SECTION 23 09 23

DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS **04/2023**

PART 1 GENERAL

1.1 REFERENCES

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

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 500-D	(1998) Laboratory Methods of Testing Dampers for Rating

ASME INTERNATIONAL (ASME)

ASME B16.5	(2003) Standard for Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24
ASME B31.1	(2007; Addenda 2008) Power Piping

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE FUN IP	(2005) Fundamentals Handbook, I-P Edition
ASHRAE 135	(2004; Int 1 thru 5 2004; Addenda A 2004; Errata 2005; Int 6 thru 15 2005; Int 16 thru 18 2006; Addenda C 2006; Addenda D 2006; Errata to Addenda D 2006; Int 19 thru 22 2007; Addenda F 2007; Addenda E 2007; Errata 2007, Errata 2008, Errata 2008; Int 23 thru 28 2008; Addenda M 2008) BACnet
ASHRAE Gdln3	(2007) Exterior Enclosure Technical Requirements for the Commissioning Process

ASTM INTERNATIONAL (ASTM)

ASTM A 126	(2004) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1B	(2002) Control Network Protocol Specification

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE Std 100	(2000) The Authoritative Dictionary of IEEE Standards Terms
IEEE C62.41	(1991; R 1995) IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
IEEE C62.45	(2002) Surge Testing for Equipment Connected to Low-Voltage (1000v and less)AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2008) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 70	(2007; AMD 1 2008) National Electrical Code - 2008 Edition

SHEET METAL AND AIR-CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible
SMACNA HVACTAB	(2002, 3rd Ed) HVAC Systems - Testing,
UL 268A	(2008) Smoke Detectors for Duct Application
UL 506	(2000; Rev thru May 2006) Standard for Specialty Transformers
UL 916	(2007) Energy Management Equipment
UL 1449	(2006) Surge Protective Devices Adjusting and Balancing

UNDERWRITERS LABORATORIES (UL)

1.2 DEFINITIONS

1.2.1 Digital Controller

1.2.1.1 Interoperable Digital Controller (IDC)

A control module which is microprocessor based Interoperable LonMarkTM or LonWorks. HVAC control is accomplished using LonMarkTM based devices where the application has a LonMarkTM profile defined and performs stand-alone operations.

1.2.1.2 Interoperable BACnet Controller (IBC)

A control module which is microprocessor based Interoperable BACnet Controller in accordance with ASHRAE 135. IBC's must be provided with product interoperability compliance statement documents that demonstrate the compliance level to the ASHRAE 135.

1.2.2 Direct Digital Control (DDC)

Digital controls, as defined in this specification, performing control logic. The controller directly senses building environment and makes control decisions based on user defined, controller resident programs. The controller outputs control signals that directly operate valves, dampers, and motor controllers. No conventional control devices, such as receiver controllers, thermostats, and logic units are present within or interface with a direct digital control loop. Actuators are electric and the controller output is converted to the appropriate type of signal.

1.2.3 DDC System

A system made up of one or more interoperable digital controllers which communicate on a network.

1.2.4 Distributed Control

The intent of distributed control is to install the controllers near their respective controlled equipment. The control system consists of stand-alone controllers, with the total number of input and output points limited to 48 or less per controller. Failure of any single controller will not cause the loss of more than 48 control points.

1.2.5 Dynamic Control

A process that optimizes energy efficiency of HVAC systems (air handling units, converters, chillers, and boilers) by increasing and decreasing set points or starting and stopping equipment in response to heating and cooling needs of the facility. A requirement of dynamic control is knowing the heating/cooling demand status of the process. Therefore, dynamic control requires controllers connected in a communications network and receiving feedback, necessary variable point data and/or actual status input to accomplish closed loop control.

1.2.6 Firmware

Firmware is software programmed into read only memory (ROM) and erasable programmable read only memory (EPROM) chips. Software may not be changed without physically altering the chip.

1.2.7 Graphic User Interface Software (GUI)

Graphic user interface software shall run on the JBLM EMCS server. The GUI employs browser like functionality that includes a tree view (like Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. Pull down menus and toolbars employ buttons, commands and navigation that permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (like a URL line), that displays the location and the selected object definition.

1.2.8 Hand-Held Terminal

A hand-held terminal is a manufacturer specific device connected directly to a communications port on a controller, through which the controller is accessed and, in some cases, programmed. This style of interface is not an acceptable installation on Joint Base Lewis McChord (JBLM).

1.2.9 Input/output (I/O) Points

I/O points refer to analog inputs (AI), digital inputs (DI), analog outputs (AO), and digital outputs (DO) in a digital controller. Another term for digital inputs and outputs is binary inputs and outputs. Inputs are from analog sensors (temperature, pressure, humidity, flow) and digital sensors (motor status, flow switches, switch position, and pulse output devices). Outputs operate modulating and on/off control devices.

1.2.10 I/O Expansion Unit

An I/O expansion unit provides additional point capacity to a digital controller and communicates with the stand-alone digital controller on a LAN. An I/O unit is not stand-alone because the control program does not reside in the I/O unit. An I/O expander which connects directly to a stand-alone controller through a multi-line microprocessor bus is restricted to reside within 3 feet of the stand-alone controller and is considered part of the stand-alone controller. The total point count of the I/O and all connected expansion units shall not exceed the 48 point limit.

1.2.11 Local Area Network (LAN)

a. A communications bus that interconnects digital controllers for peer-to-peer (see "peer-to-peer" below) communications. Different levels of LANs are possible within a single DDC system. In this case, a digital controller on a higher-level LAN act as a network controller to the controllers on the lower-level LAN. The network controller, then, has at least two LAN communications ports. One port supports peer-to-peer communications with other digital controllers on the higher-level LAN. The other port supports communications with the digital controllers on the lower-level LAN.

b. LANs permit sharing global information. This allows building and site wide control strategies such as peak demand limiting, dynamic control strategies, and coordinated response to alarm conditions, and remote monitoring and programming of digital controllers.

c. The controller’s peer-to-per communications bus is commonly referred to as "the field bus."

d. The "LAN" typically refers to the communications bus using the Ethernet protocols (Category 6) within a building.

1.2.12 Microprocessor

A microprocessor refers to the central processing unit (CPU) that contains all registers and logic circuitry that allow digital controllers to function.

1.2.13 JACE (Java Application Control Engine) Network Area Controller (NAC)

The JACE network area controller (NAC) provides the interface between a higher-level LAN or WAN and the interoperable digital controllers, providing global supervisory control functions. NAC's provide multiple user access at varying levels through password protection. The JACE shall not be used to control major HVAC equipment or systems.

1.2.14 LonMark

See LonMark International. Also, a certification issued by LonMark International to CEA-709.1B devices.

1.2.15 LonMark International

Standards committee consisting of numerous independent product developers and systems integrators dedicated to determining and maintaining the interoperability guidelines for the LonWorks industry. Maintains guidelines for the interoperability of CEA-709.1B devices and issues the LonMark Certification for CEA-709.1B devices.

1.2.16 LonWorks

The overall communications technology, developed by Echelon Corporation, for control systems. The term is often used to refer to the technology in general, and may include reference to any/all of the: protocol, network management, and interoperability guidelines where the technology is based on the CEA-709.1B protocol and employs interoperable devices along with the capability to openly manage these devices (via multiple vendors) using a network configuration (or service) tool.

1.2.17 Output Signal Conversion

Output signal conversion refers to changing one kind of control output into a proportionally related signal appropriate for direct actuation of the controlled device. An example is converting a 4 to 20 mA or 0 to 10 VDC signal to a proportional 20 to 103 kPa (3 to 15 PSIG) signal to operate a pneumatic actuator.

1.2.18 Optimum Start

Optimum start is a method of starting HVAC equipment prior to scheduled occupancy in order to have the building at set point when occupied. Optimum start is based on the zone temperatures, zone set points, and outdoor temperature.

1.2.19 Peer-to-Peer

Peer-to-peer refers to controllers connected on a communications LAN typically referred to as the "field bus" that act independently, as equals, and communicate with each other to pass information.

1.2.20 Performance Verification Test

The performance verification test (PVT) is the formal commissioning of the DDC system performed after successful contractor field testing and point to point testing of all DDC points on all equipment included in the Contract and prior to the second phase of DDC training. It is used as a means for final acceptance of the control system and provides a means to verify the system functions are performing IAW (in accordance with) the manufacturers written instructions, sequence of operation and control drawings. DDC Contractor must submit a completed copy of point to point testing for review prior to scheduling PVT. See Commissioning Appendix A as a reference.

1.2.21 PID

PID refers to proportional, integral, and derivative control; the three types of action that are used in controlling modulating equipment.

1.2.22 Resolution

Refers to the number of possible states an input value or output value can take and is a function of the digital controller I/O circuitry; the A/D converter for input and the D/A converter for output. Ten-bit resolution has 1024 possible states.

1.2.23 Stand-Alone Control

Refers to the digital controller performing required climate control, and energy management functions without connection to another digital controller or computer. Requirements for stand-alone control are a time clock, a microprocessor, resident control programs, PID control, and I/O.

All stand-alone controllers have a communication port and firmware for direct connection and interrogation with a laptop computer. This interrogation includes parameter changes and program downloads.

1.2.24 Terminal Control Unit (TCU)

An off-the-shelf, stand-alone digital controller equipped for communication on a lower-level LAN. TCUs may deviate from stand-alone only in receiving energy management and time information from a stand-alone digital controller. A TCU is commonly application specific and is used for distributed control of specific HVAC subsystems. A TCU communicates with other digital controllers. Typically, a TCU communicates on a lower-level LAN. Examples where TCUs are used include small air handling units (AHUs), variable air volume (VAV) boxes, fan coil units (FCUs), and heat pumps. TCUs shall be LonMark/Lonworks and/or BACnet based. All TCUs shall be remotely configurable via the JBLM EMCS server.

