SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
	* + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section Includes:

DDC system for monitoring and controlling of HVAC systems.

Coordinate subparagraph below with "Control Devices for Installation by Installers" and "Control Devices for Equipment Manufacturer Factory Installation" articles.

Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

* + - * 1. Related Requirements:

Retain subparagraphs below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.

Section 230923.13 "Energy Meters" for thermal and electric power energy meters that connect to DDC systems.

Section 230923.17 "Level Instruments" for liquid-level switches, sensors, and transmitters that connect to DDC systems.

Section 230923.22 "Position Instruments" for limit switches that connect to DDC systems.

Section 230923.33 "Vibration Instruments" for vibration instruments that connect to DDC systems.

Section 230923.43 "Weather Stations" for weather stations that connect to DDC systems.

Section 230993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.

Communications Cabling:

Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.

Section 271525 "Optical Fiber Cables – FAS & DDC" for fiber optic communications cable.

Raceways:

Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.

Section 260553 "Identification for Electrical Systems" for identification requirements for electrical components.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
				2. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
				3. BACnet Specific Definitions:

BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.

BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.

BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.

BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.

PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

* + - * 1. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.
				2. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.
				3. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
				4. COV: Changes of value.
				5. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
				6. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.
				7. DOCSIS: Data-Over Cable Service Interface Specifications.
				8. E/P: Voltage to pneumatic.
				9. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
				10. HLC: Heavy load conditions.
				11. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
				12. I/P: Current to pneumatic.
				13. LAN: Local area network.
				14. LNS: LonWorks Network Services.
				15. LON Specific Definitions:

FTT-10: Echelon Transmitter-Free Topology Transceiver.

LonMark: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.

LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.

LonWorks: Network technology developed by Echelon.

Node: Device that communicates using CEA-709.1-C protocol and that is connected to a CEA-709.1-C network.

Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.

Node ID: A unique 48-bit identifier assigned at factory to each CEA-709.1-C device. Sometimes called a "Neuron ID."

Program ID: An identifier (number) stored in a device (usually EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.

Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark International for configuration properties.

Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").

Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."

TP/FT-10: Free Topology Twisted Pair network defined by CEA-709.3 and is most common media type for a CEA-709.1-C control network.

TP/XF-1250: High-speed, 1.25-Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" typically used only to connect multiple TP/FT-10 networks.

User-Defined Configuration Property Type (UCPT): Pronounced "U-Keep-It." A Configuration Property format type that is defined by device manufacturer.

User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

* + - * 1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
				2. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.
				3. Modbus TCP/IP: An open protocol for exchange of process data.
				4. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
				5. MTBF: Mean time between failures.
				6. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.
				7. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
				8. Peer to Peer: Networking architecture that treats all network stations as equal partners.
				9. POT: Portable operator's terminal.
				10. PUE: Performance usage effectiveness.
				11. RAM: Random access memory.
				12. RF: Radio frequency.
				13. Router: Device connecting two or more networks at network layer.
				14. Server: Computer used to maintain system configuration, historical and programming database.
				15. TCP/IP: Transport control protocol/Internet protocol.
				16. UPS: Uninterruptible power supply.
				17. USB: Universal Serial Bus.
				18. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
				19. VAV: Variable air volume.
				20. WLED: White light emitting diode.
			1. PREINSTALLATION MEETINGS

Retain "Preinstallation Conference" paragraph below if Work of this Section is extensive or complex enough to justify a conference.

* + - * 1. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.
			1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Multiple Submissions:

If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.

Clearly identify each submittal requirement indicated and in which submission the information will be provided.

Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

* + - * 1. Product Data: For each type of product include the following:

Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

Product description with complete technical data, performance curves, and product specification sheets.

Installation, operation and maintenance instructions including factors effecting performance.

Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

Subparagraphs below are only examples of products to include.

Workstations.

Servers.

Printers.

Gateways.

Routers.

Protocol analyzers.

DDC controllers.

Enclosures.

Electrical power devices.

UPS units.

Accessories.

Instruments.

Control dampers and actuators.

Control valves and actuators.

<**Insert product**>.

When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

* + - * 1. Software close:

Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, <**Insert product**> and DDC controller.

Description and technical data of all software provided, and cross-referenced to products in which software will be installed.

Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.

Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.

Listing and description of each engineering equation used with reference source.

Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.

Description of operator interface to alphanumeric and graphic programming.

Description of each network communication protocol.

Description of system database, including all data included in database, database capacity and limitations to expand database.

Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.

Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

* + - * 1. Sustainable Design Submittals:
				2. Shop Drawings:

General Requirements:

Include cover drawing with Project name, location, Director’s Representative, Architect, Contractor and issue date with each Shop Drawings submission.

Include a drawing index sheet listing each drawing number and title that matches information in each title block.

Drawings Size: <**Insert requirements**>.

Include plans, elevations, sections, and mounting details where applicable.

Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Detail means of vibration isolation and show attachments to rotating equipment.

Plan Drawings indicating the following:

Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.

Room names and numbers with coordinated placement to avoid interference with control products indicated.

Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.

Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.

Network communication cable and raceway routing.

Information, drawn to scale, of <**Insert requirements**>.

Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.

Schematic drawings for each controlled HVAC system indicating the following:

I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.

I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.

A graphic showing location of control I/O in proper relationship to HVAC system.

Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.

Unique identification of each I/O that shall be consistently used between different drawings showing same point.

Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.

Narrative sequence of operation.

Graphic sequence of operation, showing all inputs and output logical blocks.

Control panel drawings indicating the following:

Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.

Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.

Front, rear, and side elevations and nameplate legend.

Unique drawing for each panel.

DDC system network riser diagram indicating the following:

Each device connected to network with unique identification for each.

Interconnection of each different network in DDC system.

For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.

Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

DDC system electrical power riser diagram indicating the following:

Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.

Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.

Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.

Power wiring type and size, race type, and size for each.

Monitoring and control signal diagrams indicating the following:

Control signal cable and wiring between controllers and I/O.

Point-to-point schematic wiring diagrams for each product.

Control signal tubing to sensors, switches, and transmitters.

Process signal tubing to sensors, switches, and transmitters.

Retain first subparagraph below for pneumatically actuated products.

Pneumatic main air and control signal tubing to pneumatic [**damper**] [**and**] [**valve**] actuators, pilot-positioners if applicable, and associated transducers.

Color graphics indicating the following:

Itemized list of color graphic displays to be provided.

For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.

Intended operator access between related hierarchical display screens.

* + - * 1. System Description:

Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.

Complete listing and description of each report, log and trend for format and timing, and events which initiate generation.

System and product operation under each potential failure condition including, but not limited to, the following:

Loss of power.

Loss of network communication signal.

Loss of controller signals to inputs and outpoints.

Operator workstation failure.

Server failure.

Gateway failure.

Network failure

Controller failure.

Instrument failure.

Control damper and valve actuator failure.

<**Insert potential failure conditions**>.

Complete bibliography of documentation and media to be delivered to Director’s Representative.

Description of testing plans and procedures.

Description of Director’s Representative training.

Retain "Samples" paragraph below for applications requiring special attention.

* + - * 1. Samples:

For each of the following exposed product, installed in finished space for approval of selection of aesthetic characteristics:

Gas instruments specified in Section 230923.16 "Gas Instruments."

Moisture instruments specified in Section 230923.19 "Moisture Instruments."

Motion instruments specified in Section 230923.21 "Motion Instruments."

Pressure instruments specified in Section 230923.23 "Pressure Instruments."

Temperature instruments specified in Section 230923.27 "Temperature Instruments."

<**Insert devices**>.

Retain "Delegated-Design Submittal" paragraph below if design services have been delegated to Contractor.

* + - * 1. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.

Schedule and design calculations for control dampers and actuators.

Flow at Project design and minimum flow conditions.

Face velocity at Project design and minimum airflow conditions.

Pressure drop across damper at Project design and minimum airflow conditions.

AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.

Maximum close-off pressure.

Leakage airflow at maximum system pressure differential (fan close-off pressure).

Torque required at worst case condition for sizing actuator.

Actuator selection indicating torque provided.

Actuator signal to control damper (on, close, or modulate).

Actuator position on loss of power.

Actuator position on loss of control signal.

Schedule and design calculations for control valves and actuators.

Flow at Project design and minimum flow conditions.

Pressure-differential drop across valve at Project design flow condition.

Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.

Design and minimum control valve coefficient with corresponding valve position.

Maximum close-off pressure.

Leakage flow at maximum system pressure differential.

Torque required at worst case condition for sizing actuator.

Actuator selection indicating torque provided.

Actuator signal to control damper (on, close or modulate).

Actuator position on loss of power.

Actuator position on loss of control signal.

Schedule and design calculations for selecting flow instruments.

Instrument flow range.

Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter, and output signal for remote control.

Extreme points of extended flow range with corresponding accuracy, control signal to transmitter, and output signal for remote control.

Pressure-differential loss across instrument at Project design flow conditions.

Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

Retain "Coordination Drawings" paragraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate paragraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations within the limited space.

* + - * 1. Coordination Drawings:

Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

Product installation location shown in relationship to room, duct, pipe and equipment.

Structural members to which products will be attached.

Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices and other installed devices.

Size and location of wall access panels for products installed behind walls and requiring access.

Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

Ceiling components.

Size and location of access panels for products installed above inaccessible ceiling assemblies and requiring access.

Items penetrating finished ceiling including the following:

Lighting fixtures.

Air outlets and inlets.

Speakers.

Sprinklers.

Access panels.

Motion sensors.

Pressure sensors.

Temperature sensors and other DDC control system instruments.

<**Insert item**>.

* + - * 1. Qualification Data:

Systems Provider Qualification Data:

Resume of project manager assigned to Project.

Resumes of application engineering staff assigned to Project.

Resumes of installation and programming technicians assigned to Project.

Resumes of service technicians assigned to Project.

Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity, and building's primary function.

Description of past project DDC system, noting similarities to Project scope and complexity indicated.

Names of staff assigned to past project that will also be assigned to execute work of this Project.

Director’s Representative contact information for past project including name, phone number, and e-mail address.

Contractor contact information for past project including name, phone number, and e-mail address.

Architect [**and Director’s Representative**] contact information for past project including name, phone number, and e-mail address.

Manufacturer's qualification data.

Testing agency's qualifications data.

Retain "Welding certificates" paragraph below if retaining "Welding Qualifications" paragraph in "Quality Assurance" Article.

* + - * 1. Welding certificates.

Retain "Product Certificates" paragraph below to require submittal of product certificates from manufacturers.

* + - * 1. Product Certificates:

Retain one of three subparagraphs below. Retain first subparagraph if compliance with ASHRAE 135 is required; retain second if LonWorks is required.

Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks.

Retain subparagraph below to require submittal of product certificates from manufacturers.

<**Insert list of products**>.

* + - * 1. Product Test Reports: For each product that requires testing to be performed by [**manufacturer**] [**manufacturer and witnessed by a qualified testing agency**] [**a qualified testing agency**].

Retain "Preconstruction Test Reports" paragraph below if specifying preconstruction testing in "Preconstruction Testing" Article as Contractor's responsibility.

* + - * 1. Preconstruction Test Reports: For each separate test performed.
				2. Source quality-control reports.

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
				2. Sample Warranty: For manufacturer's warranty.
			1. CLOSEOUT SUBMITTALS
				1. Operation and Maintenance Data: For DDC system to include in emergency, operation, and maintenance manuals.

Include the following:

Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.

Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.

As-built versions of submittal Product Data.

Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.

Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

Engineering, installation, and maintenance manuals that explain how to:

Design and install new points, panels, and other hardware.

Perform preventive maintenance and calibration.

Debug hardware problems.

Repair or replace hardware.

Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

Backup copy of graphic files, programs, and database on electronic media such as DVDs.

List of recommended spare parts with part numbers and suppliers.

Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

Licenses, guarantees, and warranty documents.

Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

Director’s Representative training materials.

* + - 1. MAINTENANCE MATERIAL SUBMITTALS
				1. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
				2. Include product manufacturers' recommended parts lists for proper product operation over [**four**] <**Insert time period**>-year period following warranty period. Parts list shall be indicated for each year.

Retain first paragraph below for product parts inventory over an extended operating period.

* + - * 1. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during [**one**] [**two**] <**Insert time period**>-year period following warranty period.

Retain paragraph below for spare product inventory.

* + - * 1. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:

Subparagraphs below are examples only of extra materials that may be required.

Network Controller: [**One**] <**Insert quantity**>.

Programmable Application Controller: [**One**] <**Insert quantity**>.

Application-Specific Controller: [**One**] <**Insert quantity**>.

[**Room**]Carbon Dioxide Sensor and Transmitter: [**One**] <**Insert quantity**>.

[**Room**]Moisture Sensor and Transmitter: [**One**] <**Insert quantity**>.

[**Room**]Pressure Sensor and Transmitter: [**One**] <**Insert quantity**>.

[**Room**]Temperature Sensor[**and Transmitter**]: [**One**] <**Insert quantity**>.

General-Purpose Relay: [**One**] <**Insert quantity**>.

Multifunction Time-Delay Relay: [**One**] <**Insert quantity**>.

Latching Relay: [**One**] <**Insert quantity**>.

Current-Sensing Relay: [**One**] <**Insert quantity**>.

Combination On-Off Status Sensor and On-Off Relay: [**One**] <**Insert quantity**>.

Transformer: [**One**] <**Insert quantity**>.

DC Power Supply: [**One**] <**Insert quantity**>.

Supply of [**20**] <**Insert number**> percent spare optical fiber cable splice organizer cabinets for several re-terminations.

<**Insert product**>.

* + - 1. QUALITY ASSURANCE
				1. DDC System Manufacturer Qualifications:

Nationally recognized manufacturer of DDC systems and products.

DDC systems with similar requirements to those indicated for a continuous period of [**five**] [**10**] <**Insert number**> years within time of bid.

DDC systems and products that have been successfully tested and in use on at least [**three**] [**five**] <**Insert number**> past projects.

Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.

Having full-time in-house employees for the following:

Product research and development.

Product and application engineering.

Product manufacturing, testing, and quality control.

Technical support for DDC system installation training, commissioning, and troubleshooting of installations.

Director’s Representative operator training.

* + - * 1. DDC System Provider Qualifications:

Authorized representative of, and trained by, DDC system manufacturer.

In-place facility located within <**Insert distance**> of Project.

Demonstrated past experience with installation of DDC system products being installed for period within [**three**] [**five**] <**Insert number**> consecutive years before time of bid.

Demonstrated past experience on [**five**] <**Insert number**> projects of similar complexity, scope, and value.

Each person assigned to Project shall have demonstrated past experience.

Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.

Service and maintenance staff assigned to support Project during warranty period.

Product parts inventory to support on-going DDC system operation for a period of not less than [**5**] <**Insert number**> years after Substantial Completion.

DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

Retain "Testing Agency Qualifications" paragraph below if Contractor selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article.

* + - * 1. Testing Agency Qualifications: Member company of NETA.

Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

Retain "Welding Qualifications" paragraph below if shop or field welding is required. If retaining, also retain "Welding certificates" paragraph in "Informational Submittals" Article.

* + - * 1. Welding Qualifications: Qualify procedures and personnel according to the following:

AWS D1.1, "Structural Welding Code - Steel."

AWS D1.2, "Structural Welding Code - Aluminum."

AWS D1.3, "Structural Welding Code - Sheet Steel."

AWS D1.4, "Structural Welding Code - Reinforcing Steel."

* + - * 1. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to "ASME Boiler and Pressure Vessel Code."

Retain "Mockups" paragraph below for applications with stringent requirements.

* + - * 1. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and products and for fabrication and installation.

Retain one of first two subparagraphs below, or both.

Build mockups of completed installation where products are exposed to view and are located in areas with aesthetic requirements that warrant special attention, including the following spaces:

In first subparagraph below, list specific areas requiring mockups, such as main lobbies, executive offices, conference rooms, and board rooms.

<**Insert specific locations for mockups**>.

Indicate portion of mockup on Drawings.

Build mockups of completed installation for areas indicated on Drawings.

Approval of mockups does not constitute approval of deviations from Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

* + - 1. PRECONSTRUCTION TESTING

Retain this article for preconstruction testing. Project-specific preconstruction testing of assemblies can be expensive but may be the best means of proving that performance requirements are met.

* + - * 1. Preconstruction Testing Service: [**Director’s Representative will engage**] [**Engage**] a qualified testing agency to perform preconstruction testing on field mockups.

Retain first subparagraph below if configuration of assemblies are not indicated on Drawings.

<**Insert configurations of assemblies**>.

Include test assemblies representative of proposed materials and construction.

Build mockup at testing agency facility using personnel, materials, and methods of construction that will be used at Project site.

Notify Architect [**seven**] <**Insert number**> days in advance of dates and times of tests.

* + - * 1. Preconstruction Testing: Performed by a qualified testing agency on manufacturer's standard assemblies.

Describe Project-specific preconstruction testing requirements.

<**Insert preconstruction testing requirements**>.

* + - 1. WARRANTY

When warranties are required, verify with Director’s Representative that warranties stated in this article are not less than remedies available to Director’s Representative under prevailing local laws.

* + - * 1. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Director’s Representative .

Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

Install updates only after receiving Director’s Representative’s written authorization.

Warranty service shall occur during normal business hours and commence within [**16**] [**24**] <**Insert number**> hours of Director’s Representative’s warranty service request.

Verify available warranties and warranty periods.

Warranty Period: [**Two**] <**Insert number**> year(s) from date of Substantial Completion.

For Gateway: [**Two**] [**Three**] <**Insert number**>-year parts and labor warranty for each.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. DDC SYSTEM MANUFACTURERS
				1. Manufacturers: Subject to compliance with requirements, provide products by the following:

Alerton Inc.

American Auto-Matrix.

Automated Logic Corporation.

Delta Controls Inc.

Distech Controls.

Honeywell International Inc.

Invensys Building Systems.

Johnson Controls, Inc.

KMC Controls (formerly Kreuter Manufacturing Company).

Reliable Controls Corporation.

Schneider Electric USA, Inc.

Siemens Industry, Inc., Building Technologies Division.

Teletrol Systems Incorporated.

Trane.

Approved equivalent.

* + - 1. DDC SYSTEM DESCRIPTION
				1. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

DDC system shall consist of a[**high-speed,**] peer-to-peer network of distributed DDC controllers[**, other network devices**], operator interfaces, and software.

* + - * 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
			1. WEB ACCESS

Retain this article to require web access to DDC system.

In paragraph below, retain "web based" or "web compatible" options, or both. See Evaluations for discussion. Consult manufacturers about web-access capabilities of their DDC system offerings. Limiting to only one method of web access may exclude some manufacturers.

* + - * 1. DDC system shall be [**web based**] [**or**] [**web compatible**].

Retain "Web-Based Access to DDC System" subparagraph below if retaining "web based" option in paragraph above.

Web-Based Access to DDC System:

DDC system software shall be based on server thin-client architecture, designed around open standards of web technology. DDC system server shall be accessed using a web browser over DDC system network, using Director’s Representative’s LAN, and remotely over Internet[**through** Director’s Representative’s **LAN**].

Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.

Web access shall be password protected.

Retain "Web-Compatible Access to DDC System" subparagraph below if retaining "web compatible" option in paragraph above.

Web-Compatible Access to DDC System:

[**Workstation**] [**and**] [**or**] [**server**] shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.

DDC system shall support web browser access to building data. Operator using a standard web browser shall be able to access control graphics and change adjustable set points.

Web access shall be password protected.

* + - 1. PERFORMANCE REQUIREMENTS

Retain "Delegated Design, Qualified Professional" paragraph below if Contractor is required to assume responsibility for design.

* + - * 1. Delegated Design, Qualified Professional: Engage a qualified professional to design DDC system to satisfy requirements indicated.

System Performance Objectives:

DDC system shall manage HVAC systems.

DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.

DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.

DDC system shall operate while unattended by an operator and through operator interaction.

DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

* + - * 1. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

Flame-Spread Index: [**25**] <**Insert value**> or less.

Smoke-Developed Index: [**50**] <**Insert value**> or less.

* + - * 1. DDC System Speed:

Response Time of Connected I/O:

First option in subparagraphs below is taken from ASHRAE's Guideline 13.

AI point values connected to DDC system shall be updated at least every [**five**] [**two**] seconds for use by DDC controllers. Points used globally shall also comply with this requirement.

BI point values connected to DDC system shall be updated at least every [**five**] [**two**] <**Insert number**> seconds for use by DDC controllers. Points used globally shall also comply with this requirement.

AO points connected to DDC system shall begin to respond to controller output commands within [**two**] [**one**] second(s). Global commands shall also comply with this requirement.

BO point values connected to DDC system shall respond to controller output commands within [**two**] [**one**] <**Insert number**> second(s). Global commands shall also comply with this requirement.

Display of Connected I/O:

Analog point COV connected to DDC system shall be updated and displayed at least every [**10**] [**five**] <**Insert number**> seconds for use by operator.

Binary point COV connected to DDC system shall be updated and displayed at least every [**10**] [**five**] <**Insert number**> seconds for use by operator.

Alarms of analog and digital points connected to DDC system shall be displayed within [**45**] [**30**] [**15**] <**Insert number**> seconds of activation or change of state.

Graphic display refresh shall update within [**eight**] [**four**] <**Insert number**> seconds.

Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

* + - * 1. Network Bandwidth: Design each network of DDC system to include at least [**30**] <**Insert number**> percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

Retain "DDC System Data Storage" paragraph below to provide DDC system data archived storage over an extended operating period.

* + - * 1. DDC System Data Storage:

Include capability to archive not less than [**24**] [**48**] [**60**] <**Insert number**> consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.

Local Storage:

Provide [**server**] [**workstation**] with data storage indicated. Server(s) shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" paragraph.

Cloud Storage:

Provide [**application-based**] [**and**] [**web browser**] interfaces to configure, upload, download, and manage data, and service plan with storage adequate to store all data for term indicated. Cloud storage shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

Retain "DDC Data Access" paragraph below for systems using local data storage or systems that store information locally and on the cloud. Change terminology as required. Coordinate with "Servers" Article in Part 2.

* + - * 1. DDC Data Access:

When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.

System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

* + - * 1. Future Expandability:

DDC system size shall be expandable to an ultimate capacity of at least [**two**] [**three**] [**four**] <**Insert number**> times total I/O points indicated.

Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.

Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

* + - * 1. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

Coordinate values used in subparagraphs below with accuracy of instruments specified in related sections. Values below cannot be better than other values used elsewhere.

Energy:

Thermal: Within [**5**] [**3**] [**1**] <**Insert number**> percent of reading.

Electric Power: Within [**1**] <**Insert number**> percent of reading.

Requirements indicated on Drawings for meters not supplied by utility.

Flow:

Air: Within [**5**] [**2**] <**Insert number**> percent of design flow rate.

Air (Terminal Units): Within [**10**] [**5**] <**Insert number**> percent of design flow rate.

Water: Within [**2**] [**5**] <**Insert number**> percent of design flow rate.

Steam: Within [**5**] <**Insert number**> percent of design flow rate.

