the control systems, including programming. The COTR reserves the right to modify any or all of the course outline and training material.

    h. Licenses, guaranty, and other pertaining documents for all equipment and systems.

G. Submit Performance Report to COTR prior to final inspection.

1.8 INSTRUCTIONS

1. A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below. Contractor shall also video tape instruction sessions noted below. First Phase: Formal instructions to the VA facilities personnel for a total of 20 hours, given in multiple training sessions (each no longer than four hours in length), conducted sometime between the completed installation and prior to the performance test period of the control system, at a time mutually agreeable to the Contractor and the VA. A minimum of eight hours shall be dedicated to programming.

2. Second Phase: This phase of training shall comprise of 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 subcontractor shall provide 20 hours of instructions, given in multiple training sessions (each no longer than four hours in length), to the VA facilities personnel.

3. The O/M Manuals shall contain approved submittals as outlined in Article 1.7, SUBMITTALS. The Controls subcontractor shall review the manual contents with VA facilities personnel during second phase of training.

4. Training shall be given by direct employees of the controls system subcontractor.

1.9 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

A. The peripheral devices and system support equipment shall be designed to operate in ambient condition of 20 to 35°C (65 to 90°F) at a relative humidity of 20 to 80% non-condensing.

B. The CUs used outdoors shall be mounted in NEMA 4 waterproof enclosures, and shall be rated for operation at –40 to 65°C (-40 to 150°F).

C. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.

D. 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 135-08 .... BACNET Building Automation and Control Networks

C. American Society of Mechanical Engineers (ASME):

B16.18-05 .... Cast Copper Alloy Solder Joint Pressure Fittings.
B16.22-05 .... Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

D. American Society of Testing Materials (ASTM):

B32-04 .... Standard Specification for Solder Metal
B88-03 .... Standard Specifications for Seamless Copper Water Tube
B88M-05 .... Standard Specification for Seamless Copper Water Tube (Metric)
B280-03 .... 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):

802.3-05 ....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):

70-08 ....National Electric Code
90A-09 ....Standard for Installation of Air-Conditioning and Ventilation Systems

H. Underwriter Laboratories Inc (UL):

94-06 ....Tests for Flammability of Plastic Materials for Parts and Devices and Appliances
294-05 ....Access Control System Units
486A/486B-04- ....Wire Connectors
555S-06.................................Standard for Smoke Dampers
916-07 ....Energy Management Equipment
1076-05 ....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. The Direct Digital Control (DDC) system shall be based on the Niagara^{AX} Framework (or "Niagara^{AX}"), a Java-based framework developed by Tridium. Systems not developed on the Niagara^{AX} Framework platform are unacceptable.

All NiagaraAX software shall have an open license; i.e., shall have the following NiagaraAX Compatibility Statement (NICS): "accept.station.in=*"; "accept.station.out=*" and "accept.wb.in:=" and "accept.wb.out=* ".

1.   The contractor administered by this section of the technical specifications shall install a new, independent Cat5 communication network between Building Controllers

(BC) and Programmable Equipment Controllers (PEC) communicating utilizing FOX TCP/IP communications protocol, in the same contiguous building structure.

2. Application Specific Controllers (ASC) shall communicate via LonMark/LonTalk and/or BACnet MS/TP communication protocols to Building Controllers (BC) or Programmable Equipment Controllers (PEC).

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. Network Architecture

1. The Controls communication network shall utilize FOX TCP/IP communications protocol operating over a standard Ethernet LAN and operate at a minimum speed of 100 Mb/sec.

2. The networks shall utilize only copper and optical fiber communication media as appropriate and shall comply with applicable codes, ordinances and regulations. They may also utilize digital wireless technologies as appropriate to the application and if approved by the VA.

D. Third Party Interfaces:

1. The contractor administered by this Section of the technical specifications shall include necessary hardware, equipment, software and programming to allow data communications between the controls systems and building systems supplied by other trades.

2. 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. **Integration into Existing Controls System**:

1. **The new independent controls system, provided in this project, shall be networked with the existing Niagara^{AX} JACE 200 building controller, located in the basement pump room, per the requirements of paragraph A-1 above**.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a FOX TCP/IP internetwork..

1. The Data link / physical layer protocol (for communication) acceptable to the VA throughout its facilities is Ethernet (ISO 8802-3).

B. Each controller shall have a communication port for connection to an operator interface.

C. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internetwork controller.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified control system operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address.

D. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring. Expansion shall not require operator interface hardware additions or software revisions.

E. Controllers with real-time clocks shall use the Niagara AX Time Synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable.

2.4 PORTABLE OPERATOR'S TERMINAL (POT)

A. Provide a portable operator's terminal (POT) that shall be capable of accessing all system data. POT may be connected to any point on the system network or may be connected directly to any controller for programming, setup, and troubleshooting. POT may be connected to any point on the system network or it may be connected directly to controllers POT shall be an IBM-compatible notebook-style PC including all software and hardware required. In order to function effectively at this facility, POT **must** be

compatible with guardian-edge encryption software. The Contractor administered by this section of the technical specifications shall provide a letter from the manufacturer of the POT, verifying compliance with this requirement.

B. Hardware:

1. POT shall be commercial standard with supporting 32- or 64-bit hardware (as limited by the direct-digital control system software) and software enterprise server. Internet Explorer v6.0 SP1 or higher, Windows Script Hosting version 5.6 or higher, Windows Message Queuing, Windows Internet Information Services (IIS) v5.0 or higher, minimum 2.8 GHz processor, minimum 500 GB 7200 rpm SATA hard drive with 16 MB cache, minimum 2GB DDR3 SDRAM (minimum 1333 Mhz) memory, 512 MB video card, minimum 16 inch (diagonal) screen, 10-100-1000 Base-TX Ethernet NIC with an RJ45 connector or a 100Base-FX Ethernet NIC with an SC/ST connector, 56,600 bps modem, an ASCII RS-232 interface, and a 16 speed high density DVD-RW+/- optical drive.

C. Software: POT shall include software equal to the software on the PEC's and Building Controllers.

2.5 BACNET AND LON PROTOCOL ANALYZERS

A. For ease of troubleshooting and maintenance, provide a BACnet protocol analyzer. Provide its associated fittings, cables and appurtenances, for connection to the communications network. The BACnet protocol analyzer shall be able to, at a minimum: capture and store to a file all data traffic on all network levels; measure bandwidth usage; filter out (ignore) selected traffic.

B. For ease of troubleshooting and maintenance, provide a LON network protocol analyzer. Provide its associated fittings, cables and appurtenances, for connection to the communications network. The LON network protocol analyzer shall be able to, at a minimum: capture and store to a file all data traffic on all network levels; measure bandwidth usage; filter out (ignore) selected traffic.

2.6 NETWORK AND DEVICE NAMING CONVENTION

A. Network Numbers

1. Network numbers shall be based on a "facility code, network" concept. The "facility code" is the VAMC's or VA campus' assigned numeric value assigned to a specific

facility or building. The "network" typically corresponds to a "floor" or other logical configuration within the building.

2. The network numbers are thus formed as follows: "Net #" = "FFFNN" where:

   a. FFF   = Facility code (see below)

   b. NN   = 00-99   This allows up to 100 networks per facility or building

B. Device Instances

1. . Using Agency's unique device instances are formed as follows: "Dev #" = "FFFNNDD" where

   a. FFF and N are as above and

   b. DD   = 00-99, this allows up to 100 devices per network.

2. Note Special cases, where the network architecture of limiting device numbering to DD causes excessive subnet works. The device number can be expanded to DDD and the network number N can become a single digit. In NO case shall the network number N and the device number D exceed 4 digits.

3. Facility code assignments:

4. 000-400   Building/facility number

5. Note that some facilities have a facility code with an alphabetic suffix to denote wings, related structures, etc. The suffix will be ignored. Network numbers for facility codes above 400 will be assigned in the range 000-399.

C. Device Names

1. Name the control devices based on facility name, location within a facility, the system or systems that the device monitors and/or controls, or the area served. The intent of the device naming is to be easily recognized. Names can be up to 254 characters in length, without embedded spaces. Provide the shortest descriptive, but unambiguous, name. For example, in building #123 prefix the number with a "B" followed by the building number, if there is only one chilled water pump "CHWP-1", a valid name would be "B123.CHWP. 1.STARTSTOP". If there are two pumps designated "CHWP-1", one in a basement mechanical room (Room 0001) and one in a penthouse mechanical room (Room PH01), the names could be "B123.R0001.CHWP.1. STARTSTOP " or " B123.RPH01.CHWP.1.STARTSTOP". In the case of unitary controllers, for example a VAV box controller, a name might be

"B123.R101.VAV". These names should be used for the value of the "Object_Name" property of the controllers involved so that the controller name and the EMCS name are the same.