1.3 TEMPERATURE CONTROL AND FACILITY MANAGEMENT AND CONTROL SYSTEM

The building's Temperature Control System (TCS) shall be capable of being extended to the JBLM Niagara Framework Environmental Management and Control System (EMCS), and comprised of a network of interoperable, stand-alone digital controllers communicating via LonMark/LonTalk and/or BACnet to a JACE Controller (Network NAC). The JACE Controller to be connected to the EMCS/DDC Controller through the NEC switch. NEC switch is not within the Scope of the contract. Cat-6 wiring to switch to be provided by Contractor. Access to the system shall be accomplished through the JBLM EMCS server.

The TCS shall be comprised of a network of interoperable, stand-alone digital controllers communicating to a host computer within one facility within the project using graphical user interface software. The EMCS shall communicate to third party systems such as chillers, boilers, air handling systems, energy management systems, fire-life safety systems and other building management related devices with open, interoperable communication capabilities.

Provide a TCS including associated equipment and accessories as specified. Manufacturer's products, including design, materials, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with

ASME B31.1 and NFPA 70, except as modified herein or indicated otherwise. Routers and/or gateways between the JACE NAC to the JBLM Enviro 4003 VLAN shall not be utilized due to security restrictions.

The TCS systems shall maintain stable temperature control and all other conditions as indicated. The end-to-end accuracy of the system, including temperature sensor error, wiring error, A/D conversion, and display, shall be 0.5 degree C or less.

1.4 DESIGN REQUIREMENTS

1.4.1 Control System Schematic

Provide control system schematic that includes the following:

a. Location of each input and output device

b. Flow diagram of each HVAC component, for instance flow through coils, fans, dampers

c. Name or symbol for each component-by-component name such as V-1, DM-2, and T-1 for a valve, damper motor, and temperature sensor, respectively

d. Set points

e. Sensor range

f. Actuator range

g. Valve and damper schedules and normal position

h. Switch points on input switches

i. Written sequence of operation for each control system schematic

j. Schedule identifying each sensor and controlled device with the following information:

   (1) LAN and Software point name with send and receive address if applicable

   (2) Point type (AO, AI, DO, DI)

   (3) Point range

   (4) Digital controller number for each point

1.4.2 Electrical Equipment Ladder Diagrams

Submit diagrams showing electrical equipment interlocks, including voltages and currents.

1.4.3 Component Wiring Diagrams

Submit a wiring diagram for each type of input device and each type of output device. Diagram shall show how the device is wired and powered, showing typical connections at the digital controller and each power supply, as well as at 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, proof, and humidity sensors and transmitters.

1.4.4 Terminal Strip Diagrams

Submit a diagram of each terminal strip, including digital controller base terminal strips (digital controllers shall not be directly wired for ease of removal and replacement), terminal strip location, termination numbers and the associated point names.

1.4.5 Communication Architecture Schematic

Submit a schematic showing communication networks used for all DDC system controllers, workstations, and field interface devices. Schematic shall show hierarchical topology. The supplied system must incorporate the ability to access all data using Java enabled 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/computer using a Web Supervisor for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable. All controllers shall be fully programmable and/or configurable from the JBLM EMCS server using a Niagara Workbench application and/or a Web Supervisor. Configurable controls are only acceptable in application specific topology i.e., VAV controllers' part of a distributed control network connected to a higher level controller such as an Air Handling Unit controller.

1.4.6 Symbols, Definition and Abbreviations

Symbols, definitions, and engineering unit abbreviations used in information displays, submittals and reports shall be as shown in the contract drawings. Symbols, definitions and abbreviations not in the contract drawings shall conform at a minimum to IEEE Std 100 and the ASHRAE FUN IP.

1.4.7 System Units and Accuracy

System printouts and calculations shall be performed in English (inch pound) units. Graphic User Interface (GUI) system displays shall be in English (inch-pound). Parameter modifications made through the GUI shall be displayed and accomplished in English units. Calculations shall have accuracy equal to or exceeding sensor accuracy. Displays and printouts shall have precision and resolution equal to or exceeding sensor accuracy.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

List of Drawings; G

List of abbreviations, symbols, nomenclature and identifiers used on the Drawings; G

List of I/O Points; G

List of Equipment Components; G

AC Power Table; G

SD-02 Shop Drawings

Shop Drawings; G

SD-03 Product Data DDC

hardware; G

DDC capabilities

Variable Frequency 3 Phase Motor Drives; G

Workstation software

Programming software General purpose programmable

controller operating programs

External interface files

Database

Input devices

Output devices

Surge and transient protection

Smoke detectors

SD-05 Design Data

Network Bandwidth Usage Calculations; In lieu of calculations provide a network bandwidth test to the communications contractor and COE generated from software such as Loytec Protocol Analyzer.

SD-06 Test Reports

Field tests

Point to Point tests

Preconstruction QC Checklist

Post construction QC Checklist

Commissioning Report

Performance verification test

Training

An electronic (.pdf) version of an outline for the HVAC control system training course with a proposed time schedule. Approval of the planned training schedule shall be obtained from the Government at least 60 days prior to the start of the training, five copies of the HVAC control system training course material 30 days prior to the scheduled start of the training course. The training course material shall include the operation manual, maintenance and repair manual, and paper copies of overheads used in the course.

SD-07 Certificates

Contractors' Qualifications

Training

SD-10 Operation and Maintenance (O&M) Data

Controls and HVAC System Operators

Manual

DDC Manufacturer's Hardware and Software Manuals

SD-11 Closeout Submittals

Provide administrative and closeout submittals:

Training course documentation

Service organizations

Contractor certification

Closeout QC Checklist

DDC Training DVD

1.6 OPERATING ENVIRONMENT

Protect components from humidity and temperature variations, dust, and other contaminants, within limits published by the manufacturer.

1.7 QUALITY ASSURANCE

1.7.1 Standard Products

a. Material and equipment shall be standard products of manufacturer regularly engaged in the manufacturing of such product, using similar materials, design and workmanship. The standard products shall have been in commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of similarly sized equipment and materials used under similar circumstances and sold on the commercial market through advertisements, manufacturers' catalogs, or brochures.

b. Products are supported by a local service organization.

1.7.2 Nameplates and Tags

a. Nameplates and tags bearing device unique identifiers shall be engraved or stamped. Permanently attach nameplates to HVAC control panel doors and back plates.

b. For each field mounted piece of equipment attach a plastic or metal tag with equipment name and point identifier.

1.7.3 Verification of Dimensions

The Contractor shall verify all dimensions in the field and shall advise the Contracting Officer of any discrepancy before performing work.

1.7.4 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work, and shall furnish all work necessary to meet such conditions.

1.7.5 Contractors Qualifications

The Contractor or subcontractor(s) performing the work shall have completed at least five DDC systems installations of a similar design and complexity and have successfully completed at least five Tridium integrations using both LonMark controllers and BACnet systems with the use of Niagara workbench programming software running on the Niagara platform. Contractor shall be a Certified and/or Authorized Tridium Controls Integrator.

1.7.6 Training Course Documentation

Training course documentation shall include a manual for each trainee plus one electronic (.pdf) version and 2 additional hard copies of manuals or audiovisual training aids. Documentation shall include an agenda, defined objectives for each lesson and detailed description of the subject matter of each lesson.

1.7.7 Service Organizations

Qualified service organization list that shall include the names and telephone numbers of organizations qualified to service the HVAC control systems.

1.7.8 Contractor Certification

Provide certification that the installation of the control system is complete and meets the technical requirements of this section.

1.7.9 Modification of References

The advisory provision in ASME B31.1 and NFPA 70 are mandatory. Substitute the word "shall" for "should" wherever it appears and interpret all references to the "authority having jurisdiction" and "owner" to mean the Contracting Officer.

1.7.10 Performance Verification Test

An electronic (.pdf) version of the HVAC Control System Performance Verification Test Procedures, in booklet form and indexed, 60 days before the Contractor's scheduled test dates. The performance verification test procedures shall refer to the devices by their unique identifiers as shown, shall explain, step-by-step, the actions and expected results that will demonstrate that the HVAC control system performs in accordance with the sequences of operation, the requirements of paragraph "Field Quality Control Tests", Contractor point to point tests and other contract documents. An HVAC control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

1.7.11 Commissioning Report

Submit one electronic (.pdf) version and 2 hard copies of the HVAC control system commissioning procedures, in booklet form and indexed, 60 days prior to the scheduled start of commissioning. Commissioning procedures shall be provided for each HVAC control system, and for each type of terminal unit control system. The Commissioning procedures shall reflect the format and language of this specification and refer to devices by their unique identifiers as provided by the Contractor, or if applicable, as shown. The Commissioning procedures shall be specific for each HVAC system and shall give detailed step-by-step procedures for commissioning of the system per paragraph "Field Quality Control Tests." Contractor shall provide at least 2 weeks advance notice to the Contracting Office for the Government representative to be present at commissioning.

a. The Commissioning procedures shall include detailed, product specific set-up procedures, configuration procedures, adjustment procedures, Lon and/or BACnet network testing to include simulated failures proving controllers operate as stand-alone and calibration procedures for each device. Where the detailed product specific commissioning procedures are included in manufacturer supplied manuals, reference may be made in the HVAC control system commissioning procedures to the manuals.

b. An HVAC control system commissioning procedures equipment list shall be included that lists the equipment to be used to accomplish commissioning. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

1.7.12 DDC Manufacturer's Hardware and Software Manuals

Provide one electronic (.pdf) version and 2 hard copies of the following manuals.

a. Installation and Technical Manuals for all digital controller hardware.

b. Installation and Technical Manuals for workstation.

c. Operator Manuals for all digital controllers.

d. Operator Manuals for all workstation software.

e. Programming Manuals for all digital controllers.

f. Provide one electronic (.pdf) version and 2 hard copies of programming Manuals for workstation software.