Gas:

Carbon Dioxide: Within [**50**] <**Insert value**> ppm.

Carbon Monoxide: Within [**5**] <**Insert number**> percent of reading.

Oxygen: Within [**5**] <**Insert number**> percent of reading.

Refrigerant: Within [**50**] <**Insert value**> ppm.

Moisture (Relative Humidity):

Air: Within [**5**] [**2**] <**Insert number**> percent RH.

Space: Within [**5**] [**2**] <**Insert number**> percent RH.

Outdoor: Within [**5**] [**2**] <**Insert number**> percent RH.

Level: Within [**5**] [**2**] <**Insert number**> percent of reading.

Pressure:

Air, Ducts and Equipment: [**1**] [**0.5**] <**Insert number**> percent of instrument [**range**] [**span**].

Space: Within [**1**] [**0.5**] [**0.25**] <**Insert number**> percent of instrument [**range**] [**span**].

Water: Within [**1**] [**0.5**] [**0.25**] <**Insert number**> percent of instrument [**range**] [**span**].

Steam: Within [**1**] [**0.5**] [**0.25**] <**Insert number**> percent of instrument [**range**] [**span**].

Speed: Within [**10**] [**5**] <**Insert number**> percent of reading.

Temperature, Dew Point:

Air: Within [**1 deg F** ] [**0.5 deg F**] <**Insert value**>.

Space: Within [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

Outdoor: Within [**3 deg F** ] [**2 deg F** ] <**Insert value**>.

Temperature, Dry Bulb:

Air: Within [**1 deg F** ] [**0.5 deg F** ] <**Insert value**>.

Space: Within [**1 deg F** ] [**0.5 deg F** ] <**Insert value**>.

Outdoor: Within [**2 deg F**] [**1 deg F** ] <**Insert value**>.

Chilled Water: Within [**1 deg F** ] [**0.5 deg F** ] <**Insert value**>.

Condenser Water: Within [**1 deg F** ] [**0.5 deg F** ] <**Insert value**>.

Heating Hot Water: Within [**1 deg F** ] [**0.5 deg F** ] <**Insert value**>.

Energy Recovery Runaround Liquid: Within [**1 deg F** ] [**0.5 deg F**] <**Insert value**>.

Steam: Within [**2 deg F** ] [**1 deg F** ] <**Insert value**>.

Temperature Difference: Within [**0.25 deg F** ] <**Insert value**>.

<**Insert system**>.

Other Temperatures Not Indicated: Within [**1 deg F** ] [**0.5 deg F** ] <**Insert value**>.

Temperature, Wet Bulb:

Air: Within [**1 deg F** ] [**0.5 deg F** ] <**Insert value**>.

Space: Within [**1 deg F** ] [**0.5 deg F**] <**Insert value**>.

Outdoor: Within [**2 deg F** ] [**1 deg F**] <**Insert value**>.

Vibration: Within [**5**] [**10**] <**Insert number**> percent of reading.

* + - * 1. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

Current:

Milliamperes: Nearest 1/100th of a milliampere.

Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

Energy:

Electric Power:

Rate (Watts): Nearest 1/10th of a watt through 1000 W.

Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.

Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

Thermal, Rate:

Heating: For Btu/h, nearest Btu/h up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh .

Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.

Thermal, Usage:

Heating: For Btu, nearest Btu up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu.

Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.

Flow:

Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm .

Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.

Steam: Nearest 1/10th lb/hr through 100 lbs/hr; nearest lbs/hr between 100 and 1000 lbs/hr; nearest 10 lbs/hr above 1000 lbs/hr.

Gas:

Carbon Dioxide (ppm): Nearest ppm.

Carbon Monoxide (ppm): Nearest ppm.

Oxygen (Percentage): Nearest 1/10th of 1 percent.

Refrigerant (ppm): Nearest ppm.

Moisture (Relative Humidity):

Relative Humidity (Percentage): Nearest 1 percent.

Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.

Speed:

Rotation (rpm): Nearest 1 rpm.

Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.

Position, Dampers and Valves (Percentage Open): Nearest 1 percent.

Pressure:

Air, Ducts and Equipment: Nearest 1/10th in. w.c..

Space: Nearest 1/100th in. w.c..

Steam: Nearest 1/10th psig through 100 psig; nearest psig above 100 psig .

Water: Nearest 1/10 psig through 100 psig; nearest psig above 100 psig.

Temperature:

Air, Ducts and Equipment: Nearest 1/10th of a degree.

Outdoor: Nearest degree.

Space: Nearest 1/10th of a degree.

Chilled Water: Nearest 1/10th of a degree.

Condenser Water: Nearest 1/10th of a degree.

Heating Hot Water: Nearest degree.

Heat Recovery Runaround: Nearest 1/10th of a degree.

Steam: Nearest degree.

Vibration: Nearest 1/10th in/s.

Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

* + - * 1. Control Stability: Control variables indicated within the following limits:

Coordinate values used in subparagraphs below with values used in "Input Point Displayed Accuracy" paragraph in this article and with accuracy of instruments specified in related sections. Values below cannot be better than other values used elsewhere.

Flow:

Air, Ducts and Equipment, except Terminal Units: Within [**5**] [**2**] <**Insert number**> percent of design flow rate.

Air, Terminal Units: Within [**10**] [**5**] <**Insert number**> percent of design flow rate.

Water: Within [**2**] [**5**] <**Insert number**> percent of design flow rate.

Steam: Within [**5**] <**Insert number**> percent of design flow rate.

Gas:

Carbon Dioxide: Within [**50**] <**Insert value**> ppm.

Carbon Monoxide: Within [**5**] <**Insert number**> percent of reading.

Oxygen: Within [**5**] <**Insert number**> percent of reading.

Moisture (Relative Humidity):

Air: Within [**5**] [**2**] <**Insert number**> percent RH.

Space: Within [**5**] [**2**] <**Insert number**> percent RH.

Outdoor: Within [**5**] [**2**] <**Insert number**> percent RH.

Level: Within [**5**] [**2**] <**Insert number**> percent of reading.

Pressure:

Air, Ducts and Equipment: [**1**] [**0.5**] <**Insert number**> percent of instrument [**range**] [**span**].

Space: Within [**1**] [**0.5**] [**0.25**] <**Insert number**> percent of instrument [**range**] [**span**].

Water: Within [**1**] [**0.5**] [**0.25**] <**Insert number**> percent of instrument [**range**] [**span**].

Steam: Within [**1**] [**0.5**] [**0.25**] <**Insert number**> percent of instrument [**range**] [**span**].

Temperature, Dew Point:

Air: Within [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

Space: Within [**1 deg F** ] [**0.5 deg F**] <**Insert value**>.

Temperature, Dry Bulb:

Air: Within [**2 deg F**] [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

Space: Within [**2 deg F**] [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

Chilled Water: Within [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

Condenser Water: Within [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

Heating Hot Water: Within [**2 deg F**] [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

Energy Recovery Runaround Liquid: Within [**1 deg F**] [**0.5 deg F** ] <**Insert value**>.

<**Insert system**>.

Temperature, Wet Bulb:

Air: Within [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

Space: Within [**1 deg F**] [**0.5 deg F**] <**Insert value**>.

* + - * 1. Environmental Conditions for Controllers, Gateways, and Routers:

Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

Outdoors, Protected: [**Type 2**] [**Type 3**] [**Type 12**] <**Insert type**>.

Outdoors, Unprotected: [**Type 4**] [**Type 4X**].

Indoors, Heated with Filtered Ventilation: [**Type 1**] [**Type 2**] <**Insert type**>.

Indoors, Heated with Non-Filtered Ventilation: [**Type 2**] [**Type 12**] <**Insert type**>.

Indoors, Heated and Air Conditioned: [**Type 1**] <**Insert type**>.

Mechanical Equipment Rooms:

Chiller and Boiler Rooms: [**Type 12**] [**Type 4**] [**Type 4X**] <**Insert type**>.

Air-Moving Equipment Rooms: [**Type 1**] [**Type 2**] [**Type 12**] <**Insert type**>.

Localized Areas Exposed to Washdown: [**Type 4**] [**Type 4X**] <**Insert type**>.

Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: [**Type 2**] [**Type 3**] [**Type 12**] <**Insert type**>.

Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: [**Type 4**] [**Type 4X**] <**Insert type**>.

Hazardous Locations: Explosion-proof rating for condition.

<**Insert location and enclosure requirements**>.

* + - * 1. Environmental Conditions for Instruments and Actuators:

Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated[**, cooled**] and ventilated as required by instrument and application.

Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

Outdoors, Protected: [**Type 2**] [**Type 3**] [**Type 12**] <**Insert type**>.

Outdoors, Unprotected: [**Type 4**] [**Type 4X**].

Indoors, Heated with Filtered Ventilation: [**Type 1**] [**Type 2**] <**Insert type**>.

Indoors, Heated with Non-Filtered Ventilation: [**Type 2**] [**Type 12**] <**Insert type**>.

Indoors, Heated and Air-conditioned: [**Type 1**] <**Insert type**>.

Mechanical Equipment Rooms:

Chiller and Boiler Rooms: [**Type 12**] [**Type 4**] [**Type 4X**] <**Insert type**>.

Air-Moving Equipment Rooms: [**Type 1**] [**Type 2**] [**Type 12**] <**Insert type**>.

Localized Areas Exposed to Washdown: [**Type 4**] [**Type 4X**] <**Insert type**>.

Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: [**Type 2**] [**Type 3**] [**Type 12**] <**Insert type**>.

Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: [**Type 4**] [**Type 4X**] <**Insert type**>.

Hazardous Locations: Explosion-proof rating for condition.

<**Insert location and enclosure requirements**>.

Retain "DDC System Reliability" paragraph below for projects with critical reliability requirements.

* + - * 1. DDC System Reliability:

Design, install and configure DDC controllers, [**gateways,**] [**routers,**] [**and**] <**Insert product**> to yield a MTBF of at least [**40,000**] [**20,000**] <**Insert number**> hours, based on a confidence level of at least [**90**] <**Insert number**> percent. MTBF value shall include any failure for any reason to any part of products indicated.

If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment that are being controlled, operational and under automatic control.

Critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated shall be indicated on Drawings.

Retain "Electric Power Quality" paragraph below for applications requiring additional protection.

* + - * 1. Electric Power Quality:

Power-Line Surges:

Protect [**susceptible**]DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.

Do not use fuses for surge protection.

Test protection in the normal mode and in the common mode, using the following two waveforms:

10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.

8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

Power Conditioning:

Protect [**susceptible**]DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:

At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.

During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.

Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.

Total harmonic distortion shall not exceed 3-1/2 percent at full load.

Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

* + - * 1. Backup Power Source:

HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

Retain "UPS" paragraph below for applications requiring uninterrupted power.

* + - * 1. UPS:

DDC system products powered by UPS units shall include the following:

Five subparagraphs below are examples only for equipment that should be provided with UPS.

Desktop workstations.

Printers.

Servers.

Gateways.

DDC controllers[**, except application-specific controllers**].

DDC system instruments and actuators powered by UPS units shall include the following:

Instruments associated with the following systems controlled by DDC system:

<**Insert list of systems**>.

Dampers and actuators associated with the following systems controlled by DDC system:

<**Insert list of systems**>.

Valves and actuators associated with the following systems controlled by DDC system:

<**Insert list of systems**>.

Retain "Continuity of Operation after Electric Power Interruption" paragraph below for applications with systems and equipment connected to backup power systems that must remain operational without operator intervention. Coordinate requirement with other sections.

* + - * 1. Continuity of Operation after Electric Power Interruption:

Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

* + - 1. PANEL-MOUNTED, MANUAL OVERRIDE SWITCHES

Retain "Manual Override of Control Dampers" paragraph below to provide manual override capability for control dampers.