2.7 BUILDING CONTROLLERS

A. The DDC system contractor shall supply one or more Building Controllers (BC) as part of this contract. Number of BC's required is dependent on the type and quantity of PEC and ASC devices provided.

B. The Building Controller (BC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the BC. It shall be capable of executing application control programs to provide:

1. Calendar functions

2. Scheduling

3. Trending

4. Alarm monitoring and routing

5. Time synchronization

6. Integration of controller data through NiagaraAX drivers installed in the ECC.

7. Network Management functions for all controllers

C. The Building Controller (BC) shall provide the following hardware features as a minimum:

1. One Ethernet Port – 10/100 Mbps

2. One LonWorks Interface Port – 78KB FTT-10A

3. One RS-485 Port

4. Battery Backup

5. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller shall contain a hard disk with minimum 1 gigabyte storage capacity)

6. The BC shall be capable of operation over a temperature range of 32 to 122°F

7. The BC shall be capable of withstanding storage temperatures of between 0 and 158°F

8. The BC shall be capable of operation over a humidity range of 5 to 95% RH, non-condensing

D. The BC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the BC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.

E. The BC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users.

F. Event Alarm Notification and actions

1. The BC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.

2. The BC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.

3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:

a. To alarm

b. Return to normal

c. To fault

4. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.

5. Provide timed (schedule) routing of alarms by class, object, group, or node.

6. Provide alarm generation from binary object "runtime" and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Control equipment and network failures shall be treated as alarms and annunciated.

H. Alarms shall be annunciated in any of the following manners as defined by the user:

1. Screen message text

2. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:

    a. Day of week

    b. Time of day

    c. Recipient

3. Pagers via paging services that initiate a page on receipt of email message

4. Graphic with flashing alarm object(s)

I. The following shall be recorded by the BC for each alarm (at a minimum):

1. Time and date

2. Location (building, floor, zone, office number, etc.)

3. Equipment (air handler #, accessway, etc.)

4. Acknowledge time, date, and user who issued acknowledgement.

5. Number of occurrences since last acknowledgement.

J. Alarm actions shall have the ability to be initiated by user defined programmable objects created for that purpose.

K. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.

L. A log of all alarms shall be maintained by the ECC and shall be available for review by the user.

M. Provide a "query" feature to allow review of specific alarms by user defined parameters.

N. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

O. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

P. Data Collection and Storage

1. The BC shall have the ability to collect data for any property of any object and store this data for future use.

2. The data collection shall be performed by log objects, resident in the BC that shall have, at a minimum, the following configurable properties:

   a. Designating the log as interval or deviation.

   b. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.

   c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, shall initiate logging of the object.

   d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.

   e. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

3. All log data shall be stored in a relational database at the ECC and the data shall be accessed from a server (if the system is so configured) or a standard Web browser.

4. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

5. All log data shall be available to the user in the following data formats:

   a. HTML

   b. XML

   c. Plain Text

   d. Comma or tab separated values

6. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.

7. The BC shall have the ability to archive its log data either locally (to itself), or remotely to a server or ECC on the network. Provide the ability to configure the following archiving properties, at a minimum:

   a. Archive on time of day

   b. Archive on user-defined number of data stores in the log (buffer size)

   c. Archive when log has reached it's user-defined capacity of data stores

   d. Provide ability to clear logs once archived

Q. Audit Log

   1. Provide and maintain an Audit Log that tracks all activities performed at the ECC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (at the ECC), or to a server. For each log entry, provide the following data:

      a. Time and date

      b. User ID

      c. Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

R. Database Backup and Storage

   1. The BC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.

   2. Copies of the current database and the most recently saved database shall be stored in the BC. The age of the most recently saved database is dependent on the user-defined database save interval.

   3. The BC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

S. Graphical User Interface Software

1. Operating System:

2. The GUI shall run on Microsoft Windows XP Professional.

3. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

4. Real-Time Displays: The GUI, shall at a minimum, support the following graphical features and functions:

   a. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable.   In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.

   b. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.

   c. Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.

   d. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.

      1. Schedule times shall be adjusted using a graphical slider, without requiring any keyboard entry from the operator.

2. Holidays shall be set by using a graphical calendar without requiring any keyboard entry from the operator.

e. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.

f. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.

5. System Configuration: At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:

Create, delete or modify control strategies.

Add/delete objects to the system.