1.7.13 Controls and HVAC System Operators Manual

Submit one electronic (.pdf) version and 2 hard copies of the Control and HVAC Systems Operators Manual. Provide in hard copies in a 3 ring binder with a minimum of the following 6 sections. Use tabs to divide each section.

a. Description of HVAC Systems: Provide a description of the HVAC system components and control system. Include sequence of operation and a complete List of I/O Points.

b. Controls Drawings: Provide drawings as specified in submittal paragraph.

c. Control Program Listings: Provide listing of all control programs, including terminal equipment controller setup pages if used.

d. Current Operating Parameters: Provide printouts of input and output setup information, (database setups). This section provides information such as point addresses, slopes and offsets for all points, database of points, etc.

e. Control Equipment Technical Data Sheets: Provide technical data sheets for all controller hardware and accessories.

f. Backup of Control Program: Provide backup copies of the control program and ACAD control drawings on CD-ROM.

PART 2 PRODUCTS

2.1 DDC SYSTEM

a. Provide a DDC system as a distributed control system. The system shall have stand-alone Interoperable LonMarkTM or LonWorks, or BACnet digital controllers, and a communications Network. Licensed to the Government as "GSA" in the License owner section. The installing controls contractor should be included in the owner section for system access during construction and warranty period. LonMark/LonWorks controllers and/or BACnet controllers shall be connected to a Tridium JACE Network Area Controller (provided by controls contractor) to be node licensed to the existing JBLM EMCS Master Web Server.

b. Provide an operator programmable system to perform closed-loop, modulating control of building equipment. Connect all digital controllers through the communication network to share common data with the JBLM EMCS server capable of programming and monitoring the digital controllers.

   The control system shall be capable of downloading programs between the JBLM EMCS server and digital controllers.

c. Provide the quantity of digital controllers as required to perform the sequences of operation, or where shown, or as indicated on the drawings to perform required climate control, energy management, and alarm functions. The quantity of controllers shall be no less than that required to perform the sequences of operation within the parameters indicated in these specifications and contract drawings. All material used shall be currently in production.

2.1.1 Interoperable Direct Digital Controllers

DDC hardware shall be UL 916 rated. Interoperable controllers (IDC's) shall be LonMarkTM or LonWorks bearing the applicable LonMarkTM interoperability logo and shall be compatible with the Niagara Framework (a Tridium partner). Where LonMarkTM devices are not available, devices based on LonWorks are acceptable providing that the controllers are programmable or configurable through the JACE controller. Interoperable BACnet Controllers (IBC's) shall be in accordance with ASHRAE 135 and shall be compatible with the Niagara Framework. IBC's must be provided with product interoperability compliance statement documents that demonstrate the compliance level to the ASHRAE 135.

2.1.1.1 Distributed Control

Apply digital controllers in a distributed control manner.

2.1.1.2 I/O Point Limitation

Total number of I/O hardware points, including those communicated over a LAN, used by a single stand-alone digital controller, including I/O expansion units shall not exceed 48.

2.1.1.3 Environmental Operating Limits

Provide digital controllers that operate in environmental conditions between 32 and 120 degrees F.

2.1.1.4 Stand-Alone Control

Provide stand-alone digital controllers.

2.1.1.5 Internal Clock

Provide a clock with each stand-alone controller. Each controller shall have its clock backed up by a battery or capacitor with sufficient capacity to maintain clock operation for a minimum of 72 hours during power outage.

2.1.1.6 Memory

a. Provide sufficient memory for each controller to support required control, communication, trends, alarms, and messages.

b. Memory Protection: Programs residing in memory shall be protected either by using EEPROM, flash memory, or by an uninterruptible power source (battery or uninterruptible power supply (UPS)). The backup power source shall have sufficient capacity to maintain volatile memory during an AC power failure. Where the uninterruptible power source is rechargeable (a rechargeable battery), provide sufficient back-up capacity for a minimum of seventy-two hours. The rechargeable power source shall be constantly charged while the controller is operating under normal line power. Where a non-rechargeable power source is used, provide sufficient capacity for a minimum of two years accumulated power failure. Batteries shall be replaceable without soldering.

2.1.1.7 Inputs

Provide input function integral to the direct digital controller. Provide input type(s) as required by the DDC design. For each type of input used on high-level controllers, provide at least one similar spare input point per controller.

a. Analog Inputs: Allowable input types are 100 ohm (or higher) platinum RTDs, thermistors, 4 to 20 mA, and 0-10 VDC. Thermistor and direct RTD inputs must have appropriate conversion curves stored in controller software or firmware. Analog to digital (A/D) conversion shall have 10-bit minimum resolution.

b. Digital Inputs: Digital inputs shall sense open/close, on/off, or other two state indications.

2.1.1.8 Outputs

Provide output function integral to the direct digital controller. Provide output type(s) as required by the DDC design. For each type of output used on high-level controllers, provide at least one similar spare output point per controller.

a. Analog Outputs: Provide controllers with a minimum output resolution of 10 bits. Output shall be 4 to 20 mA or 0 to 10 VDC.

b. Digital Outputs: Provide contact closure with contacts rated at a minimum of 1 ampere at 24 volts.

2.1.1.9 PID Control

Provide controllers with proportional integral, and derivative control capability. Terminal controllers are not required to have the derivative component.

2.1.1.10 Digital Controller Networking Capabilities

The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate both the ASHRAE 135 BACnet and LonWorks technology communication protocols in one open, interoperable system. The upper-level digital controllers shall be Tridium JACE controllers capable of networking with the existing JBLM EMCS server. Upper-level controllers shall also be capable of communicating over JBLM EMCS network between buildings. The JACE Controller is to be connected to the EMCS through the NEC switch. NEC switch is not within the Scope of the contract. Cat-6 wiring to switch to be provided by Contractor.

2.1.1.11 Communications Ports

a. Controller-to-Controller LAN Communications Ports: Controllers in the building DDC system shall be connected in a communications network. Controllers shall have controller to controller communication ports to both peer controller (upper-level controllers) and terminal controllers (lower-level controllers). Network may consist of more than one level of local area network and one level may have multiple drops. Communications network shall permit sharing information between controllers, allowing execution of dynamic control strategies, and coordinated response to alarm conditions. Minimum baud rate for the lowest level LAN shall be 9600 Baud. Minimum baud rate for the highest-level LAN shall be 9600 Baud. Minimum baud rate for a DDC system consisting of a single LAN shall be 9600 Baud.

b. On-Site Interface Ports: Provide a RS-232, RS-485, or RJ-11 communications port for each digital controller that allows direct connection of a computer or laptop and through which the controller

may be fully accessed. Controller access shall not be limited to access through another controller. On-site interface communication ports shall be in addition to the communications port(s) supporting controller to controller communications. Communication rate shall be 9600-Baud minimum. Every controller on the highest-level LAN shall have a communications port supporting direct connection of a computer; a handheld terminal port is not sufficient. The following operations shall be available:
Downloading and uploading control programs, modifying programs and program data base, and retrieving or accepting trend reports, status reports, messages, and alarms.

2.1.1.12 Digital Controller Cabinet

Each indoor digital controller cabinet shall protect the controller from dust and shall be rated NEMA 1, unless specified otherwise. Each outdoor digital controller cabinet shall protect the controller from all outside conditions and shall be rated NEMA 4. Cabinets for high level controllers shall be hinged door, lockable, and have offset removable metal back plate.

2.1.1.13 Main Power Switch

Each controller on the highest-level LAN or each control cabinet shall have a main external power switch for isolation of the controller from AC power. The switch shall be in the DDC cabinet and shall be labeled.

2.1.2 Terminal Control Units (TCUs)

a. TCUs shall automatically start-up on return of power after a failure, and previous operating parameters shall exist or shall be automatically downloaded from a digital controller on a higher-level LAN.

b. TCUs do not require an internal clock, if they get time information from a higher-level digital controller.

2.1.3 DDC Software

The Contracting Officer's representative shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to JBLM as defined by the manufacturer's license agreement but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. 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 ASHRAE 135, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an **XIF file** for the device. For each BACnet device, the device supplier must provide a **PICS document** showing the installed device's compliance level. Minimum compliance is Level 6; with the ability to support data read and write functionality. All integration and programming shall be via the Niagara Framework network engineering software tools, Niagara Workbench.

2.1.3.1 Sequence of Control

Provide, in the digital controllers, software to execute the sequence of control. Provide one registered copy of all software used to program control sequences in direct digital controllers, LAN controllers and field configurable smart controllers on the stationary workstation. Provide any access keys which restrict programming language software functions or the ability to compile or prepare programming for download to controllers while editing parameters offline. Provide final copy of each program used in the system in both compiled and editable formats. Where specially programmed factory configured smart controllers are used in the system, provide the minimum factory programming tools and specialized controller programs ready for download to replacement controllers. At minimum, controllers must be capable of performing programming functions outlined in the following "Parameter Modification" section. The units for graphic display, parameter modification and maintenance interface shall be English, even if the project is a metric design.

2.1.3.2 Parameter Modification

Provide software capable of modifying all control parameters. Parameter modification shall be accomplished for all controllers (high level and low-level application specific) through the main workstation computer and with laptop computer or keypad terminal directly at each controller. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. Modifications shall be accomplished without having to make changes directly in line-by-line programming. Block programming languages shall provide for modification of these database parameters in fill-in-the-blank screens. Parameters of like type, including those in different high level and low-level controllers, may be grouped together for a single, global change. For example, an operator may group all second-floor space temperature set points into a group and raise the set point by two degrees with a single command. The following parameters shall be modifiable in this way:

a. Set points (English Units)

b. Dead band limits and spans

c. Reset schedules

d. Switch over points

e. PID gains and time between control output changes

f. Time

g. Timed local override time

h. Occupancy schedules

i. Holidays

j. Alarm points, alarm limits, and alarm messages

k. Point definition database

l. Point enable, disable, and override

m. Trend points, trend intervals, trend reports

n. Analog input default values

o. Passwords

p. Communications parameters including network and telephone communications setups

q. User thermostat/sensor set point limitations

2.1.3.3 Differential

Where set point is in response to some analog input such as temperature, pressure, or humidity, include a set point differential for the control loop to prevent short cycling of control devices.

2.1.3.4 Motor and Flow Status Delay

Provide an adjustable delay between when a motor is commanded on or off and when the control program looks to the motor or flow status input for confirmation of successful command execution.