* + - * 1. Manual Override of Control Dampers:

Include panel-mounted, two-position, selector switch for each automatic control damper being controlled by DDC controller.

Label each switch with damper designation served by switch.

Label switch positions to indicate either "Manual" or "Auto" control signal to damper.

With switch in "Auto" position signal to control damper actuator shall be control loop output signal from DDC controller.

With switch in "Manual" position, signal to damper actuator shall be controlled at panel with either an integral or separate switch to include local control.

For Binary Control Dampers: Manual two-position switch shall have "Close" and "Open" switch positions indicated. With switch in "Close" position, damper shall close. With switch in "Open" position, damper shall open.

For Analog Control Dampers: A gradual switch shall have "Close" and "Open" switch limits indicated. Operator shall be able to rotate switch knob to adjust damper to any position from close to open.

DDC controller shall monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller shall signal an override condition to alert operator that damper is under manual, not automatic, control.

Retain first subparagraph below to require override independent of DDC controller. Some manufacturers offer manual override feature integral to DDC controller, thus making the manual override feature more affordable. Standalone manual override switches will dramatically increase cost of manual override feature.

Configure manual override switches to allow operator to manually operate damper while at panel without DDC controller [**installed**] [**and**] [**operational**].

Terminal equipment including [**VAV units,**] [**fan-coil units,**] [**and**] [**unit heaters**] do not require manual override unless otherwise indicated by sequence of operation.

Retain "Manual Override of Control Valves" paragraph below to provide manual override capability for control valves.

* + - * 1. Manual Override of Control Valves:

Include panel-mounted, two-position, selector switch for each automatic control valve being controlled by a DDC controller.

Label each switch with valve designation served by switch.

Label switch positions to indicate either "Manual" or "Auto" control signal to valve.

With switch in "Auto" position, signal to control-valve actuator shall be a control loop output signal from DDC controller.

With switch in "Manual" position, signal to valve actuator shall be controlled at panel with either an integral or a separate switch to include local control.

For Binary Control Dampers: Manual two-position switch shall have "Close" and "Open" switch positions indicated. With switch in "Close" position, damper shall close. With switch in "Open" position, damper shall open.

For Analog Control Dampers: A gradual switch shall have "Open" and "Close" switch limits indicated. Operator shall be able to rotate switch knob to adjust damper to any position from close to open.

DDC controller shall monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller shall signal an override condition to alert operator that valve is under manual, not automatic, control.

Retain first subparagraph below to require override independent of DDC controller. Some manufacturers offer manual override feature integral to DDC controller, thus making the manual override feature more affordable. Standalone manual override switches will dramatically increase cost of manual override feature.

Configure manual override switches to allow operator to manually operate valve while at panel without DDC controller [**installed**] [**and**] [**operational**].

Terminal equipment including [**VAV units,**] [**fan-coil units,**] [**and**] [**unit heaters**] do not require manual override unless otherwise indicated by sequence of operation.

* + - 1. SYSTEM ARCHITECTURE
				1. System architecture shall consist of no more than [**two**] [**or**] [**three**] <**Insert number**> levels of LANs.

Level one LAN shall connect network controllers and operator workstations.

[**Level one**] [**or**] [**Level two**] LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.

[**Level two**] [**or**] [**Level three**] LAN shall connect application-specific controllers to programmable application controllers and network controllers.

[**Level two**] [**or**] [**Level three**] LAN shall connect application-specific controllers to application-specific controllers.

Coordinate requirements in "Minimum Data Transfer and Communication Speed" paragraph below with "Networks" Article to ensure that speed requirements retained for a project can be achieved by networks retained for a project.

* + - * 1. Minimum Data Transfer and Communication Speed:

In first subparagraph below, retain "100" or "10" option for Ethernet networks. Retain "2.5" option for ATA 878.1 networks. Retain "1.25" option for CEA-709.1-C networks.

LAN Connecting Operator Workstations and Network Controllers: [**100**] [**10**] [**2.5**] [**1.25**] <**Insert value**> Mbps.

LAN Connecting Programmable Application Controllers: [**1000**] [**100**] <**Insert value**> kbps.

LAN Connecting Application-Specific Controllers: [**115,000**] [**76,800**] [**38,400**] [**19,200**] <**Insert value**> bps.

* + - * 1. DDC system shall consist of dedicated[**and separated**] LANs that are not shared with other building systems and tenant data and communication networks.
				2. System architecture shall be modular and have inherent ability to expand to not less than [**two**] [**three**] <**Insert number**> times system size indicated with no impact to performance indicated.
				3. System architecture shall perform modifications without having to remove and replace existing network equipment.
				4. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.
				5. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.
				6. Special Network Architecture Requirements:

Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

<**Insert additional requirements**>.

* + - 1. DDC SYSTEM OPERATOR INTERFACES
				1. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

Desktop and portable workstation with hardwired connection through LAN port.

Portable operator terminal with hardwired connection through LAN port.

Portable operator workstation with wireless connection through LAN router.

Mobile device and application with secured wireless connection through LAN router or cellular data service.

Remote connection through web access.

* + - * 1. Access to system, regardless of operator means used, shall be transparent to operator.
				2. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

Seven subparagraphs below are examples only.

Each mechanical equipment room.

Each boiler room.

Each chiller room or outdoor chiller yard.

Each cooling tower location.

Each different roof level with roof-mounted air-handling units or rooftop units.

Security system command center.

Fire-alarm system command center.

* + - * 1. Desktop Workstations:

Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.

Able to communicate with any device located on any DDC system LAN.

* + - * 1. Portable Workstations:

Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.

Able to communicate with any device located on any DDC system LAN.

Connect to DDC system [**Level two**] [**or**] [**Level three**] LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.

Connect to system through a wireless router connected to Level one LAN.

Connect to system through a cellular data service.

Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.

Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.

Have dynamic graphic displays that are identical to desktop workstations.

* + - * 1. POT:

Connect DDC controller through a communications port local to controller.

Able to communicate with any DDC system controller that is directly connected [**or with LAN**] [**or connected to DDC system**].

* + - * 1. Mobile Device:

Connect to system through a wireless router connected to LAN [**and cellular data service**].

Able to communicate with any DDC controller connected to DDC system using [**a dedicated application**] [**and**][**secure web access**].

Retain "Telephone Communications" paragraph below for legacy systems.

* + - * 1. Telephone Communications:

Through use of a standard modem, operator shall be able to communicate with any device connected to any system LAN.

Have auto-dial and auto-answer communications to allow desktop and portable workstations and DDC controllers to communicate with remote workstations and remote DDC controllers via telephone lines.

Desktop and Portable Workstations:

Operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected to system LAN.

Have routines to automatically answer calls, and either file or display information sent remotely.

Communications taking place over telephone lines shall be completely transparent to operator.

Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers so it is not required to remember or manually dial telephone numbers.

DDC Controllers:

Not have modems unless specifically indicated for a unique controller.

Controllers with modems shall automatically place calls to report critical alarms, or to upload trend and historical information for archiving.

Analyze and prioritize alarms to minimize initiation of calls.

Buffer noncritical alarms in memory and report them as a group of alarms, or until an operator manually requests an upload.

Make provisions for handling busy signals, no-answers, and incomplete data transfers.

Call default devices when communications cannot be established with primary devices.

* + - * 1. Critical Alarm Reporting:

Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.

DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.

DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

* + - * 1. Simultaneous Operator Use: Capable of accommodating up to [**five**] [**10**] [**20**] <**Insert number**> simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.
			1. NETWORKS
				1. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

Retain applicable subparagraphs below to suit DDC system size and complexity. See Evaluations.

ATA 878.1, ARCNET.

CEA-709.1-C.

IP.

IEEE 8802-3, Ethernet.

<**Insert type**>.

* + - * 1. Acceptable networks for connecting programmable application controllers include the following:

Retain applicable subparagraphs below to suit DDC system size and complexity. See Evaluations.

ATA 878.1, ARCNET.

CEA-709.1-C.

IP.

IEEE 8802-3, Ethernet.

<**Insert type**>.

* + - * 1. Acceptable networks for connecting application-specific controllers include the following:

Retain applicable subparagraphs below to suit DDC system size and complexity. See Evaluations.

ATA 878.1, ARCNET.

CEA-709.1-C.

EIA-485A.

IP.

IEEE 8802-3, Ethernet.

<**Insert type**>.

* + - 1. NETWORK COMMUNICATION PROTOCOL

See Evaluations for additional information on network communication protocols.

* + - * 1. Network communication protocol(s) used throughout entire DDC system shall be open to Director’s Representative and available to other companies for use in making future modifications to DDC system.

Retain "ASHRAE 135 Protocol" paragraph below to limit entire DDC system communication protocol to ASHRAE 135.

* + - * 1. ASHRAE 135 Protocol:

ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.

DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.

If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.

Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

Retain "CEA-709.1-C Protocol" paragraph below to limit entire DDC system communication protocol to CEA-709.1-C.

* + - * 1. CEA-709.1-C Protocol:

DDC system shall be an open implementation of LonWorks technology using CEA 709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for communication throughout DDC system.

LNS shall be used for all network management including addressing and binding of network variables.

Final LNS database shall be submitted with Project closeout submittals.

All devices shall be online and commissioned into LNS database.

All devices connected to DDC system network(s) shall use CEA-709.1-C protocol and be installed so SCPT output from any node on network can be bound to any other node in the domain.

Retain "Industry Standard Protocols" paragraph below to give choice to use one or multiple industry standard protocols.

* + - * 1. Industry Standard Protocols:

DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:

First four subparagraphs below are examples only.

ASHRAE 135.

CEA-709.1-C.

Modbus Application Protocol Specification V1.1b.

<**Insert standard protocol**>.

Operator workstations [**and network controllers**]shall communicate through [**ASHRAE 135**] [**or**] [**CEA-709.1-C**] protocol.

Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.

Portions of DDC system networks using CEA-709.1-C communication protocol shall be an open implementation of LonWorks technology using CEA-709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for DDC system.

Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.

Gateways shall be used to connect networks and network devices using different protocols.

* + - 1. DDC SYSTEM WIRELESS NETWORKS
				1. Use [**Zigbee**] [**or**] [**an open industry standard and technology used by multiple DDC system manufacturers**] <**Insert wireless technology**> technology to create a wireless mesh network to provide wireless connectivity for network devices at multiple system levels including communications from programmable application controllers and application-specific controllers to temperature sensors and from network controllers to programmable application controllers and application-specific controllers.
				2. Installer shall design wireless networks to comply with DDC system performance requirements indicated. Wireless network devices shall co-exist on same network with hardwired devices.
				3. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.
				4. A wireless coordinator shall provide a wireless interface between programmable application controllers, application-specific controllers, and network controllers.
				5. Wireless Coordinators:

Each wireless mesh network shall use wireless coordinator(s) for initiation and formation of network.

Use direct sequence spread spectrum RF technology.

Operate on the 2.4-GHz ISM Band.

Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.

FCC compliant to 47 CFR 15, Subpart B, Class A.

Operate as a bidirectional transceiver with sensors and routers to confirm and synchronize data transmission.

Capable of communication with sensors and routers up to a maximum distance of 250 feet in line of sight.

Include visual indicators to provide diagnostic information required for operator verification of operation.

* + - * 1. Wireless Routers:

Each wireless mesh network shall use wireless routers with any controller to provide a wireless interface to a network controller, through a wireless coordinator.

Use direct sequence spread spectrum RF technology.

Operate on the 2.4-GHz ISM Band.

Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.

FCC compliant to 47 CFR 15, Subpart B, Class A.