Tune control loops through the adjustment of control loop parameters.

Enable or disable control strategies.

Generate hard copy records or control strategies on a printer.

Select points to be alarmable and define the alarm state.

Select points to be trended over a period of time and initiate the recording of values automatically.

6. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

7. Security: Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system

application, full screen editor, and object.   Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

8. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

9. Alarm Console:

    a. The system shall be provided with a dedicated alarm window or console. This window shall notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console shall have the ability to be enabled or disabled by the system administrator.

    b. When the Alarm Console is enabled, a separate alarm notification window shall supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window shall notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

2.8 PROGRAMMABLE EQUIPMENT CONTROLLERS (PEC)

A. All PEC controllers shall be Niagara^{AX} based Jace-200's or Jace-600's. BACNet or LON based PEC's requiring manufacturer specific engineering/programming software tool are not acceptable.

B. Controls shall be microprocessor based Interoperable Niagara^{AX} Programmable Equipment Controllers (PEC) in accordance with the JSR-60 Baja Specification. PEC's shall be provided for applications as shown on the drawings. The application control program shall be resident within the same enclosure as the discrete input/output circuitry, which translates the sensor and actuator signals; the PEC shall communicate serially using standard protocols with control devices of the equipment that it is controlling. The system supplier shall provide a NICS document showing the installed system's compliance level to the Software Licensing Agreement of this specification.

C. The PECs shall communicate using FOX communication protocol with the BC(s) via an Ethernet connection at a baud rate of not less than 10 Mbps.

D. All PEC's shall be fully application programmable. Controllers require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the PEC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

E. Each major HVAC system (air handling unit, chilled water system, hot water system, etc.) shall have its own stand-alone PEC DDC controller. Control of a major HVAC system shall not be split between multiple PEC controllers. If a large HVAC system exceeds the point capacity of one PEC then monitor only points shall be connected to a separate PEC or IO module.

F. TheDDC system contractor shall provide documentation for each PEC, with the following information at a minimum:

1. IP and MAC address, name, type and HostID

2. Niagara Objects; name, type and instance number

G. The supplier of any programmable Niagara PEC shall ensure that the proper Niagara objects are provided in each PEC, as required by the points list shown on the drawings.

2.9 LONWORKS APPLICATION SPECIFIC CONTROLLERS (ASC)

A. Each Application Specific Controller (ASC) shall operate as a stand-alone LonMark® compliant controller capable of performing its specified control responsibilities independent of other controllers in the network.

B. Each ASC's application shall comply with one of the following LONMARK® interoperability profile guidelines:

1. Variable Air Volume (VAV) boxes   - Profile 8502

2. Constant Air Volume (CAV) boxes   - Profile 8502

3. Fan Coil Units   - Profile 8501

4. Heat Pumps   - Profile 8503

5. Unit Ventilators   - Profile 8505

6. VAV AHU   - Profile 8610

C. Network access shall be accomplished at the ASC room sensor or the ASC. Where applicable system node access shall be available from connecting to the room sensor jack.

D. All ASC's shall include all inputs and outputs necessary to perform the specified control sequences. Analog and digital outputs shall be industry standard signals such as 0-10V and 3-point floating control allowing for interface to a variety of industry standard modulating actuators. The ASC inputs shall consist of industry standards types such as 10K thermistor, 0-10V, 4-20mA and digital inputs. Inputs shall be electrically isolated from outputs, communications and power.

E. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the network is not acceptable.

F. The control program shall reside in the ASC. The application program configuration information shall be stored in non-volatile memory with no battery back up.

G. After a power failure the ASC shall run the control application using the current setpoints and configuration. Reverting to default or factory setpoints is not acceptable.

2.10 BACNET APPLICATION SPECIFIC CONTROLLERS (ASC)

A. Provide BTL-Listed B-ASC application specific controllers for each piece of equipment for which they are constructed. Application specific controllers shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute) Property service.

1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.

2. Each B-ASC shall contain sufficient I/O capacity to control the target system.

3. Communication.

   a. Each controller shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of Programmable Equipment Controllers and application specific controllers.Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port where shown.

4. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

5. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.

6. Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

7. Transformer. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type.

2.11   DIRECT DIGITAL CONTROLLER APPLICATION SOFTWARE

1. Application Software: The controllers shall provide the following programs as a minimum for the purpose of optimizing energy consumption while maintaining comfortable environment for occupants. All application software shall reside and run in the associated system digital controllers. Editing of the application shall occur at the ECC or via a portable operator's terminal, when it is necessary, to access directly the programmable unit.

   a. Economizer: An economizer program shall be provided for VAV systems. This program shall control the position of air handler relief, return, and outdoor air dampers.   If the outdoor air dry bulb temperature and humidity fall below changeover set point the energy control center shall modulate the dampers to provide 100 percent outdoor air. The operator shall be able to override the economizer cycle and return to minimum outdoor air operation at any time.

   b. Night Setback/Morning Warm up Control: The system shall provide the ability to automatically adjust set points for this mode of operation. The control system shall have the ability for Night Setback/Morning Warmup; however, the controls shall be set up for 24/7 occupied operation.

   c. Optimum Start/Stop (OSS): Optimum start/stop program shall automatically be coordinated with event scheduling. The OSS program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by the time of occupancy, and it shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period and still maintain desired comfort conditions. The OSS program shall

consider both outside weather conditions and inside zone conditions. The program shall automatically assign longer lead times for weekend and holiday shutdowns. The program shall poll all zones served by the associated AHU and shall select the warmest and coolest zones. These shall be used in the start time calculation. It shall be possible to assign occupancy start times on a per air handler unit basis. The program shall meet the local code requirements for minimum outdoor air while the building is occupied. Modification of assigned occupancy start/stop times shall be possible via the ECC. The control system shall have the ability for optimum start/stop; however, the controls shall be set up for 24/7 occupied operation..

d. Maintenance Management (PM): The program shall monitor equipment status and generate maintenance messages based upon the operators defined equipment run time, starts, and/or calendar date limits. A preventative maintenance alarm shall be printed indicating maintenance requirements based on pre-defined run time. Each preventive message shall include point description, limit criteria and preventative maintenance instruction assigned to that limit. A minimum of 480-character PM shall be provided for each component of units such as air handling units.

2.12 SENSORS (AIR, WATER AND STEAM)

A. Sensors' measurements shall be read back to the DDC system, and shall be visible by the ECC.

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 User set-point adjustment, override switch, numerical temperature display on sensor cover, and communication port. Match room thermostats. Provide a tooled-access cover.

         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. Outdoor air temperature sensors shall have watertight inlet fittings and be shielded from direct sunlight.

      e. Room security sensors shall have stainless steel cover plate with insulated back and security screws.

      f. Wire: Twisted, shielded-pair cable.

      g. Output Signal: 4-20 ma.

   2. Humidity Sensors: Bulk polymer sensing element type.

      a. Duct and room sensors shall have a sensing range of 20 to 80 percent with accuracy of $\pm$ 2 to $\pm$ 5 percent RH, including hysteresis, linearity, and repeatability.

      b. Outdoor humidity sensors shall be furnished with element guard and mounting plate and have a sensing range of 0 to 100 percent RH.

      c. 4-20 ma continuous output signal.

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. 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.

E. 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.

2.13 CONTROL CABLES

A. General:

1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Comply with Sections 26 05 26.

2. Cable conductors to provide protection against induction in circuits. Crosstalk attenuation within the System shall be in excess of -80 dB throughout the frequency ranges specified.

3. Minimize the radiation of RF noise generated by the System equipment so as not to interfere with any audio, video, data, computer main distribution frame (MDF), telephone customer service unit (CSU), and electronic private branch exchange (EPBX) equipment the System may service.

4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.

5. Label system's cables on each end. Test and certify cables in writing to the COTR before conducting proof-of-performance testing. Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in the frequency ranges used. Make available all cable installation and test records at demonstration to the COTR. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.

6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.

B. Analogue control cabling shall be not less than No. 18 AWG solid, with thermoplastic insulated conductors as specified in Section 26 05 21.

C. Optical digital communication fiber, if used, shall be Multimode or Singlemode fiber, 62.5/125 micron for multimode or 10/125 micron for singlemode micron with SC or ST connectors as specified in TIA-568-C.1. Fiber-optic cable shall be suitable for use with the 100Base-FX or the 100Base-SX standard (as applicable) as defined in IEEE Std 802.3.