2.1.3.5 Runtime Accumulation

Provide resettable run time accumulation for each controlled digital output.

2.1.3.6 Timed Local Override

Provide user definable adjustable run time for each push of a momentary contact timed local override. Pushes shall be cumulative with each push designating the same length of time. Provide a user definable limit on the number of contact closures summed, such as 6, before the contact closures are ignored. Timed local overrides are disabled during occupancy periods.

2.1.3.7 Time Programs

Provide programs to automatically adjust for leap years and make daylight savings time and standard time adjustments.

2.1.3.8 Scheduling

a. Individual controlled equipment shall be schedulable with schedule based on time of day, day of week, and day of year. Equipment may be associated into groups. Each group may be associated with a different schedule. Changing the schedule of a group shall change the schedule of all equipment in the group. Groups may be modified, created and deleted by the operator.

b. Provide capability that will allow current schedules to be viewed and modified in a seven-day week format. When control program does not automatically compute holidays, provide capability to enter holiday schedules one full year at a time.

2.1.3.9 Point Override

I/O and virtual points shall accept software overrides to any possible value.

2.1.3.10 Alarming

I/O points and software points shall be configured to alarm. Alarms may be enabled and disabled for every point and shall be initiated as shown on the Point Schedule. Alarm limits shall be adjustable on analog points. Controllers connected to an external communications device such as a printer, terminal, or computer, shall download alarm and alarm message when alarm occurs. Alarms will be stored and automatically downloaded to a Supervisor/Server. The following conditions shall generate alarms:

a. Motor is commanded on or off but the motor status input indicates no change

b. Temperature, humidity, or pressure strays outside selectable limits

c. An analog input takes a value indicating sensor failure

d. A module is not communicating on the LAN

e. A power outage occurs

f. Do not alarm a "return to normal state"

2.1.3.11 Messages

Messages shall be operator defined and assigned to alarm or status conditions. Messages shall be displayed on the workstation or printer when these conditions occur.

2.1.3.12 Trending

DDC system shall have the capability to trend all I/O and virtual points. Trend logs shall be initialed for the points identified in the Point Schedule. Points may be associated into groups. A trend report may be set up for each group. The period between logging consecutive trend values shall range from 1 minute to 15 minutes at a minimum. The minimum number of consecutive trend values stored at one time shall be 30 per variable. When trend memory is full, the most recent data shall overwrite the oldest data. Trend data shall be capable of being uploaded to computer. Trend data shall be available on a real time basis; trend data shall appear numerically and graphically on a connected computer's screen as the data is processed from the DDC system. Trend reports shall be capable of uploading to computer for storage.

2.1.3.13 Status Display

Current status of I/O and virtual points shall be displayed on command. Points shall be associated into functional groups, such as all the I/O and virtual points associated with control of a single air handling unit, and displayed as a group, so the status of a single mechanical system can be readily checked. A group shall be selectable from a menu of groups having meaningful names, such as AHU-4, Second Floor, Chiller System, and other such names.

2.1.3.14 Diagnostics

Each controller shall perform self-diagnostic routines and provide messages to an operator when errors are detected. The DDC system shall be capable of recognizing a non-responsive module on a LAN. The remaining, responsive modules on a LAN shall not operate in a degraded mode.

2.1.3.15 Power Loss

During a power outage, each controller shall assume a disabled status and outputs shall go to a user definable state. Upon restoration of power, DDC system shall perform an orderly restart, with sequencing of outputs without a need for human interaction.

2.1.3.16 Program Transfer

Provide software for download of control programs and database from a computer to controllers and upload of same to computer from controllers.

Every digital controller in the DDC system shall be capable of being downloaded and uploaded to a single controller on the highest-level LAN. At project completion the Station shall be integrated into the JBLM N4 server and a Station Backup shall be copied to the server at building 2012.

2.1.3.17 Password Protection

Provide at least three levels of password protection to the DDC system permitting different levels of access to the system. The lowest level allows monitoring only. The highest level allows full control of all functions, including setting new passwords.

2.1.4 Workstation

a. If the project is stand-alone (cannot be connected to a JBLM network switch) the contractor is to provide a central workstation computer installed with Web Supervisor Niagara Workbench software to provide an interface for monitoring, troubleshooting, and adjusting the program or operating parameters of all DDC controllers, including TCUs. The workstation shall also be capable of programming all controllers, including TCUs.

b. DDC system shall operate continuously without connection to the workstation. Information at the workstation is not required for day-to-day operations of the direct digital controllers.

c. Per Executive Order 13423, desktop computers, notebook computers, and PC monitors shall be registered under the Electronic Product Environmental Assessment Tool (EPEAT) (IEEE 1680 standard for personal computer products) at a minimum Bronze level, but preferably at Silver or above (http://www.epeat.net/). These items shall also meet applicable FEMP recommended standby power requirements (http://www1.eere.energy.gov/femp/procurement/eep_standby_power.html).

2.1.5 Hardware

The DDC system manufacturer shall assure compatibility of all workstation computer equipment and peripherals. The workstation shall be configured to operate according to the DDC system manufacturer's specifications. Workstation hardware shall be configured to allow operation of software, uploading and downloading of programs, and creation of graphics.

a. Security Workstation Cabinet features: Locking upper compartment with Plexiglas window provided viewable access to most 20 inch monitors; Locking pull-out drawer facilitates ergonomic operation of keyboard, mouse, and convenient storage of small supplies;

Keyboard and supplies can be accessed even while top and bottom compartments are locked; Full size locking bottom doors in front and rear for complete access to equipment and cables; Lower compartment features one fixed bottom and one adjustable shelf for desktop or tower style PCs, printer, paper or supplies; Louvers in rear provide equipment ventilation; Heavy duty all welded steel top and bottom sections bolt together for easy assembly; Top Level Compartment (internal): 20¾" W x 21¾" D x 19¼" H; Lower Level Compartment (internal): 20¾" W x 21¼ D x 23½" H; Overall Dimensions: 21" W x 22½" D x 59½" H

2.1.6 Software

Workstation software shall be Web Supervisor with the appropriate Niagara Workbench services and configured to operate according to the DDC system manufacturer's specifications. Software shall be resident in the workstation computer and permit monitoring, programming and troubleshooting of the DDC system. Workstation software permits modification of controller parameters and control for all controllers, both high level and low-level application specific. Operations shall be menu selected. Menu selections shall be made with a mouse.

a. Menu System: Menu system shall allow an operator to select a particular function or access a particular screen through successive menu penetration.

b. Controller Parameter Modification: The workstation software shall be an interface for performance specified in paragraph entitled "Parameter Modification" and available through direct connection of a computer to a digital controller. Parameter modification shall require only that an operator "fill in the blank" for a parameter on a screen requesting the information in plain language. Parameter modifications shall download to the appropriate controllers at operator request.

c. Program modification: All systems shall use block programming languages that provide a capability for linking blocks together to create new programs or modify existing programs. Custom written programming shall not be used. Program modifications shall download to appropriate controllers at operator request.

2.1.7 Graphic-Based Software

The workstation shall use graphic-based software to provide a user-friendly interface to the DDC system. Graphic-based software shall provide graphical representation of the building, the buildings mechanical systems, and the DDC system. The current value and point name of every I/O point shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

a. Graphics shall follow the style of the examples in Appendix B in representing mechanical systems, sensors, controlled devices, point names, colors, fonts, navigation buttons, etc. Graphics shall utilize the standard library included in the Niagara Workbench/Web Supervisor software.

b. Graphic Title: All graphics pages shall include building location, building function, building number, version of Niagara and controller software. Reference Appendix B.

c. Dynamic Update: When the workstation is on-line with the control system, point data shall update dynamically on the graphic images.

d. Graphic Penetration: Provide graphic penetration when the capability exists. For systems without graphic penetration, provide menu penetration for selection of individual graphics to give the same hierarchical affect provided by graphic penetration.

e. Graphic Types: Graphic-based software shall have graphics of the building exterior, building section, floor plans, and mechanical systems. Provide the following graphics:

(1) Building Exterior Graphic: Show exterior architecture, major landmarks, and building number.

(2) Building Section Graphic: Show floors in section graphic with appropriate floor name on each floor.

(3) Floor Plan Graphics: Provide a single graphic for each floor, unless the graphic will contain more information than can reasonably be shown on a single graphic. Each heating or cooling zone within a floor plan shall have a zone name and its current temperature displayed within the zone outline. Show each controlled variable in the zone. Provide visual warning for each point in alarm.

Mechanical System Graphics: Provide two-dimensional drawings to symbolize mechanical equipment; do not use line drawings. Show controlled or sensed mechanical equipment. Each graphic shall consist of a single mechanical system; examples are a graphic for an air handling unit, a graphic for a VAV box, a graphic for a heating water system, and a graphic for a chiller system. Place sensors and controlled devices associated with mechanical equipment in their appropriate locations. Place point name and point value adjacent to sensor or controlled device. Provide visual warning of each point in alarm. Condition, such as zone temperature, associated with the mechanical system shall be shown on the graphic. Point values shall update dynamically on the graphic.

f. Graphic Editing: Full capacity as provided by a draw software package shall be included for operator editing of graphics. Graphics may be created, deleted, modified, and text added. Provide capability to store graphic symbols in a symbol directory and import these symbols into graphics. A minimum of 256 colors shall be available.

g. Dynamic Point Editing: Provide full editing capability for deleting, adding, and modifying dynamic points on graphics.

h. Trending: Trend data shall be displayed graphically, with control variable and process variable plotted as functions of time on the same chart. Graphic display of trend data shall be internal to the JACE software and not resulting from download of trend data into a third-party spreadsheet program such as Excel, unless such transfer is automatic and transparent to the operator, and the third-party software is included with the workstation software package. At the operator's discretion, trend data shall be plotted real time.

2.1.8 Maintenance Personnel Interface Tools

Provide special interface tools as required to change set points, make operational changes and troubleshoot.

2.2 SENSORS AND INPUT DEVICES

2.2.1 Field Installed Temperature Sensors

Input hardware/devices are not to be integral with digital controllers.