Operate as a bidirectional transceiver with other mesh network devices to ensure network integrity.

Capable of communication with other mesh network devices at a maximum distance of 250 feet in line of sight.

Include indication for use in commissioning and troubleshooting.

* + - * 1. Wireless Temperature Sensors:

Wireless temperature sensors shall sense and transmit room temperatures, temperature set point, room occupancy notification and low battery condition to an associated router.

Use direct sequence spread spectrum RF technology.

Operate on the 2.4-GHz ISM Band.

Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.

FCC compliant to CFR 15, Subpart B, Class A.

Include set point adjustment between 55 to 85 deg F.

Multiple sensors shall be able to report to a router connected to a DDC controller for averaging or high and low selection.

* + - * 1. One-to-One Wireless Network Receivers:

One-to-one wireless receivers shall receive wireless RF signals containing temperature data from multiple wireless room temperature sensors and communicate information to programmable application controllers or application-specific controllers.

Use direct sequence spread spectrum RF technology.

Operate on the 2.4-GHz ISM Band.

Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.

FCC compliant to 47 CFR 15, Subpart B, Class A.

Operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.

Capable of communication up to a distance of 200 feet.

Include visual indication of the following:

Power.

Receiver activity.

Wireless RF transmission from wireless sensors.

No transmission, weak signal, adequate signal or excellent signal.

* + - * 1. One-to-One Wireless Network Sensors:

One-to-one wireless sensors shall sense and report room temperatures to one-to-one receiver.

Use direct sequence spread spectrum RF technology.

Operate on the 2.4-GHz ISM Band.

Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.

FCC compliant to CFR 15, Subpart B, Class A.

Include set point adjustment between 55 to 85 deg F.

* + - 1. DESKTOP WORKSTATIONS

If multiple desktop workstations having unique requirements are required, copy this article and re-edit for each workstation's requirements.

* + - * 1. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.
				2. Manufacturers: Subject to compliance with requirements, provide products by the following:

Dell Inc.

HP.

Lenovo.

Approved equivalent.

* + - * 1. Performance Requirements:

Performance requirements may dictate equipment exceeding minimum requirements indicated.

Energy Star compliant.

* + - * 1. Personal Computer:

Minimum Processor Speed: <**Insert gigahertz**>.

RAM:

Capacity: [**2**] [**4**] [**8**] <**Insert value**> [**GB**].

Speed and Type: [**1333**] <**Insert value**> MHz, <**Insert type**>.

Hard Drive:

Media: [**Solid state**] [**Rotating disc, nominal rotational speed of 7200 rpm**] [**Hybrid solid-state and rotating disc**].

Number of Hard Drives: [**One**] [**Two**] <**Insert number**>.

Capacity: <**Insert number and measurement unit**>.

Minimum Average Seek Time: <**Insert number and measurement unit**>.

Cache Buffer Size: <**Insert number and measurement unit**>.

<**Insert requirements**>.

Second Hard Drive:

Media: [**Solid state**] [**Rotating disc, nominal rotational speed of 7200 rpm**] [**Hybrid solid-state and rotating disc**].

Capacity: <**Insert number and measurement unit**>.

Minimum Average Seek Time: <**Insert number and measurement unit**>.

Cache Buffer Size: <**Insert number and measurement unit**>.

<**Insert requirements**>.

Optical Drive:

Type: <**Insert type**>.

Minimum Average Access Time: <**Insert number**> ms.

Data Transfer Speed: <**Insert number**> [**MB**] [**TB**]/s.

Reading Formats: Data, audio, recordable, <**Insert other**> and rewritable.

Optical Read and Write Drive:

Include with at least 2 MB of data buffer.

Type: <**Insert type**>.

Minimum Data Buffer Capacity: <**Insert number and measurement unit**>.

Minimum Average Access Time: <**Insert number**> ms.

Nominal Data Transfer Rates:

Reading: <**Insert number**> [**MB**] [**TB**]/s.

Writing: <**Insert number**> [**MB**] [**TB**]/s.

Average access time of 150 ms or less.

MTBF of at least 100,000 power-on hours.

At least four expansion slots of [**32**] [**64**] <**Insert number**> bit.

Video Card:

Resolution: [**1920 by 1200**] <**Insert values**> pixels.

RAM: <**Insert number**> [**MB**] [**GB**] [**TB**].

Controller Speed: <**Insert number**> [**MHz**] [**GHz**].

On-Board Memory Speed: <**Insert number**> [**MHz**] [**GHz**].

On-Board Memory Data Width: <**Insert number**> bit.

Sound Card:

At least 128 voice wavetable synthesis.

Capable of delivering three-dimensional sound effects.

High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

Network Interface Card: Include card with connection, as applicable.

10-100-1000 base TX Ethernet with RJ45 connector port.

100 base FX Ethernet with SC or ST port.

* + - * 1. Wireless Ethernet, 802.11 a/b/g/n.

Retain "Optical Modem" subparagraph below for direct connection to optical fiber cable.

Optical Modem: Full duplex link for connection to optical fiber cable provided.

I/O Ports:

Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.

One serial port.

One parallel port.

Two PS/2 ports.

One RJ-45.

One stereo line-in and headphone/line-out on back panel.

One microphone and headphone connector on front panel.

One IEEE 1394 on front and back panel with PCI-e card.

One ESATA port on back panel.

Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

* + - * 1. Keyboard:

101 enhanced keyboard.

Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.

Wireless operation within up to 72 inches in front of workstation.

* + - * 1. Pointing Device:

Either a two- or three-button mouse.

Wireless operation within up to 72 inches in front of workstation.

* + - * 1. Flat Panel Display Monitor:

Copy and re-edit "Display" subparagraph below if requirements are different for multiple displays.

Display:

Color display with <**Insert inches** > diagonal viewable area.

[**Digital**] [**or**] [**analog**] input signal.

Aspect Ratio: [**16 to 9**] <**Insert value**>.

Antiglare display.

Response Time: <**Insert number**> ms.

Dynamic Contrast Ratio: [**50000 to 1**] <**Insert ratio**>.

Brightness: [**250 cd/sq. m**] <**Insert value**>.

Tilt adjustable base.

Energy Star compliant.

Resolution: [**1920 by 1080**] <**Insert value**> pixels at 60 Hz with pixel size of [**0.277**] <**Insert number**> mm or smaller.

Number of Displays: [**One**] [**Two**] <**Insert number**>.

* + - * 1. Speakers:

Two, with individual controls for volume, bass and treble.

Signal to Noise Ratio: At least 65 dB.

Power: At least 4 W per speaker/channel.

Magnetic shielding to prevent distortion on the video monitor.

* + - * 1. I/O Cabling: Include applicable cabling to connect I/O devices.
			1. PORTABLE WORKSTATIONS

If multiple portable workstations having unique requirements are required, copy this article and re-edit to specify requirements for each workstation.

* + - * 1. Description: A self-contained computer designed to allow for normal use in different locations and conditions.
				2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Dell Technologies Inc.

HP Inc.

Lenovo Holding Co., Inc.; Lenovo Group Ltd.

Approved equivalent.

* + - * 1. Performance Requirements:

Performance requirements may dictate equipment exceeding minimum requirements indicated.

Energy Star compliant.

Hardware and software shall support local down-loading to DDC controllers.

Data transfer rate to DDC controller shall be at network speed.

* + - * 1. Processor:

Minimum Processor Speed: <**Insert gigahertz**>.

RAM:

Capacity: <**Insert value**> [**GB**] [**TB**].

Speed and Type: <**Insert value**> MHz, <**Insert type**>.

Copy and re-edit "Hard Drive" subparagraph below if requirements are different for multiple hard drives.

Hard Drive:

Number of Hard Drives: [**One**] [**Two**] <**Insert number**>.

Capacity: <**Insert number and measurement unit**>.

Minimum Average Seek Time: <**Insert number and measurement unit**>.

Cache Buffer Size: <**Insert number and measurement unit**>.

<**Insert requirements**>.

Video Card: <**Insert number and measurement unit**> of RAM.

* + - * 1. Input and Output Ports:

Serial port.

Shared port for external keyboard or mouse.

Four USB 3.0 ports.

Ethernet port.

HDMI port.

IEEE 1394 port.

* + - * 1. Battery:

Capable of supporting operation of portable workstation for a minimum of [**8**] <**Insert number**> hours.

Battery life of at least three years.

Battery charge time of less than three hours.

Spare Battery(ies). [**One**] [**Two**].

* + - * 1. Keyboard:

85-key [**backlit**]keyboard.

Full upper- and lowercase ASCII keyset.

* + - * 1. Integral Pointing Device: Touchpad with two buttons. Gesture enabled.
				2. Display:

<**Insert inches** > diagonal or larger high-definition WLED color display.

Antiglare screen.

[**1920 by 1080**] <**Insert value**> pixel resolution.

Brightness: 300 nits.

* + - * 1. Network Interfaces:

Network Interface Card: Include card with connection, as application.

10-100-1000 base TX Ethernet with RJ45 connector port.

100 base FX Ethernet with SC or ST port.

Wireless:

Internal with integrated antenna, capable of supporting 802.11 a/b/g/n.

* + - * 1. Digital Video Disc Rewrite Recorder (DVD+/-RW):

Compatible with DVD disks and data, audio, recordable and rewritable compact disks.

Nominal Data Transfer Rates:

Reading: <**Insert number**> [**MB**] [**TB**]/s.

Writing: <**Insert number**> [**MB**] [**TB**]/s.

160-ms access time.

* + - * 1. Accessories:

Nylon carrying case.

Docking station.

Mobile broadband card.

Wireless optical mouse.

<**Insert value**> [**GB**] [**TB**] portable hard drive.

Light-sensitive web cam and noise-cancelling digital array microphone.

Category 6a patch cable. Minimum cable length shall be <**Insert length**>.

HDMI cable. Minimum cable length shall be <**Insert length**>.

* + - 1. PORTABLE OPERATOR TERMINAL
				1. Description: Handheld device with integral keypad or touch screen operator interface.
				2. Display: Multiple lines of text display for use in operator interaction with DDC system.
				3. Cable: Flexible [**coiling**]cable, at least 36 inches long, with a plug-in jack for connection to DDC controllers, network ports or instruments with an integral LAN port. As an alternative to hardwired connection, POT shall be accessible to DDC controllers through a wireless network connection.
				4. POT shall be powered through network connection.
				5. Connection of POT to DDC system shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.
				6. POT shall give operator the ability to do the following:

Remaining subparagraphs below are examples only.

Display and monitor BI point status.

Change BO point set point (on or off, open or closed).

Display and monitor analog point values.

Change analog control set points.

Command a setting of AO point.

Display and monitor I/O point in alarm.

Add a new or delete an existing I/O point.

Enable and disable I/O points, initiators, and programs.

Display and change time and date.

Display and change time schedules.

Display and change run-time counters and run-time limits.

Display and change time and event initiation.

Display and change control application and DDC parameters.

Display and change programmable offset values.

Access DDC controller initialization routines and diagnostics.

<**Insert requirements**>.

* + - 1. SERVERS

Retain this article for DDC systems with large data storage requirements.

* + - * 1. Description: x86-based permanently installed computer used for client-server computing.
				2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Dell Technologies Inc.

HP Inc.

Lenovo Holding Co., Inc.; Lenovo Group Ltd.

Approved equivalent.

* + - * 1. Mounting: [**Rack**] [**Blade**] [**Tower**] [**Tower able to be rack-mounted**].
				2. Power: [**Single**] [**Dual**] power supply, minimum 300 W.
				3. Performance Requirements:

Performance requirements may dictate equipment exceeding minimum requirements indicated.

Energy Star compliant.

Minimum Processor Speed: <**Insert gigahertz**>.