2.14 THERMOSTATS AND HUMIDISTATS

A. Room thermostats controlling unitary standalone heating and cooling devices not connected to the DDC system shall have three modes of operation (heating - null or dead band - cooling). Thermostats for patient bedrooms shall have capability of being adjusted to eliminate null or dead band. Wall mounted thermostats shall have manufacturer's recommended finish, setpoint range and temperature display and external adjustment:

1. Electronic Thermostats: Solid-state, microprocessor based, programmable to daily, weekend, and holiday schedules.

   a. Public Space Thermostat: Public space thermostat shall have a thermistor sensor and shall not have a visible means of set point adjustment. Adjustment shall be via the digital controller to which it is connected.

   b. Patient Room Thermostats: thermistor with in-space User set point adjustment and an on-casing room temperature numerical temperature display.

   c. Psychiatric Patient Room Sensors: Electronic duct sensor as noted under Article 2.4.

   d. Battery replacement without program loss.

B. Strap-on thermostats shall be enclosed in a dirt-and-moisture proof housing with fixed temperature switching point and single pole, double throw switch.

C. Freezestats shall have a minimum of 300 mm (one linear foot) of sensing element for each 0.093 square meter (one square foot) of coil area. A freezing condition at any increment of 300 mm (one foot) anywhere along the sensing element shall be sufficient to operate the thermostatic element. Freezestats shall be manually-reset.

2.15 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. Power Operated Control Dampers (other than VAV Boxes): Factory fabricated, balanced type dampers. All modulating dampers shall be opposed blade type and gasketed. Blades for two-position, duct-mounted dampers shall be parallel, airfoil (streamlined) type for minimum noise generation and pressure drop.

   1. Leakage: Outside air and relief air dampers shall be insulated and thermally broken with an air leakage rating not to exceed 4.5 cfm/sq. ft. at 4" differential static pressure. Return air and other control dampers leakage rate shall not exceed 10.5 cfm/sq. ft. at 4" differential static pressure.

   2. Frame shall be galvanized steel channel with seals as required to meet leakage criteria.

   3. Blades shall be galvanized steel or aluminum, 200 mm (8 inch) maximum width, with edges sealed with neoprene, felt, or rubber as required to meet leakage criteria.

   4. Bearing shall be nylon, bronze sleeve or ball type.

   5. Hardware shall be zinc-plated steel. Connected rods and linkage shall be non-slip. Working parts of joints shall be brass, bronze, nylon or stainless steel.

   6. Shafts: Galvanized steel.

   7. Maximum air velocity and pressure drop through free area of the fully open dampers:

      a. Smoke damper in air handling unit: 305 meter per minute (1000 fpm).

      b. Duct mounted damper: 600 meter per minute (2000 fpm).

      c. Maximum static pressure loss: 50 Pascal (0.20 inches water gage).

D. Smoke Dampers and Combination Fire/Smoke Dampers: Dampers and operators are specified in Section 23 31 00, HVAC DUCTS AND CASINGS. Control of these dampers is specified under this Section.

E. Control Valves:

   1. Valves shall be rated for a minimum of 150 percent of system operating pressure at the valve location but not less than 900 kPa (125 psig).

2. Valves 50 mm (2 inches) and smaller shall be bronze body with threaded or flare connections.

3. Valves 60 mm (2 1/2 inches) and larger shall be bronze or iron body with flanged connections.

4. Brass or bronze seats except for valves controlling media above 100 degrees C (210 degrees F), which shall have stainless steel seats.

5. Flow characteristics:

   a. Three way modulating valves shall be globe pattern. Position versus flow relation shall be linear relation for steam or equal percentage for water flow control.

   b. Two-way modulating valves shall be globe pattern. Position versus flow relation shall be linear for steam and equal percentage for water flow control.

   c. Two-way 2-position valves shall be ball, gate or butterfly type.

6. Maximum pressure drop:

   a. Two position steam control: 20 percent of inlet gauge pressure.

   b. Modulating Steam Control: 80 percent of inlet gauge pressure for 15 psi or less; 50 percent of inlet gauge pressures for greater than 15 psi. (acoustic velocity limitation).

   c. Modulating water flow control, greater of 3 meters (10 feet) of water or the pressure drop through the apparatus.

7. Two position water valves shall be line size.

F. Damper and Valve Operators and Relays:

1. Electric operator shall provide full modulating control of dampers and valves. A linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct or externally in the duct or externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient closeoff torque.

   a. Minimum valve closeoff pressure shall be equal to the system pump's dead-head pressure, minimum 50 psig for valves smaller than 4 inches.

2. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient closeoff torque.

   a. VAV Box actuator shall be mounted on the damper axle or shall be of the air valve design, and shall provide complete modulating control of the damper. The motor shall have a closure torque of 35-inch pounds minimum with full torque applied at close off to attain minimum leakage.