2.2.1.1 Thermistors

Precision thermistors may be used in temperature sensing applications below 200 degrees F. Sensor accuracy over the application range shall be 0.36 degree F or less between the ranges of 0 to 66 degrees C (32 to 150 degrees F). Stability error of the thermistor over five years shall not exceed 0.14 degrees C (0.25 degree F) cumulative. Sensor element and leads shall be encapsulated. Bead thermistors are not allowed. A/D conversion resolution error shall be kept to 0.06 degree C (0.1 degree F). Total error for a thermistor circuit shall not exceed 0.28 degree C (0.5 degree F), which includes sensor error and digital controller A/D conversion resolution error. Provide 18 gauge twisted and shielded cable for thermistors.

2.2.1.2 Resistance Temperature Detectors (RTDs)

Provide RTD sensors with 1000 ohm, or higher, platinum elements that are compatible with the digital controllers. Sensors shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (1000 ohms) at 0 degrees C (32 degrees F). Temperature sensor stability error over five years shall not exceed 0.14 degree C (0.25 degree F) cumulative. Direct connection of RTDs to digital controllers, without transmitters, is preferred. Provide transmitters only when required due to distance between sensor and controller, or when controller does not support direct connection of sensor. When RTDs are connected directly to the controller, keep lead resistance error to 0.14 degree C (0.25 degree F) or less. Total error for a RTD circuit shall not exceed 0.28 degree C (0.5degree F), which includes sensor error, lead resistance error or 4 to 20 mA or 0 to 10 VDC transmitter error, and A/D conversion resolution error.

2.2.1.3 Temperature Sensor Details

a. Room Type: Conceal element behind protective cover matched to the room interior. Room temperature sensors connected directly to application specific controllers shall have integral pushbutton, system override digital input button, and a set point adjustment lever that is limited through software programming.

b. Duct Averaging Type: Continuous averaging RTDs for ductwork applications shall be 30 centimeters in length for each 0.37 square meters (one foot in length for each 4 square feet) of ductwork cross-sectional area with a minimum length of 1.8 meter (6 feet). Probe type duct sensors of 30 centimeter (one foot) length minimum are acceptable in ducts 1.1 square meter (12 feet square) and less.

c. Immersion Type: 75 mm (3 inches) total immersion for use with sensor wells, unless otherwise indicated.

d. Sensor Wells: Stainless steel material. Provide heat-sensitive transfer agent between exterior sensor surface and interior well surface.

e. Outside Air Type: Provide element on the building's north side with sunshade to minimize solar effects. Mount element at least 75 mm (3 inches) from building outside wall. Sunshade shall not inhibit the flow of ambient air across the sensing element. Shade shall protect sensing element from snow, ice, and rain.

2.2.2 Transmitters

Transmitters shall have 4 to 20 mA or 0 to 10 VDC output linearly scaled to the temperature, pressure, humidity, or flow range sensed. Transmitter shall be matched to the sensor, factory calibrated, and sealed. Total error shall not exceed 0.1 percent at any point across the measured span. Supply voltage shall be 24 volts ac or dc. Transmitters shall have non-interactive offset and span adjustments. For temperature sensing, transmitter stability shall not exceed 0.05 degrees C (0.09 degrees F) a year. Transmitters are not required unless warranted by signal travel distance.

2.2.2.1 Spans and Ranges

Transmitter spans or ranges shall meet the following:

a. Temperature:

   (1) 28 degrees C (50 degrees F) span: Room, chilled water, cooling coil discharge air, return air sensors

   (2) 56 degrees C (100 degrees F) span: Outside air, hot water, heating coil discharge air, mixed air sensors

   (3) 111 degrees C (200 degrees F) span: High temperature hot water, heating hot water, chilled/hot water system sensors.

b. Pressure:

   (1) -125 to 125 pascals (-0.5 to 0.5 inches water) differential range: static pressure control of rooms

   (2) 0 to 1250 pascals (0 to 5 inches water) differential range: Duct static pressure

   (3) 0 to 689 kPa (0 to 100 psig) differential: Water differential pressure

   (4) 0 to 750 pascals (0 to 3 inches water) differential range: Static pressure across filters

c. Relative Humidity:

   (1) 10 to 90 percent minimum relative humidity range

2.2.3 Relative Humidity Transmitters

Provide integral humidity transducer and transmitter. Output of relative humidity instrument shall be a 4 to 20 mA or 0 to 10 VDC signal proportional to full range of relative humidity input. Accuracy shall be 2 percent of full scale, long-term stability shall be less than one percent drift per year. Sensing element shall be polymer or thin film polymer type.

2.2.4 Pressure Transmitters

Provide integral pressure transducer and transmitter. Output of pressure instrument shall be a 4 to 20 mA or 0 to 10 VDC signal proportional to the pressure span. Span shall be as specified. Accuracy shall be 1.0 percent. Linearity shall be 0.1 percent.

2.2.5 Current Transmitters

Provide current transmitters to monitor amperage of motors. Select current transmitters for normal measured amperage to be near 50 percent of full-scale range. Current transmitters shall have an accuracy of one percent and 4 to 20 mA or 0 to 10 VDC output signal.

2.2.6 Air Quality Sensors

2.2.6.1 Carbon Dioxide (CO2) Sensor and/or Nitrogen Oxide (NOx) Sensor

Provide CO2 and/or NOx sensors with integral transducers where shown or required by the sequence of operations. Output signal shall be 4 to 20 mA or 0 to 10 VDC. Accuracy shall be 5 percent of full scale.

2.2.7 Input Switches

2.2.7.1 Timed Local Override

Provide momentary contact push button override with override time set in controller software. Provide to override DDC time of day program and activate occupancy program for assigned units. Upon expiration of override time, the control system shall return to time-of-day program. Time interval for the length of operation shall be software adjustable and shall expire unless reset.

2.2.7.2 Insertion Freeze Protection Switch

Electric switch shall be capillary type. Provide special purpose insertion thermostats with flexible elements a minimum of 6 meters (20 feet) in length for coil face areas up to 3.7 square meters (40 square feet). Switch contacts shall be rated for motor starter circuit voltage being interrupted. Switch shall be equipped with auxiliary set of contacts for input of switch status to digital controller. Provide additional elements or longer elements for larger coils at the rate of 30 centimeters (1-foot) of element per .37 square meters (4 square feet) of coil. Serpentine capillaries perpendicular to the air flow to uniformly sense the entire airflow. A freezing condition at 18-inch increments along the sensing element shall activate the thermostatic switch. Switch shall require manual reset after activation.

2.2.7.3 Electronic Airflow Measurement Stations and Transmitters

a. Station - Each station shall contain an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. The velocity sensing elements shall be of the RTD or thermistor type. The sensing elements shall be distributed across the duct cross section in the quantity and pattern set forth for measurements and instruments of ASHRAE Gdln3 and SMACNA HVACTAB for the traversing of ducted air flows. The resistance to airflow through the airflow measurement station shall not exceed 20 pascals' (0.08 inch water gauge) at an airflow of 10.16 meters per second (2,000 fpm). Station construction shall be suitable for operation at airflow of up to 25.4 meters per second (5,000 fpm) over a temperature range of 4 to 49 degrees C (20 to 120 degrees F), and accuracy shall be plus or minus 3 percent over a range of 0.635 to 12.7 meters per second (125 to 2,500 fpm) scaled to air volume.

b. Each transmitter shall produce a linear, temperature compensated 4 to 20 mA or 0 to 10 VDC output corresponding to the actual air flow. The transmitter shall be a 2-wire, loop powered device. The output error of the transmitter shall not exceed 0.5 percent of the calibrated measurement.

2.3 OUTPUT DEVICES

2.3.1 Control Dampers

Damper shall conform to SMACNA 1966 (2005) HVAC Duct Construction Standards Metal and Flexible.

a. A single damper section shall have blades no longer than 1220 mm(48 inches) and shall be no higher than 1830 mm (72 inches). Maximum damper blade width shall be 203 mm (8 inches). Larger sized damper shall be made from a combination of sections.

b. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blades shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of 102 L/s per square meter (20 cfm per square foot) at 996 Pa (4 inches water) gauge static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 degrees C to 93 degrees C

(40 degrees F to 200 degrees F). Dampers shall be rated at not less than 10 m/s (2000 fpm) air velocity. All blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section will not be located directly in the air stream. Damper axles shall be 13 mm (0.5 inch) (minimum) plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 10 Pa gauge at 5 m/s (0.04 inch water gauge at 1000 fpm) in the wide open position. Frames shall not be less than 50 mm (2 inches) in width. Dampers shall be tested in accordance with AMCA 500-D.

c. Operating links external to dampers (such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers) shall withstand a load equal to twice the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Moving parts in contact with one another shall be of different materials. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crank arms shall control the open and closed position of dampers.

2.3.2 Control Valves

2.3.2.1 Valve Assembly

Valves shall have stainless steel stems. Valve bodies shall be designed for not less than 862 kPa (gauge) (125 PSIG) working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Cv. Class 125 copper alloy valve bodies and Class 150 steel or stainless steel valves shall conform to ASME B16.5 as a minimum. Cast iron valve components shall conform to ASTM A 126 Class B or C as a minimum. Valves for heating coils shall fail normally open.

2.3.2.2 Butterfly Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service and for modulation to the fully closed position, with noncorrosive discs, stainless steel shafts supported by bearing, and EPDM seats suitable for temperatures from minus 29 degrees C to plus 121 degrees C (minus 20 degrees F to plus 250 degrees F). Valves shall have a manual means of operation independent of the actuator.

2.3.2.3 Two-Way Valves

Two-way modulating valves shall have equal percentage characteristics.

2.3.2.4 Three-Way Valves

Three-way valves shall have equal percentage characteristics.

2.3.2.5 Duct Coil and Terminal Unit Coil Valves

Provide control valves with either flare-type or solder-type ends provided for duct or terminal-unit coils. Provide flare nuts for each flare-type end valve.