RAM:

Capacity: <**Insert value**> [**GB**] [**TB**].

Speed and Type: <**Insert value**> MGz, <**Insert type**>.

Expandable Capacity: <**Insert value**> [**GB**] [**TB**].

See Evaluations for discussion of redundant array of independent disks levels.

Redundant Array of Independent Disks: [**Zero**] [**One**] [**Two**] [**Three**] [**Four**] [**Five**] <**Insert number**> configuration.

Drive Bays: Eight at 2.5 inches or eight at 3.5 inches.

Hard-Drive Storage: [**Two**] [**Three**] [**Four**] drives each with <**Insert value**> [**GB**] [**TB**] storage and nominal rotational speed of 7200 rpm.

Network Interface: [**Dual port Gigabit Ethernet**] [**Optical fiber**].

DVD +RW Drive.

Color, flat-screen display with <**Insert inches** > diagonal viewable area.

Keyboard and mouse.

Next-day on-site warranty for [**two**] [**three**] <**Insert number**>-year period following Substantial Completion.

* + - * 1. Servers shall include the following:

Full-feature backup server (server and backup minimum requirement).

Software licenses.

Cable installation between server(s) and network.

* + - * 1. Web Server:

If required to be separate, include web server hardware and software to match, except backup server is not required.

Firewalls between server web and networks.

Password protection for access to server from web server.

Cable installation between the server(s) and building Ethernet network.

* + - * 1. Power each server through a [**dedicated**]UPS unit.
			1. PRINTERS
				1. Black and White Laser Printer:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Brother International Corporation.

Epson America, Inc.

Hewlett-Packard Company.

Approved equivalent.

[**1200 by 1200**] <**Insert value**> dots per inch resolution.

First sheet printed within 10 seconds.

<**Insert number**> page per minute rated print speed at best quality mode.

Print buffer with at least <**Insert value**> MB of RAM, expandable to at least 288 MBs.

Complies with Energy Star requirements.

Capable of handling letter- and legal-size paper and overhead transparencies.

Two paper trays; one tray with <**Insert number**> sheet capacity, and one tray with <**Insert number**> sheet capacity.

At least <**Insert number**> page toner/cartridge capacity.

* + - * 1. Color Laser Printer:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Brother International Corporation.

Epson America, Inc.

Hewlett-Packard Company.

Approved equivalent.

[**1200 by 1200**] <**Insert value**> dots per inch resolution black and white, [**1200 by 1200**] <**Insert value**> dots per inch resolution black and white and color.

First sheet printed within 10 seconds.

<**Insert number**> page per minute rated print speed at best quality mode.

Print buffer with at least [**512**] <**Insert value**> MB of RAM, expandable to at least [**one**] <**Insert value**> GB.

Complies with Energy Star requirements.

Capable of handling letter- and legal-size paper and overhead transparencies.

Two paper trays; one tray with <**Insert number**> sheet capacity, and one tray with 500 <**Insert number**> sheet capacity.

Two-sided printing.

At least <**Insert number**> page toner/cartridge capacity.

* + - * 1. Color Inkjet Printer:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Brother International Corporation.

Epson America, Inc.

Hewlett-Packard Company.

Approved equivalent.

Inkjet technology with true four-color printing (black, cyan, magenta, and yellow).

Print quality of [**1200 by 600**] <**Insert value**> dots per inch with black on inkjet paper and [**4800 by 1200**] <**Insert value**> dots per inch color printing on premium photo paper.

Rated speed of <**Insert number**> pages per minute printing black and white in normal mode and <**Insert number**> pages per minute printing color in normal mode.

Two paper trays; one tray with <**Insert number**> sheet capacity, and one tray with <**Insert number**> sheet capacity.

Capable of handling letter- and legal-size paper and overhead transparencies.

<**Insert number**> MB of RAM.

Duplex printing (printing on both sides of paper).

* + - * 1. Dot Matrix Printer:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Epson America, Inc.

OKI Data Americas.

Tally Dascom

Approved equivalent.

Letter-quality, wide-carriage, 24-pin dot matrix printer.

<**Insert number**> kb print buffer.

Minimum Print Speed:

330 characters per second (draft).

110 characters per second (letter quality).

Seven print fonts.

Continuous - forms feed with manual single sheet feed.

Capable of handling 16-inch- wide continuous-feed paper.

* + - 1. SYSTEM SOFTWARE
				1. System Software Minimum Requirements:

Real-time multitasking and multiuser [**32-**] [**or**] [**64-**]bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.

Operating system shall be capable of operating DOS and Microsoft Windows applications.

Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.

Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.

Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.

Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

* + - * 1. Operator Interface Software:

Minimize operator training through use of English language prorating and English language point identification.

Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.

Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.

Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.

Operator sign-on and sign-off activity shall be recorded and sent to printer.

Security Access:

Operator access to DDC system shall be under password control.

An alphanumeric password shall be field assignable to each operator.

Operators shall be able to access DDC system by entry of proper password.

Operator password shall be same regardless of which computer or other interface means is used.

Additions or changes made to passwords shall be updated automatically.

Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.

Software shall have at least five access levels.

Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.

Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

Data Segregation:

Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.

Include at least [**32**] <**Insert number**> segregation groups.

Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.

Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.

Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.

Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.

Operators shall be able to perform commands including, but not limited to, the following:

Start or stop selected equipment.

Adjust set points.

Add, modify, and delete time programming.

Enable and disable process execution.

Lock and unlock alarm reporting for each point.

Enable and disable totalization for each point.

Enable and disable trending for each point.

Override control loop set points.

Enter temporary override schedules.

Define holiday schedules.

Change time and date.

Enter and modify analog alarm limits.

Enter and modify analog warning limits.

View limits.

Enable and disable demand limiting.

Enable and disable duty cycle.

Display logic programming for each control sequence.

<**Insert requirements**>.

Reporting:

Generated automatically and manually.

Sent to displays, printers and disk files.

Types of Reporting:

General listing of points.

List points currently in alarm.

List of off-line points.

List points currently in override status.

List of disabled points.

List points currently locked out.

List of items defined in a "Follow-Up" file.

List weekly schedules.

List holiday programming.

List of limits and deadbands.

Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

* + - * 1. Graphic Interface Software:

Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.

Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.

Include at least 10 levels of graphic penetration with the hierarchy operator assignable.

Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.

Graphic displays shall be online user definable and modifiable using the hardware and software provided.

Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.

Graphics are to be online programmable and under password control.

Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.

Graphics shall also contain software points.

Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.

Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.

Display operator accessed data on the monitor.

Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.

Include operator with means to directly access graphics without going through penetration path.

Dynamic data shall be assignable to graphics.

Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.

Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.

Points shall be dynamic with operator adjustable update rates on a per point basis from [**one**] <**Insert value**> second to over a [**minute**] <**Insert value**>.

For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.

For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.

Keyboard equivalent shall be available for those operators with that preference.

Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.

Help Features:

On-line context-sensitive help utility to facilitate operator training and understanding.

Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.

If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.

Available for Every Menu Item:

Index items for each system menu item.

Graphic generation software shall allow operator to add, modify, or delete system graphic displays.

Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols[**similar to those indicated**].

Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:

Define background screens.

Define connecting lines and curves.

Locate, orient and size descriptive text.

Define and display colors for all elements.

Establish correlation between symbols or text and associated system points or other displays.

* + - * 1. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

Subparagraphs below are examples only.

Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.

Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

Room layouts with room identification and name.

Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.

Location and identification of each hardware point being controlled or monitored by DDC system.

<**Insert requirements**>.

Control schematic for each of following, including a graphic system schematic representation[**, similar to that indicated on Drawings,**] with point identification, set point and dynamic value indication[**, sequence of operation**] [**and**] [**control logic diagram**].

Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.

DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, [**gateways**] [**operator workstations**] [**and**] [**other network devices**].

* + - * 1. Customizing Software:

Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.

Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.

As a minimum, include the following modification capability:

Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.

Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.

System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.

System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.

Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.

Point related change capability shall include the following:

System and point enable and disable.

Run-time enable and disable.

Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.

Assignment of alarm and warning limits.

Application program change capability shall include the following:

Enable and disable of software programs.

Programming changes.

Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.

Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.

Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:

Proportional control (P).

Proportional plus integral (PI).

Proportional plus integral plus derivative (PID).

Adaptive and intelligent self-learning control.

Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.

Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.

Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.

Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.

Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

* + - * 1. Alarm Handling Software:

Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers[**, gateways**] [**and other network devices**].

Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.

Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.

Alarms display shall include the following:

Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."

"Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."

Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."

Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.

Send e-mail alarm messages to designated operators.

Send e-mail, page, text and voice messages to designated operators for critical alarms.

Alarms shall be categorized and processed by class.

Class 1:

Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.

Unacknowledged alarms to be placed in unacknowledged alarm buffer.

All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

Class 2:

Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.

Acknowledgement may be through a multiple alarm acknowledgment.

Class 3:

General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.

Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.

Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.

Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

Class 4:

Routine maintenance or other types of warning alarms.

Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.

To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

* + - * 1. Reports and Logs:

Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.

Each report shall be definable as to data content, format, interval and date.

Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on [**workstation**] [**server**] for historical reporting.

Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.

Reports and logs shall be stored on [**workstation**] [**and**] [**server**] hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.

Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

* + - * 1. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

All I/O: With current status and values.

Alarm: All current alarms, except those in alarm lockout.

Disabled I/O: All I/O points that are disabled.

Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.

Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.

Logs:

Alarm history.

System messages.

System events.

Trends.

* + - * 1. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

Retain "Tenant Override Reports" paragraph below if required to report individual tenant use of above building standard HVAC operation.

* + - * 1. Tenant Override Reports: Prepare Project-specific reports.

Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.

Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.

Annual summary report that shows after-hours HVAC usage on a monthly basis.

Retain "HVAC Equipment Reports" paragraph below to require Project-specific HVAC equipment reports to be prepared by a DDC system installer.

* + - * 1. HVAC Equipment Reports: Prepare Project-specific reports.

Chiller Report: Daily report showing operating conditions of each chiller according to ASHRAE 147, including, but not limited to, the following:

Revise subparagraphs below to suit Project. Include DDC system with instruments required to provide information indicated.

Chilled-water entering temperature.

Chilled-water leaving temperature.

Chilled-water flow rate.

Chilled-water inlet and outlet pressures.

Evaporator refrigerant pressure and temperature.

Condenser refrigerant pressure and liquid temperature.

Condenser-water entering temperature.

Condenser-water leaving temperature.

Condenser-water flow rate.

Refrigerant levels.

Oil pressure and temperature.

Oil level.

Compressor refrigerant discharge temperature.

Compressor refrigerant suction temperature.

Addition of refrigerant.

Addition of oil.

Vibration levels or observation that vibration is not excessive.

Motor amperes per phase.

Motor volts per phase.

Refrigerant monitor level (PPM).

Purge exhaust time or discharge count.

Ambient temperature (dry bulb and wet bulb).

Date and time logged.

<**Insert requirements for each type of HVAC equipment requiring a report**>.

Retain "Utility Reports" paragraph below to require Project-specific utility reports to be prepared by a DDC system installer.

* + - * 1. Utility Reports: Prepare Project-specific reports.

Revise subparagraphs below to suit Project. Include DDC system with instruments required to provide reports indicated.

Electric Report:

Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.

Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.

Include annual report showing the monthly electrical consumption and peak electrical demand with time and date stamp for each meter.

For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as lighting, receptacles and HVAC equipment showing daily electrical consumption and peak electrical demand.

For each weekly, monthly and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.

Natural Gas Report:

Include weekly report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.

Include monthly report showing the daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.

Include annual report showing the monthly natural gas consumption and peak natural gas demand with time and date stamp for each meter.

For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.

For each weekly, monthly and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.