3. Damper actuators shall be externally mounted on standoffs where required, to provide complete insulation coverage.

4. See drawings for required control operation.

2.16 AIR FLOW CONTROL

A. Airflow and static pressure shall be controlled via digital controllers with inputs from airflow control measuring stations and static pressure inputs as specified. Controller outputs shall be analog or pulse width modulating output signals. The controllers shall include the capability to control via simple proportional (P) control, proportional plus integral (PI), proportional plus integral plus derivative (PID), and on-off. The airflow control programs shall be factory-tested programs that are documented in the literature of the control manufacturer.

B. Air Flow Measuring Station -- Electronic Thermal Type:

1. Air Flow Sensor Probe:

   a. Each air flow sensor shall contain two individual thermal sensing elements. One element shall determine the velocity of the air stream while the other element shall compensate for changes in temperature. Each thermal flow sensor and its associated control circuit and signal conditioning circuit shall be factory calibrated and be interchangeable to allow replacement of a sensor without recalibration of the entire flow station. The sensor in the array shall be located at the center of equal area segment of the duct and the number of sensors shall be adequate to accommodate the expected velocity profile and variation in flow and temperature. The airflow station shall be of the insertion type in which sensor

support structures are inserted from the outside of the ducts to make up the complete electronic velocity array.

b. Thermal flow sensor shall be constructed of hermetically sealed thermistors or nickel chromium or reference grade platinum wire, wound over an epoxy, stainless steel or ceramic mandrel and coated with a material suitable for the conditions to be encountered. Each dual sensor shall be mounted in an extruded aluminum alloy strut.

2. Air Flow Sensor Grid Array:

a. Each sensor grid shall consist of a lattice network of temperature sensors and linear integral controllers (ICs) situated inside an aluminum casing suitable for mounting in a duct. Each sensor shall be mounted within a strut facing downstream of the airflow and located so that it is protected on the upstream side. All wiring shall be encased (out of the air stream) to protect against mechanical damage.

b. The casing shall be made of welded aluminum of sufficient strength to prevent structural bending and bowing. Steel or iron composite shall not be acceptable in the casing material.

c. Pressure drop through the flow station shall not exceed 4 Pascal (0.015" W.G.) at 1,000 meter per minute (3,000 FPM).

3. Fan Inlet Air Flow Measuring Stations:

Fan inlet airflow measuring stations for installation at supply and return fan inlets shall include flow transducers with minimum .50% full-scale accuracy signal processors. The minimum accuracy shall be 2% of reading or better thru a velocity range of 500-8000 fpm.

4. Electronics Panel:

a. Electronics Panel shall consist of a surface mounted enclosure complete with solid-state microprocessor and software.

b. Electronics Panel shall be A/C powered 24 VAC and shall have the capability to transmit signals of 0-5 VDC, 0-10 VCD or 4-20 ma for use in control of the HVAC Systems. The electronic panel shall have the capability to accept user defined scaling parameters for all output signals.

c. Electronics Panel shall have the capability to digitally display airflow in CFM and temperature in degrees F. The displays shall be provided as an integral part of the electronics panel. The electronic panel shall have the capability to totalize the output flow in CFM for two or more systems, as required. A single output signal may be provided which will equal the sum of the systems totalized. Output signals shall be provided for temperature and airflow. Provide remote mounted air flow or temperature displays where indicated on the plans.

d. Electronics Panel shall have the following:

1) Minimum of 12-bit A/D conversion.

2) Field adjustable digital primary output offset and gain.

3) Airflow analog output scaling of 100 to 10,000 FPM.

4) Temperature analog output scaling from -45°C to 70°C (-50°F to 160°F).

5) Analog output resolution (full scale output) of 0.025%.

e. All readings shall be in I.P. units.

5. Thermal flow sensors and its electronics shall be installed as per manufacturer's instructions. The probe sensor density shall be as follows:

Probe Sensor Density	
Area (sq.ft.)	Qty. Sensors
<=1	2
>1 to <4	4
4 to <8	6
8 to <12	8
12 to <16	12
>=16	16

a. Complete installation shall not exhibit more than ± 2.0% error in airflow measurement output for variations in the angle of flow of up to 10 percent in any direction from its calibrated orientation. Repeatability of readings shall be within ± 0.25%.