2.3.2.6 Valves for Hot Water Service

Valves for hot water service below 121 degrees C (250 Degrees F):

a. Bodies for valves 40 mm(1 1/2 inches) and smaller shall be brass or bronze with threaded or union ends. Bodies for valves larger than 50 mm (2 inches) shall have flanged-end connections. Water valves shall be sized for a 21 kPa (3 psi) differential through the valve at rated flow, except as indicated otherwise. Select valve flow coefficient (Cv) for an actual pressure drop not less than 50 percent or greater than 125 percent of the design pressure drop at design flow.

b. Internal trim, including seats, seat rings, modulation plugs, and springs, of valves controlling water hotter than 99 degrees C (210 degrees F) shall be Type 316 stainless steel.

c. Internal trim for valves controlling water 99 degrees C (210degrees F) or less shall be brass or bronze.

d. Non-metallic parts of hot water control valves shall be suitable for a minimum continuous operating temperature of 121 degrees C or

28 degrees C (250 degrees F or 50 degrees F) above the system design temperature, whichever is higher.

e. Valves 100 mm (4 inches) and larger shall be butterfly valves.

2.3.3 Actuator

2.3.3.1 Electric Actuators

Provide direct drive electric actuators for all control applications. When operated at rated voltage, each actuator shall be capable of delivering torque required for continuous uniform motion and shall have end switch to limit travel or shall withstand continuous stalling without damage. Actuators shall function properly with range of 85 to 110 percent of line voltage.

Provide gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torque less than 1.8 Newton meters (16 inch pounds). Provide hardened steel running shafts in sleeve bearing of copper alloy, hardened steel, nylon, or ball bearing. Provide two-position actuators of the single direction, spring return, or reversing type. Provide proportioning actuators capable of stopping at all points in the cycle and starting in either direction, from any point.

Provide reversing and proportioning actuators with limit switches to limit travel in either direction unless operator is stall type. Actuators shall have a simple switch for reversing direction, and a button to disengage clutch for manual adjustments. Provide reversible shaded pole, split capacitor, synchronous, or stepper type electric motors.

2.3.4 Output Switches

2.3.4.1 Control Relays

Shall be double pole, double throw (DPDT), UL listed, with contacts rated to the application, indicator light, and dust proof enclosure. Light indicator is lit when coil is energized and is off when coil is not energized. Relays shall be socket type, plug into a fixed base, and replaceable without need of tools or removing wiring. Encapsulated "PAM" type relays are permissible for terminal control applications.

2.4 ELECTRICAL POWER AND DISTRIBUTION

For control power provide a new, dedicated source 120 volts or less, 60 Hz, three wire (black, white, and green). Run green ground wire to panel ground; conduit grounds are not sufficient.

2.4.1 Transformers

Transformers shall conform to UL 506. Power digital controllers and terminal control units (TCU's) from dedicated circuit breakers with surge protection specified. Transformers for digital controllers serving terminal equipment on lower-level LANs may be grouped to have specified surge protection sized for the number of controllers on a single transformer. Provide a fuse on the secondary side of the transformer.

2.4.2 Surge Protection

Surge and transient protection consist of devices installed externally to digital controllers.

2.4.2.1 Power Line Surge Protection

Surge suppressors external to digital controller, shall be installed on all incoming AC power. Surge suppressor shall be rated by UL 1449, have a fault indicating light, and have clamping voltage ratings below the following levels:

a. Unit is a transient voltage surge suppressor 120 VAC/1 phase/2 wire plus ground, hard wire individual equipment protector.

b. Unit must react within 5 nanoseconds and automatically reset.

c. Voltage protection threshold, line to neutral, starts at no more than 211 volts peak on the 120 VAC line.

d. The transient voltage surge suppressor must have an independent secondary stage equal to or greater than the primary stage joule rating.

e. The primary suppression system components must be pure Silicon Avalanche Diodes.

f. Silicon Avalanche Diodes or Metal Oxide Varistors are acceptable in the independent secondary suppression system.

g. The Transient Suppression System shall incorporate an indication light which denotes whether the primary and/or secondary transient protection components is/are functioning.

h. All system functions of the Transient Suppression System must be individually fused and not short circuit the AC power line at any time.

i. The Transient Suppression System shall incorporate an EMI/RFI noise filter with a minimum attenuation of 13 dB at 10 kHz to 300 MHz.

j. The system must comply with IEEE C62.41, Class "B" requirements and be tested according to IEEE C62.45.

k. The system shall operate at -20 to degrees C (-4 to 122 degrees F).

2.4.2.2 Telephone and Communication Line Surge Protection

Provide transient surge protection to protect the DDC controllers and LAN related devices from surges that occur on the phone lines (modem or direct connect) and on inter-unit LAN communications. Devices shall be UL listed.

a. The surge protection shall be a rugged package with continuous, non-interrupting protection and not use crowbar technology. Instant automatic reset after safely eliminating transient surges, induced lightning, and other forms of transient over voltages.

b. Unit must react within 5 nanoseconds using only solid-state silicone avalanche technology.

c. Unit shall be installed at the proper distance as recommended by the manufacturer.

2.4.2.3 Controller Input/Output Protection

Controller input/output points shall surge protection with optical isolation, metal oxide varistors (MOV), or silicon avalanche devices. Fuses are not permitted for surge protection.

2.4.3 Wiring

Provide complete electric wiring for DDC System, including wiring to transformer primaries. Control circuit wiring shall not run in the same conduit as power wiring over 100 volts. Circuits operating at more than 100 Volts shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Circuits operating at 100 Volts or less shall be defined as low voltage and shall be run in rigid or flexible conduit, metallic tubing, metal raceways or wire trays. Provide circuit and wiring protection as required by NFPA 70. Aluminum-sheathed cable or aluminum conduit may be used but shall not be buried in concrete. Use conduit in HVAC plenums.
HVAC plenums include the space between a drop ceiling and the architectural ceiling, within walls, and within ductwork. Protect exposed wiring from abuse and damage.

2.4.3.1 AC Control Wiring

a. Control wiring for 24 V circuits shall be insulated copper 18 AWG minimum and rated for 300 VAC service.

b. Wiring for 120 V shall be 14 AWG minimum and rated for 600 V service.

2.4.3.2 Analog Signal Wiring

Analog signal wiring shall be 18 AWG single or multiple twisted pair. Each cable shall be 100 percent shielded, and have 20 AWG drain wire. Each wire shall have insulation rated to 300 V ac. Cables shall have an overall aluminum-polyester or tinned-copper (cable-shield tape). Install analog signal wiring in conduit separate from AC power circuits.

2.5 FIRE PROTECTION DEVICES

Fire protection features for all air handling, heating, ventilation, and exhaust systems, such as smoke detectors, fire dampers and smoke dampers, must comply with the requirements of NFPA 90A, except as modified by UFC

3600-1, specifically section 28-1 specifies duct smoke are not required where air distribution systems are incapable of spreading smoke beyond the enclosing walls, floors and ceilings of the room or space in which the smoke is generated. Duct smoke detectors are not required when the air distribution system supplies a space or room that has area smoke detection. Fire protection devices shall all be powered, controlled and monitored by the FACP and only monitored for status by the DDC and show visual alarm on the DDC screen when the fire protection device shuts down the AHU.

2.5.1 Smoke Detectors

Provide in systems having air handling capacity over 944 l/s (2,000 cfm) in accordance with NFPA 90A. Design for detection of abnormal smoke densities by the ionization or photoelectric principle, responsive to both invisible and visible particles of combustion, and not susceptible to operation by changes to relative humidity. Provide UL listed or FM approved detectors for duct installation. Provide duct detectors with an approved duct housing, mounted exterior to duct, and with perforated sampling tubes extending across width of duct. Provide 115 V ac power supply unit integral with duct housing. Duct smoke detectors shall conform to the requirements of UL 268A. Duct smoke detectors shall have perforated sampling tubes extended into the air duct. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. Detectors shall have automatic reset and the AHU shall auto restart when alarm condition clears. Detectors shall be rated for air velocities that include air flows between 2.5 and 20 m/s. 500 and 4000 fpm. Detectors shall be powered from the fire alarm control panel. Detectors shall have two sets of normally open alarm contacts and 2 sets of normally closed alarm contacts.

2.6 INDICATORS

2.6.1 Thermometers

Provide fluid filled or bi-metal thermometers for manual temperature reference. Thermometers shall have either 9 inch scales or 3.5 inch dials. Provide with an adjustable angle suitable for the service. Provide thermometer and corrosion resistant separable socket well. Fluid filled thermometers (mercury is not acceptable) shall have a nominal scale diameter of 125mm. Construction shall be stainless steel case with molded glass cover, stainless steel stem and bulb. Stem shall be straight, length as required to fit well.

2.6.2 Pressure Gauges

a. Gauges for low differential pressure measurements shall be 4 1/2 inch (nominal) size with two sets of pressure taps, and shall have a diaphragm actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge shall have ranges and graduations as appropriate for the application, or as shown. Accuracy shall be plus or minus 2 percent of scale range.

2.7 VARIABLE FREQUENCY 3 PHASE MOTOR DRIVES

The variable frequency drive (VFD) shall convert 208 or 460 volt (10 percent), three phase, 60 hertz (2Hz), utility grade power to adjustable voltage/frequency, three phase, AC power for step less motor control from 5 percent to 105 percent of base speed.

2.7.1 Description

The variable frequency drive (VFD) shall produce an adjustable AC voltage/ frequency output for complete motor speed control. The VFD must meet all of the following criteria.

a. The VFD shall use sine coded PWM technology. The sine coded PWM calculations are performed by the VFD microprocessor.

b. The VFD shall use IGBT transistors for the inverter's three phase output.

c. The VFD shall use a three phase diode bridge converter to charge the VFD constant voltage capacitor buss.

d. The VFD shall have the ability for control by either a remote 4-20 mA or 0 to 10 VDC control signal or from a local control panel located on the VFD itself.

e. The VFD shall use microprocessor technology for VFD control. The VFD shall be programmable with a permanently mounted keypad included with each VFD.

f. The VFD shall be fully self-diagnostic. No external programmers, analyzers, interrogators, or diagnostic boards, shall be needed to annunciate VFD faults or drive internal status.