Service Water Report:

Include weekly report showing daily service water consumption and peak service water demand with time and date stamp for each meter.

Include monthly report showing the daily service water consumption and peak service water demand with time and date stamp for each meter.

Include annual report showing the monthly service water consumption and peak service water demand with time and date stamp for each meter.

For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as cooling tower makeup and irrigation showing daily service water consumption and peak service water demand.

For each weekly, monthly and annual report, include sum total of all submeters in building showing service water consumption and peak service water demand.

<**Insert requirements for each utility requiring a report**>.

Retain "Energy Reports" paragraph below for projects with emphasis on energy performance.

* + - * 1. Energy Reports: Prepare Project-specific daily, weekly, monthly [**and annual**] [**, annual and since-installed**] energy reports.

Prepare report for each purchased energy utility, indicating the following:

Time period being reported with beginning and end date, and time indicated.

Consumption in units of measure commonly used to report specific utility consumption over time.

Gross area served by utility.

Consumption per unit area served using utility-specific unit of measure.

Cost per utility unit.

Utility cost per unit area.

Convert all utilities to a common energy consumption unit of measure and report for each utility.

Consumption per unit area using common unit of measure.

Retain first subparagraph below to report renewable energy.

Prepare report for each renewable energy source, indicating the following:

Time period being reported with beginning and end date, and time indicated.

Harvested energy in units of measure commonly used to report specific harvested energy consumption over time.

Gross area served by renewable energy source.

Harvested energy per unit area served using specific unit of measure.

Cost per purchased utility unit displaced by renewable energy.

Cost savings attributed to harvested energy source.

Cost savings per unit area attributed to harvested energy.

Convert all renewable energy sources to a common energy consumption unit of measure and report for each.

Harvested energy per unit area using common unit of measure.

Retain first subparagraph below to report energy by submetered areas.

Prepare purchased energy utility report for each submetered area that indicates the following:

Time period being reported with beginning and end date, and time indicated.

Gross area served.

Energy consumption by energy utility type.

Energy consumption per unit area by energy utility type.

Total energy consumption of all utilities in common units of measure.

Total energy consumption of all utilities in common units of measure per unit area.

Unit energy cost by energy utility type.

Energy cost by energy utility type.

Energy cost per unit area by energy utility type.

Total cost of all energy utilities.

Total cost of all energy utilities per unit area.

Prepare Project total purchased energy utility report that combines all purchased energy utilities and all areas served. Project total energy report shall indicate the following:

Time period being reported with beginning and end date, and time indicated.

Gross area served.

Energy consumption by energy utility type.

Energy consumption per unit area by energy utility type.

Total energy consumption of all utilities in common units of measure.

Total energy consumption of all utilities in common units of measure per unit area.

Unit energy cost by energy utility type.

Energy cost by energy utility type.

Energy cost per unit area by energy utility type.

Total cost of all energy utilities.

Total cost of all energy utilities per unit area.

Retain "HVAC System Efficiency Reports" paragraph below for projects with emphasis on energy performance.

* + - * 1. HVAC System Efficiency Reports: Prepare Project-specific [**daily**] [**weekly**] [**monthly**] [**and annual**] [**, annual and since-installed**] HVAC system efficiency reports.

Prepare report for [**each**]chilled-water system, indicating the following:

Time period being reported with beginning and end date, and time indicated.

Cooling energy supplied during time period.

Power energy consumed during time period by cooling equipment used to produce cooling energy supplied.[**List power consumed for each individual piece of equipment in system and summed total of all equipment in system.**]

Energy efficiency coefficient of performance determined by dividing power energy consumed into cooling energy supplied.

Energy efficiency determined by dividing cooling energy supplied into power energy consumed.

Units of measure used in report shall be consistent with units indicated for system.

Prepare report for [**each**]hot-water system, indicating the following:

Time period being reported with beginning and end date, and time indicated.

Cooling energy supplied during time period.

Fuel consumed during time period by boilers used to produce heating energy supplied.[**List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.**]

Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.

Units of measure used in report shall be consistent with units indicated for system.

Prepare report for [**each**]steam system, indicating the following:

Time period being reported with beginning and end date, and time indicated.

Cooling energy supplied during time period.

Fuel consumed during time period by boilers used to produce heating energy supplied.[**List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.**]

Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.

Units of measure used in report shall be consistent with units indicated for system.

<**Insert requirements for each HVAC system requiring a report**>.

Retain "PUE Reports" paragraph below for data center projects with emphasis on energy performance.

* + - * 1. PUE Reports: Prepare Project-specific [**daily**] [**weekly**] [**monthly**] [**and annual**] [**, annual and since-installed**] PUE reports.

Prepare separate report for each [**tenant**] <**Insert category**>.

Prepare Project PUE report that combines PUE and all tenants served.

Calculate PUE following guidelines in [**The Green Grid, White Paper No. 22**] <**Insert requirements**>.

Retain "Weather Reports" paragraph below to require Project-specific weather reports to be prepared by a DDC system installer.

* + - * 1. Weather Reports:

Revise subparagraphs below to suit Project. Include DDC system with instruments required to provide reports indicated.

Include daily report showing the following:

Daily minimum, maximum, and average outdoor dry-bulb temperature.

Daily minimum, maximum, and average outdoor wet-bulb temperature.

Daily minimum, maximum, and average outdoor dew point temperature.

Number of heating degree-days for each day calculated from a base temperature of [**55 deg F** ] <**Insert temperature**>.

Number of cooling degree-days for each day calculated from a base temperature of [**65 deg F**] <**Insert temperature**>.

Daily minimum, maximum, and average outdoor carbon dioxide level.

Daily minimum, maximum, and average relative humidity.

Daily minimum, maximum, and average barometric pressure.

Daily minimum, maximum, and average wind speed and direction.

Include weekly report showing the following:

Daily minimum, maximum, and average outdoor dry-bulb temperature.

Daily minimum, maximum, and average outdoor wet-bulb temperature.

Daily minimum, maximum, and average outdoor dew point temperature.

Number of heating degree-days for each day calculated from a base temperature of [**55 deg F**] <**Insert temperature**>.

Number of cooling degree-days for each day calculated from a base temperature of [**65 deg F**] <**Insert temperature**>.

Weekly minimum, maximum, and average outdoor carbon dioxide level.

Daily minimum, maximum, and average relative humidity.

Daily minimum, maximum, and average barometric pressure.

Daily minimum, maximum, and average wind speed and direction.

Include monthly report showing the following:

Daily minimum, maximum, and average outdoor dry-bulb temperature.

Daily minimum, maximum, and average outdoor wet-bulb temperature.

Daily minimum, maximum, and average outdoor dew point temperature.

Number of heating degree-days for each day calculated from a base temperature of [**55 deg F**] <**Insert temperature**>.

Number of cooling degree-days for each day calculated from a base temperature of [**65 deg F**] <**Insert temperature**>.

Monthly minimum, maximum, and average outdoor carbon dioxide level.

Daily minimum, maximum, and average relative humidity.

Daily minimum, maximum, and average barometric pressure.

Daily minimum, maximum, and average wind speed and direction.

Include annual (12-month) report showing the following:

Monthly minimum, maximum, and average outdoor dry-bulb temperature.

Monthly minimum, maximum, and average outdoor wet-bulb temperature.

Monthly minimum, maximum, and average outdoor dew point temperature.

Number of heating degree-days for each month calculated from a base temperature of [**55 deg F**] <**Insert temperature**>.

Number of cooling degree-days for each month calculated from a base temperature of [**65 deg F**] <**Insert temperature**>.

Annual minimum, maximum, and average outdoor carbon dioxide level.

Monthly minimum, maximum, and average relative humidity.

Daily minimum, maximum, and average barometric pressure.

Daily minimum, maximum, and average wind speed and direction.

* + - * 1. Standard Trends:

Trend all I/O point present values, set points, and other parameters indicated for trending.

Trends shall be associated into groups, and a trend report shall be set up for each group.

Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching [**75**] <**Insert value**> of DDC controller buffer limit, or by operator request, or by archiving time schedule.

Preset trend intervals for each I/O point after review with Director’s Representative.

Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.

When drive storage memory is full, most recent data shall overwrite oldest data.

Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

* + - * 1. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

Each trend shall include interval, start time, and stop time.

Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on [**workstation**] [**server**] hard drives.

Data shall be retrievable for use in spreadsheets and standard database programs.

* + - * 1. Programming Software:

Include programming software to execute sequences of operation indicated.

Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.

Retain "as follows" option in first subparagraph below to limit the type of programming software to a specific type. Retain "any of the following" option to allow choice to use any programming type. Retain "one of the following" option to allow choice to allow use of just one of multiple programming types indicated. Revise subparagraphs to limit programming options.

Programming software shall be [**as follows**] [**any of the following**] [**one of the following**]:

Graphic-based programming is the easiest method of programming options indicated and best suited for operators with limited programming experience. Not all DDC system manufacturers offer graphic-based programming. Consult manufacturers.

Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.

Programming tools shall be viewable in real time to show present values and logical results of each function block.

Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.

Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

Retain "Database Management Software" paragraph below for DDC systems with database requirements that use SQL. Coordinate with other DDC system database requirements indicated.

* + - * 1. Database Management Software:

Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.

Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.

Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:

Backup.

Purge.

Restore.

Database management software shall support the following:

Statistics: Display database server information and trend, alarm, event, and audit information on database.

Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.

Backup: Include means to create a database backup file and select a storage location.

Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.

Database management software shall include information of current database activity, including the following:

Ready.

Purging record from a database.

Action failed.

Refreshing statistics.

Restoring database.

Shrinking a database.

Backing up a database.

Resetting Internet information services.

Starting network device manager.

Shutting down the network device manager.

Action successful.

Database management software monitoring functions shall continuously read database information once operator has logged on.

Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.

Monitoring settings window shall have the following sections:

Allow operator to set and review scan intervals and start times.

E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.

Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.

Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.

Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.

Monitoring settings taskbar shall include the following informational icons:

Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.

Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.

Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.

* + - 1. OFFICE APPLICATION SOFTWARE
				1. Manufacturers: Subject to compliance with requirements, provide products by the following:

Microsoft Corporation.

Apache OpenOffice

WPS Office

Approved equivalent.

* + - * 1. Include current version of office application software at time of Substantial Completion.
				2. Office application software package shall include multiple separate applications and use a common platform for all applications, similar to Microsoft's "Office Professional."

Database.

E-mail.

Presentation.

Publisher.

Spreadsheet.

Word processing.

* + - 1. MAINTENANCE MANAGEMENT SOFTWARE

Retain this article for Project with rigorous requirements for maintenance management. Consult Director’s Representative to discuss requirements for maintenance.

* + - * 1. Scope:

Include complete and functional software-driven maintenance management system. Software shall perform scheduling of preventive maintenance and generation of work orders, for mechanical and electrical equipment and systems.

Work orders shall be automatically generated from alarm conditions, run time, and calendar time. Each work order generated shall list parts, tools, craftspeople, and define task to be performed.

Work order generated shall be used to schedule a repair or preventive maintenance routine.

Work order shall be used to track completion of work, parts used and total cost of repair.

A database shall include an inventory tracking system. Work orders generated shall automatically update inventory database to show quantity of tools, repair parts and expendables used for a work order.

Work orders and preventive maintenance schedules shall be printed on a dedicated printer assigned solely to maintenance management function.

* + - * 1. Additional Hardware Requirements:

Maintenance management software shall not require additional hardware, except for an additional printer that is dedicated to maintenance management.

Maintenance management software shall be integrated into DDC system.

* + - * 1. Software Requirements:

From main menu of maintenance management system, it shall be possible through selection of icons to penetrate to individual functions described below.