C. Static Pressure Measuring Station: shall consist of one or more static pressure sensors and transmitters along with relays or auxiliary devices as required for a complete functional system. The span of the transmitter shall not exceed two times the design static pressure

at the point of measurement. The output of the transmitter shall be true representation of the input pressure with plus or minus 25 Pascal (0.1 inch) W.G. of the true input pressure:

1. Static pressure sensors shall have the same requirements as Airflow Measuring Devices except that total pressure sensors are optional, and only multiple static pressure sensors positioned on an equal area basis connected to a network of headers are required.

2. For systems with multiple major trunk supply ducts, furnish a static pressure transmitter for each trunk duct. The transmitter signal representing the lowest static pressure shall be selected and this shall be the input signal to the controller.

3. The controller shall receive the static pressure transmitter signal and CU shall provide a control output signal to the supply fan capacity control device. The control mode shall be proportional plus integral (PI) (automatic reset) and where required shall also include derivative mode.

4. In systems with multiple static pressure transmitters, provide a switch located near the fan discharge to prevent excessive pressure during abnormal operating conditions. High-limit switches shall be manually-reset.

D. Airflow Synchronization:

1. Systems shall consist of an air flow measuring station for each supply and return duct, the CU and such relays, as required to provide a complete functional system that will maintain a constant flow rate difference between supply and return air to an accuracy of $\pm10\%$. In systems where there is no suitable location for a flow measuring station that will sense total supply or return flow, provide multiple flow stations with a differential pressure transmitter for each station. Signals from the multiple transmitters shall be added through the CU such that the resultant signal is a true representation of total flow.

2. The total flow signals from supply and return air shall be the input signals to the CU. This CU shall track the return air fan capacity in proportion to the supply air flow under all conditions.

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 COTR for resolution before proceeding with installation.

2. Work Coordination: GENERAL CONDITIONS.

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.

B. Electrical Wiring Installation:

1. All wiring cabling shall be installed in conduits. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS. Conduits carrying control wiring and cabling shall be dedicated to the control wiring and cabling: these conduits shall not carry power wiring. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.

2. Install analog signal and communication cables in conduit and in accordance with Specification Section 26 05 21.

3. Install conduit and wiring between digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.

4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage (less than 50 volt) power is required, provide suitable Class B transformers.

5. Install all system components in accordance with local Building Code and National Electric Code.

   a. Splices: Splices in shielded and coaxial 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.

   b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. 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. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.

   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.

6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.

7. 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.

8. 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 46" above the finished floor, to comply with ADA requirements.

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

f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.

g. 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:

    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.

    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. Provide a separate digital control panel for each major piece of equipment, such as air handling unit, chiller, pumping unit etc. Points used for control loop reset such as outdoor air, outdoor humidity, or space temperature can be located on any of the remote control units.

    2. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25 percent of available memory free for future use.

    3. System point names shall be modular in design, permitting easy operator interface without the use of a written point index.

    4. Provide software programming for the applications intended for the systems specified, and adhere to the strategy algorithms provided.

    5. Provide graphics for each piece of equipment and floor plan in the building. This includes each chiller, air handling unit, fan, terminal unit, pumping 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 all aspects of the controls and instrumentation system.

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 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 COTR 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 shall be demonstrated by the installer in the presence of the COTR or other VA representative on random samples of equipment as dictated by the COTR or other VA representative. Should random sampling indicate improper commissioning, the COTR reserves the right to subsequently witness complete calibration of the system at no additional cost to the Government.

2. Demonstrate to the COTR or other VA representative that all required safeties and life safety functions are fully functional and complete.

3. Make accessible, personnel to provide necessary adjustments and corrections to systemsas directed by balancing agency.

4. The following witnessed demonstrations of field control equipment shall be included:

   a. Observe HVAC systems in shut down condition. Check dampers and valves for normal position.

   b. Test application software for its ability to communicate with digital controllers, operator workstation, and uploading and downloading of control programs.

   c. Demonstrate the software ability to edit the control program off-line.

d. Demonstrate reporting of alarm conditions for each alarm and ensure that these alarms are received at the assigned location.

e. Demonstrate ability of software program to function for the intended applications-trend reports, change in status etc.

f. 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.

g. 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.

h. Prepare and deliver to the COTR graphed trends of all control loops to demonstrate that each control loop is stable and the set points are maintained.

i. Demonstrate that each control loop responds to set point adjustment and stabilizes within one (1) minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.

----- END -----