2.7.2 Code Standards

VFD shall be UL listed as delivered to the end user. The VFD shall meet current National Electrical Code.

2.7.3 VFD Quality Assurance

To ensure quality, each and every VFD shall be subject to a series of in plant quality controlled inspections before approval for shipment from the manufacture's facilities.

a. All components shall be tested prior to assembly and the complete unit shall be tested under full load conditions to ensure maximum product reliability.

b. The VFDs shall be the current standard production unit with at least 10 identical units already in the field.

c. Engineering support shall be available from the factory of the VFD. Phone support shall be free of charge to the end user for the life of the equipment. Factory support shall be available in the English language.

2.7.4 VFD Service

The VFD shall be supplied with:

a. 24 month parts and labor warranty. The warranty shall start when the system is accepted by the end user or 30 months from date of shipment.

b. Installation, operation, and troubleshooting guide(s).

c. A district service support group shall provide the following additional services:

(1) Factory trained personal on-site for start-up for up to one working day at no additional cost. Personnel shall be competent in operation and repair of the particular model of VFD that is installed.

(2) On-site training of customer personnel in basic installation, troubleshooting, and operation of VFDs at no additional cost. This training shall be conducted for up to 6 personnel at the installation site for a minimum of 4 hours.

2.7.5 Basic VFD Features

The VFD shall have the following basic features with no more than three separate internal electronic boards.

a. VFD mounted operator control keypad capable of:

(1) Remote/Local operator selection with password access.

(2) Run/Stop and manual speed commands.

(3) All programming functions.

(4) Scrolling through all display functions.

b. Digital display capable of indicating:

   (1) VFD status.

   (2) Frequency.

   (3) RPM of motor.

   (4) Phase current.

   (5) Fault diagnostics in descriptive text.

   (6) All programmed parameters.

c. Standard PI loop controller with input terminal for controlled variable and parameter settings made while inverter running.

d. User interface terminals for end-user remote control of VFD speed, speed feedback, and isolated form C SPDT relay energized on drive fault condition.

e. An isolated form C SPDT auxiliary relay energized on run command.

f. The VFD shall have a metal NEMA 1 enclosure.

g. The VFD shall have an adjustable carrier frequency with 16 KHz minimum upper limit.

h. The VFD shall have a built in or external line reactor with 3% minimum impedance to protect DC buss capacitors and rectifier section diodes.

2.7.6 Programmable Parameters

The VFD shall include the following operator programmable parameters:

a. Upper limit frequency.

b. Lower limit frequency.

c. Acceleration rate.

d. Deceleration rate.

e. Variable torque volts per Hertz curve.

f. Starting voltage level.

g. Starting frequency level.

h. Display speed scaling.

i. Enable/disable auto-restart feature.

j. Enable/disable soft stall feature.

k. Motor overload level.

l. Motor stall level.

m. Jump frequency and hysteresis band.

n. PWM carrier frequency.

2.7.7 Protective Circuits and Features

a. An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.

b. An electronic adjustable soft stall feature, allowing the VFD to lower the frequency to a point where the motor will run at FLA when an overload condition exists at the requested frequency. The VFD will automatically return to the requested frequency when load condition permit.

c. The VFD will have a separate electronic stall at 110% VFD rated current and a separate hardware trip at 190% current.

d. The VFD shall have ground fault protection that protects output cables and motor from grounds during both starting and continuous running conditions.

e. The VFD shall have the ability to restart after the following faults:

(1) Overcurrent (drive or motor).

(2) Power outage.

(3) Phase loss.

(4) Overvoltage/Under voltage.

e. The VFD shall restart into a rotating load without tripping or damaging the VFD or the motor.

f. The VFD shall keep a log of a minimum of four previous fault conditions, indicating type and time of occurrence in descriptive text.

g. The VFD shall be able to sustain 110% rated current for 60 sec.

h. The VFD shall respond to and record the following fault conditions:

(1) Over current (and have an indication if the over current was during acceleration, deceleration, or running).

(2) Overcurrent internal to the drive.

(3) Motor overload at start-up.

(4) Over voltage from the utility power.

(5) Motor running overload.

(6) Overvoltage during deceleration.

(7) VFD over heat.

(8) Load end ground fault.

(9) Abnormal parameters or data in VFD EEPROM.

2.7.8 Operational Conditions

The VFD shall be designed and constructed to operate within the following service conditions.

a. Ambient Temperature Range, -17.7 to 48.8 degrees C (0 to 120 deg.F).

b. Non-condensing relative humidity to 90 percent.

2.7.9 Available Options

Provide the following options:

a. RFI/EMI filters

b. LonWorks or BACnet interface card with application software which can both control and monitor the VFD from the DDC system.

c. A manual bypass circuit and switch integral or external to the drive to allow drive bypass drive and operate at 100% speed. Overload fuses and other protective hardware shall remain in the circuit during bypass.

2.8 DRAWINGS

2.8.1 Shop Drawings

Drawings shall be on A1 (841 mm by 594 mm) 34 by 22 inch sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall have a unique identifier as shown. The HVAC Control System Drawings shall be delivered together as a complete submittal. Deviations must be approved by the Contracting Officer. List of Drawings shall be submitted along with Submittal SD-01, Preconstruction Submittals

2.8.2 List of Drawings

HVAC Control System Drawings shall include the following:

Sheet One: Drawing Index, HVAC Control System Legend.

Sheet Two: Valve Schedule, Damper Schedule.

Sheet Three: Control System Schematic and Equipment Schedule.

Sheet Four: Sequence of Operation and Data Terminal Strip Layout.

Sheet Five: Control Loop Wiring Diagrams and Ladder Diagrams.

Sheet Six: Motor Starter and Relay Wiring Diagram.

Sheet Seven: Communication Network Architecture and Block Diagram.

Sheet Eight: DDC Panel Installation and Block Diagram.

(Repeat Sheets Four through Seven for each AHU System.)

2.8.3 Drawing Index

The HVAC Control System Drawing Index shall show the name and number of the building and military site. The Drawing Index shall list HVAC Control System Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The HVAC Control System Legend shall show generic symbols and the name of devices shown on the HVAC Control System Drawings.

2.8.4 Valve Schedule

The valve schedule shall include each valve's unique identifier, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure data, dimensions, and access and clearance requirements data. Valve schedules may be submitted in advance but shall be included in the complete submittal.

2.8.5 Damper Schedule

The damper schedule shall contain each damper's and each actuator's identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, spring ranges, operation rate, positive positioner ranges, locations of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the maximum leakage rate at the operating static-pressure differential. The Damper Schedule shall contain actuator selection data supported by calculations of the torque required to move and seal the dampers, access and clearance requirements. Damper schedules may be submitted in advance but shall be included in the complete submittal.

2.8.6 Schematics

The HVAC control system schematics shall show all control and mechanical devices associated with the HVAC system. A system schematic drawing shall be submitted for each HVAC system.

2.8.7 Equipment Schedule

The HVAC control system equipment Schedule shall be developed. All devices shall have unique identifiers and shall be referenced in the equipment schedule. Information to be included in the equipment schedule shall be the control loop, device unique identifier, device function, set point, input range, and additional important parameters (i.e., output range). An equipment schedule shall be submitted for each HVAC system.

2.8.8 Sequence of Operation

The HVAC control system sequence of operation shall reflect the language and format of this specification and shall refer to the devices by their unique identifiers as shown on the contract drawings. No operational deviations from specified sequences will be permitted without prior written approval of the Contracting Officer. Sequences of operation shall be submitted for each HVAC control system including each type of terminal unit control system.

2.8.9 Wiring Diagrams

The HVAC control system wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to HVAC control panel terminal blocks and to the identified terminals of devices, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for HVAC control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, HVAC system control panel, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each HVAC control system. Contractor will provide a lamented copy of the as built control drawings that will be attached to the JACE panel in the mechanical room.

PART 3 EXECUTION

3.1 INSTALLATION

Perform installation under supervision of competent technicians regularly employed in the installation of DDC systems.

3.1.1 Wiring Criteria

a. Input/output identification: *Permanently label each field wire, cable, or pneumatic tube at each end with unique descriptive identification.*

b. Rigid or flexible conduit shall be terminated at all sensors and output devices.

c. Surge Protection: Install surge protection per manufacturer's specification.

d. Grounding: Ground controllers and cabinets to a good earth ground. Ground controller to a ground in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Grounding of the green ac ground wire, at the breaker panel, alone is not adequate. Run metal conduit from controller panels to adequate building grounds. Ground sensor drain wire shields at controller end.

e. Contractor is responsible for correcting all associated ground loop problems.

f. Wiring in panel enclosures shall be run in covered wire track.

3.1.2 Digital Controllers

a. Do not divide control of a single mechanical system such as an air handling unit, boiler, chiller, or terminal equipment between two

or more controllers. A single controller shall manage control functions for a single mechanical system. It is permissible, however, to manage more than one mechanical system with a single controller.

b. Provide lockable digital control cabinets that protect digital controller electronics from dust and moisture as required by the manufacturer.

c. Controllers shall not be installed in elevator equipment or communication rooms.

3.1.3 Temperature Sensors

Provide temperature sensors in locations to sense the appropriate condition. Provide sensor where they are easy to access and service without special tools. Calibrate sensors to accuracy specified. In no case will sensors designed for one application be installed for another application.

3.1.3.1 Room Temperature Sensors

Provide on interior walls to sense average room temperature conditions. Avoid locations near heat sources or which may be covered by office furniture. Room temperature sensors shall not be mounted on exterior walls when other locations are available. Mount center of sensor at 5 feet above finished floor.

3.1.3.2 Duct Temperature Sensors

a. Provide sensors in ductwork in general locations as indicated. Select specific sensor location within duct to accurately sense appropriate air temperatures. Sensors shall not be located in dead air spaces or positions obstructed by ducts or equipment. Install gaskets between the sensor housing and duct wall. Seal duct and insulation penetrations.

b. String duct averaging sensors between two rigid supports in a serpentine position to sense average conditions. Insulate temperature sensing elements from supports. Provide hinged duct access doors to install averaging sensors if needed.

c. Locate freeze protection sensors in appropriate locations to sense lowest temperatures, to avoid potential problems with air stratification.

3.1.3.3 Immersion Temperature Sensors

Provide thermometer wells for sensors measuring temperatures in liquid applications or pressure vessels. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide thermometer wells with thermal transmission material within the well.

3.1.3.4 Outside Air Temperature Sensors

Provide outside air temperature sensor in weatherproof enclosure on north side of the building, away from exhaust hoods, air intakes and other areas that may affect temperature readings. Provide sunshields to from direct sunlight.

3.1.4 Damper Actuators

Actuators shall not be mounted in the air stream.

3.1.5 Thermometers

Provide thermometers at locations indicated. Mount thermometers to allow reading when standing on the floor.

3.1.6 Pressure Sensors

3.1.6.1 Differential Pressure

a. Duct Static Pressure Sensing: Locate duct static pressure tip approximately two-thirds of distance from supply fan to end of duct with the greatest pressure drop.

b. Pumping Proof with Differential Pressure Switches: Install high pressure side between pump discharge and check valve.

c. Steam Pressure Sensing: Install snubbers and isolation valves on steam pressure sensing applications.

d. Variable Speed Control: The cycle time and characteristics of the input signal from the differential pressure sensors shall be fully compatible with the variable speed controller. Coordinate the requirements with the provided associated equipment.

e. Equipment filters are to be monitored by the DDC using an analog point and displaying the loading of filters in inches wc on the graphics.

3.1.7 Current Transmitters

Provide current transmitters on all HVAC motors for status unless provided through a LON or BACnet interface.

3.1.8 Control Drawings

a. Post laminated copies of as-built control system drawings in each mechanical room.

b. Provide 3 sets of as-built control drawings to the Contracting Officer.

3.2 TEST AND BALANCE SUPPORT

The Contractors Field Tests shall be completed and the control system fully functional prior to balancing. Controls Contractor will coordinate with and provide full time on-site technical support to test and balance (TAB) personnel specified under Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC or any other documents in the project specification. This support shall include:

a. On-site operation of control systems for proper operating modes during all phases of balancing and testing.

b. Control set point adjustments for proper balancing of all relevant mechanical systems, including VAV boxes.

c. Setting all control loops with set points and adjustments determined by TAB personnel.

3.3 FIELD QUALITY CONTROL TESTS

3.3.1 General

a. Demonstrate compliance of the heating, ventilating, and air conditioning control system with the contract documents. Furnish personnel, equipment, instrumentation, and supplies necessary to perform calibration and site testing. Ensure that test personnel are regularly employed in the testing and calibration of DDC systems.

b. Testing will include the field tests, point to point tests and the performance verification tests. Field tests shall demonstrate proper calibration of input and output devices, and the operation of all equipment. Performance verification test shall ensure proper execution of the sequence of operation and proper tuning of control loops, as well as system communication.

c. Obtain approval of the field test plan and performance verification test plan for each phase of testing before beginning that phase of testing. Give to the Contracting Officer written notification of planned testing at least 30 days prior to test. Notification shall be accompanied by the proposed test procedures. In no case will the Contractor be allowed to start testing without written Government approval of field test plan and performance verification test plan.

Before scheduling the performance verification test, furnish field test documentation, point to point test documentation and written Certified Statement of Field Test Completion to the Contracting Officer for approval. The statement, certified by the DDC system provider, states that the installed system has been calibrated, tested, and is ready for the performance verification test. Do not start the performance verification test prior to receiving written permission from the Government.

d. Tests are subject to oversight and approval by the Contracting Officer. The testing shall not be run during scheduled seasonal off-periods of heating and cooling systems.

3.3.2 Test Reporting for Field Testing and Performance Verification Tests

a. During and after completion of the Field Tests, point to point tests and again after the Performance Verification Tests, identify, determine causes, replace, repair or calibrate equipment that fails to meet the specification, and submit a written report to the Government.

b. Document all tests with detailed test results. Explain in detail the nature of each failure and corrective action taken. Provide a written report containing test documentation after the Field Tests, point to point tests and again after the Performance Verification Tests. Convene a test review meeting at the job site to present the results to the Government. As part of this test review meeting, demonstrate by performing all portions of the field tests or performance verification test that each failure has been corrected. Based on the report and test review meeting, the Government will determine either the restart point or successful completion of testing. Do not retest until after receipt of written notification by the Government. At the conclusion of retest, assessment will be repeated.

3.3.3 Contractor's Field Tests

Field tests shall include the following:

3.3.3.1 System Inspection

Observe the HVAC system in its shutdown condition. Check dampers and valves for proper normal positions. Document each position for the test report.

3.3.3.2 Calibration Accuracy and Operation of Inputs Test

Verify correct calibration and operation of input instruments. For each sensor and transmitter, including those for temperature, pressure, humidity, and air quality, record the reading at the sensor or transmitter location using calibrated test equipment. On the same table, record the corresponding reading at the digital controller for the test report. The test equipment shall have been calibrated within one year of use. Test equipment calibration shall be traceable to the measurement standards of the National Institute of Standards and Technology.

3.3.3.3 Actuator Range Adjustment Test

With the digital controller, apply a control signal to each actuator and verify that the actuator operates properly from its normal position to full range of stroke position. Record actual spring ranges and normal positions for all modulating control valves and dampers. Include documentation in the test report.

3.3.3.4 Digital Controller Startup and Memory Test

Demonstrate that programming is not lost after a power failure, and digital controllers automatically resume proper control after a power failure.

3.3.3.5 Surge Protection Test

Show that surge protection, meeting the requirements of this specification, has been installed on incoming power to the digital controllers and on communications lines.

3.3.3.6 Application Software Operation Test

Test compliance of the application software for:

a. Ability to communicate with the digital controllers, uploading and downloading of control programs

b. Text editing program: Demonstrate the ability to edit the control program off line.

c. Reporting of alarm conditions: Force alarms conditions for each alarm, and ensure that workstation receives alarms.

d. Reporting trend and status reports: Demonstrate ability of software to receive and save trend and status reports.

3.3.4 Performance Verification Tests

100 percent of Controls and Sequences shall be tested. Testing and Balancing (TAB) shall be complete prior to commencing Performance Verification Tests. Conduct the performance verification tests to demonstrate control system maintains set points, control loops are tuned, and controllers are programmed for the correct sequence of operation. Conduct performance verification testing during seven days of continuous HVAC and DDC systems operation and before final acceptance of work. Provide at least 14 days advance notice to the Contracting Officer in order for a Department of Public Works (DPW) Business Operation and Integration Division (BOID) representative to be present to witness the PVT. Specifically the performance verification test shall demonstrate the following:

3.3.4.1 Execution of Sequence of Operation

Demonstrate the HVAC system operates properly through the complete sequence of operation, for example seasonal, occupied/unoccupied mode, and warm-up mode. Demonstrate proper control system response for abnormal conditions by simulating these conditions. Demonstrate hardware interlocks and safeties work. Demonstrate the control system performs the correct sequence of control after a loss of power.

3.3.4.2 Control Loop Stability and Accuracy

Furnish the Government graphed trends of control loops to demonstrate the control loop is stable and that set point is maintained. Control loop response shall respond to set point changes and stabilize in 3 minutes. Control loop trend data shall be real time and the time between data points shall not be greater than one minute. Provide and electronic version and several print copies of trend data for review.

3.3.4.3 Workstation

Demonstrate the ability to monitor, command and revise the controlled systems, points, etc.

3.3.4.4 System Communication

Demonstrate system communication by downloading program and configuration programs to controllers over the network from the JBLM EMCS server.

3.4 TRAINING

Submit a training course schedule, syllabus, and training materials (O&M Manuals, Control Drawings and redlined drawings) 14 days prior to the start of training. Furnish a qualified instructor to conduct training courses for designated personnel in the maintenance and operation of the HVAC and DDC system. Orient training to the specific system being installed under this contract. Use Operation and Maintenance manual as the primary instructional aid in Contractor provided activity personnel training. Base training on the Operations and Maintenance manuals and a DDC training manual. Manuals shall be delivered for each trainee with one electronic (.pdf) version and 5 hard copies of additional sets delivered for archiving at the project site. Training manuals shall include an agenda, defined objectives and a detailed description of the subject matter for each lesson. Furnish audio-visual equipment and all other training materials and supplies. A training day is defined as 8 hours of classroom or lab instruction, including two 15 minute breaks and excluding lunch time, Tuesday through Thursday, during the daytime shift in effect at the training facility. For guidance, the Contractor should assume the attendees will have a high school education and are familiar with HVAC systems. DDC Phase I and II training shall be videotaped by a qualified videographer for future Government training. Submit two DVD copies at closeout.

3.4.1 DDC Training Phase I

The first class shall be taught for a period of 1 training day at least 2 weeks prior to the scheduled Performance Verification Test. The first course shall be taught in a Government provided facility on base. Training shall be classroom, but have hands-on operation of similar digital controllers. A maximum of 8 personnel will attend this course. Upon completion of this course, each student, using appropriate documentation, should be able to perform elementary operations, with guidance, and describe the general hardware architecture and functionality of the system. This course shall include but not be limited to:

a. Theory of operation

b. Hardware architecture

c. Operation of the system

d. Operator commands

e. Control sequence programming

f. Data base entry

g. Reports and logs

h. Alarm reports

i. Diagnostics

3.4.2 DDC Training Phase II

The second course shall be taught in the field, using the operating equipment at the project sites for a total of 1 day. A maximum of 8 personnel will attend the course. The course shall consist of hands-on training under the constant monitoring of the instructor. Course content shall duplicate DDC Training Phase I course as applied to the installed system. The instructor shall determine the level of the password to be issued to each student before each session. Upon completion of this course, students should be fully proficient in the operation of each system function.

-- End of Section --