Work Orders:

Automatically generate work orders initiated from alarm conditions, accumulated run time or calendar time. Work orders generated shall specify a particular task to be accomplished including the labor, material and tools needed to accomplish work.

Include at least two of the following types of work orders:

Corrective and emergency maintenance work orders shall be generated for a specific job or repair for emergency, breakdown, or scheduled work.

Preventive maintenance that are used on a periodic basis to generate preventive maintenance work orders.

Include the following functions:

Work Order Tracking: Perform every function related to processing work orders including creating, approving and initiating work orders, checking their status history and closing or reworking them when appropriate.

Work Requests: Report any problems that require corrective maintenance activity generated by dispatchers and those people designated to request work orders.

Quick Reporting: Report work done on an open work order or a small job.

Work Manager: Specify the type of labor to be applied to a specific work order at specific times. It shall include the capability to dispatch one or more laborers to top-priority jobs on as-needed basis and to interrupt work in progress to reassign labor to higher priority tasks.

Reports:

Daily Maintenance Schedule by Supervisor: List a schedule of open work orders for a specified date by supervisor.

Equipment Cost Roll-up Report: Include a roll-up of equipment costs incurred since the date the report was last run.

Delinquent Work Order Report: List open work orders whose target completion date is earlier than the date the report is run.

Employee Job Assignments: List labor codes that have job assignments for the specified date.

Daily Work Order Assignment: List work orders that have labor assignments for the specified date.

Estimated versus Actual Work Order Costs: List a cost summary of outstanding work orders.

Open Work Orders Report: List open work orders for locations and equipment.

Inventory:

Include an inventory tracking system to keep track of stocked, non-stocked and special-order items.

Link inventory tracking to database and when items are consumed, as noted on a work order issued by system, inventory of stocked items shall be automatically updated.

Include the following functions:

Inventory Control: Enter, display, and update information on each inventory item. It shall allow viewing of master inventory records that are independent of storeroom locations or item/location records. Include a screen that lists inventory transactions that move items in or out of inventory or from one storeroom location to another. Minimum information tracked shall include the following:

Vendors supply items.

Item balances, including the bin and lot level for each storeroom location.

Alternative items.

Issues and Transfers: Issue stock directly from inventory, with or without a work order. When transfer of stock from one location to another location occurs, provide appropriate adjustments in stock balance record. Include a trace record of stock transfers from one storeroom to another.

Item Assembly Structures: Include modeling of equipment with inventory items and building of equipment and location hierarchies.

Metered Material Usage:

Track usage by a piece of equipment.

Record against a standing work order for a selected piece of equipment.

Material usage transaction shall be written for each item of material used and be provided as an input to calculation for per unit material consumption report for a piece of equipment.

Reports:

Inventory Analysis Report: List for a given storeroom location, inventory items analysis information that allows quick identification of which inventory items represent greatest monetary investment for dollar value and rate of turnover.

Inventory Cycle Count Report: List for a specified storeroom, inventory items that are due to be cycle-counted, based on cycle-count frequency and last count date.

Economic Order Quantity Report: For a given storeroom location, display optimum economic ordering quantity for items in selected results set.

Inventory Pick Report: A pick list, by work order for items needed to be pulled from a designated storeroom's inventory for work orders having a target start date of specified date.

Suggested Order Report: List inventory items in selected results set that are due to be recorded, for a specified storeroom location, based on the following calculation: Suggest a reorder if current balance minus reserve quantity plus on-order quantity is less than reorder point.

Reorder Point Report: List selected set of items and optimum minimum level to have in stock based on demand, lead delivery time and a reserve safety stock.

Inventory Valuation Report: Gives an accounting of cost of current inventory, for inventory records in a designated storeroom location.

Item Order Status: Lists items on order.

List of Expired Items: Lists expired lot items in a storeroom. Report shall include item number, description, expiration date, bin number, lot number, manufacturer lot number, and quantity of expired items in that lot and bin.

Item Availability at All Locations: Lists alternative storeroom locations for selected items.

Where Used Report: List equipment on which item is recorded as being used.

Equipment:

Include equipment and location records; establish relationships between equipment, between locations, and between equipment and locations; track maintenance costs; and enter and review meter readings.

Include the following functions:

Equipment: Store equipment numbers and corresponding information including equipment class, location, vendor, up/down status and maintenance costs for each piece of equipment. Include building of equipment assemblies. Equipment assemblies hierarchical ordering shall be provided for arrangement of buildings, departments, equipment and sub-assemblies.

Operating Locations: Facilitate creation of records for operating locations of equipment, and track equipment that is used in multiple locations. In addition, allow hierarchical organization of equipment operating in facility by means of grouping equipment locations into areas of responsibility.

Failure Codes: Develop and display failure hierarchies to acquire an accurate history of types of failures that affect equipment and operating locations.

Condition Monitoring: Display time related or limit measurements recorded for a piece of equipment. It shall be possible to generate work orders from this screen and to take immediate action on problem conditions.

Reports:

Availability Statistic by Location: List equipment availability by location over a user-specified time period.

Equipment Failure Summary: List total number of failures by problem code for a piece of equipment for a specified time period.

Detailed Equipment Failure Report by Equipment: List of failure reports for the current piece of equipment for a specified time period.

Equipment Hierarchy Report: List of equipment.

Equipment History Graphs: Include a graphical report in histogram format that displays equipment breakdown history over a specified period.

Equipment Measurement Report: Tabular listing and description of each measurement point for a piece of equipment and the history of measurements taken for that point.

Maintenance Cost by Equipment: List of transactions costs for elected equipment in the specified date range.

Failure Count by Equipment: Graphically report the number of failures for each piece of equipment showing number of failures for each piece of equipment over a specified time period, occurrence of each problem code within set of failures and failures by problem code.

Failure Analysis Graphs: Graphically report number of failures for each piece of equipment over a specified time period, number of occurrences of each problem code within set of failures and failures by problem code.

Failure Code Hierarchy Report: List of failure codes in each level of the failure hierarchy.

Location Failure Summary: A summary for each selected location of failures reported and any hierarchy level locations for specified time period.

Failure Summary by Location: A summary of failures for the selected location and their subordinate locations that are part of the hierarchical system.

Detailed Failure Report by Location: List all failures for selected location and its subordinate locations that are part of a hierarchical system.

Maintenance Cost by System: List of total costs reported in a given date range for locations in selected hierarchical system.

Location Hierarchy Report: Lists member locations of a hierarchical system displayed in hierarchical fashion.

Purchasing:

Include preparation and generation of purchase requisitions and purchase orders; to report receipt of both items and services, match invoices with purchase orders and receipts and define and convert foreign currencies.

Include the following functions:

Purchase Requisition: Create and process purchase requisitions for items and services.

Purchase Orders: Create and process purchase orders for items and services from scratch or from purchase requisitions. Record receipts of items and services.

Invoices: Include functionality to match purchase orders with invoices and receipts. It shall also be possible to match a service receipt to an invoice. Project for entering of an invoice for bills that do not require purchase orders or receipts.

Currency Management: Define currencies and specify exchange rates. Include preparation of purchase requisitions and purchase orders in currency of vendor, while tracking costs in systems base currency.

Reports:

Invoice Approval Report: Include an approval form for entered invoices.

Inventory Receipts Register: List purchase orders and inventory received for the user-specified time frame.

Direct Purchase Back-Order Report: List of items ordered as a direct purchase not received by the required delivery date.

Standard Purchase Order: A printing of primary purchase order with vendors shipping information, and items purchased.

Purchase Order Status Report: List of purchase orders whose status has changed during a certain time period.

Standard Purchase Requisition: A printing of primary purchase requisition, including vendor name and shipping information.

Job Plans:

Include creation of a detailed description of work to be performed by a work order. The job plan shall contain operations, procedures and list of estimated material, labor and tools required for work.

Labor:

Store information on employees, contractors, and crafts and include the following functions:

Labor: Create, modify and view employee records. Employee records shall contain pay rate, overtime worked, overtime refused, specials skills and certifications.

Crafts: Create, modify and view craftspeople records.

Labor Reporting: Report labor usage by employee or craft externally from the work orders module.

Reports:

Employee Attendance Analysis: List of planned attendance, actual attendance, vacation and sick time in hours as a percentage of planned attendance for selected employees for specified time period.

Labor Productivity Analysis: List of actual labor hours by labor report category showing each by percentage.

Labor Availability versus Commitments by Crafts: A graphical report that details available labor hours versus committed work order hours by craft and day.

Calendars:

Establish calendar records indicating working time for equipment, location, craft, and labor records.

Resources:

Include entry and retrieval of data associated with resources required to maintain facility and to include the following functions:

Companies: Establish and update data on vendors and other companies.

Tools: Create and maintain information on the tools used on jobs. The information contained within this module shall be available to job plans and work orders.

Service Contracts: Specify information on service contracts with vendors or manufacturers.

Custom Applications:

Include creation of customized database tables and application screens that supplement functions specified.

Setup:

Include configuration of database, security and setup applications.

Perform the following functions:

Reports and Other Applications: Register reports and other applications for use within system.

Documents: Enter, track and link information from Drawings to equipment and inventory items.

Chart of Accounts: Add or modify accounts; set up financial periods; enter inventory accounts, company accounts, and resource recovery accounts; and define tax codes and rates.

Signature Security: Establish each user's access rights to modules, applications, screens and options.

Database Configuration: Customize database, including adjusting field lengths and modifying data types.

Application Setup: Change position of icons and menu items on the main menu screen.

Application Launching: Allow for connecting of third-party applications to data fields and push buttons.

Utilities:

Include utilities module that allows system administrator to customize system and to maintain database.

Include the following functions:

Interactive SQL: Include access to database for database management functions of import/export and backup.

Edit Windows: Display a dialog box to customize an application.

Archive Data: Remove records from database and store them for future reference.

* + - * 1. Documentation:

Include complete documentation for the system consisting of a User Manual and Systems Administrator Guide.

User Manual shall describe how to use each application module and screen with step-by-step instructions detailing entry and retrieval of data for functions specified.

Include a step-by-step description of how each report is defined and retrieved.

Bind documentation and clearly title it indicating volume number and use.

Retain "ASHRAE 135 Gateways" Article below for DDC systems using ASHRAE 135 protocol.

* + - 1. ASHRAE 135 GATEWAYS

Gateways require a thorough understanding of their application. Use caution when connecting non-BACnet to BACnet protocol. It may be more practical to select products that are already "BACnet ready." Research gateway manufacturers for price, options, and performance. Design for each gateway should include an interoperability schedule showing each point or event on non-BACnet side that BACnet "client" will read, and each parameter that BACnet network will write to for BACnet services, or BACnet BIBBs, defined in ASHRAE 135, Annex K.

* + - * 1. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, <**Insert equipment,**> and variable-speed drives.
				2. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Director’s Representative .
				3. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
				4. Gateway Minimum Requirements:

Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.

Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.

Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.

Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.

Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.

Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

Retain "ASHRAE 135 Protocol Analyzer" Article below for DDC systems using ASHRAE 135 protocol.

* + - 1. ASHRAE 135 PROTOCOL ANALYZER

Retain protocol analyzer after consulting Director’s Representative and confirming operators require it, as it takes a moderate level of skill and knowledge to use.

Protocol analyzer is typically software for connecting a computer to any ASHRAE 135 network for use in gathering basic system information. It is most useful for integration projects with poorly documented systems and where different manufacturers' products reside on same network.

* + - * 1. Analyzer and required cables and fittings for connection to ASHRAE 135 network.
				2. Analyzer shall include the following minimum capabilities:

Capture and store to a file data traffic on all network levels.

Measure bandwidth usage.

Filtering options with ability to ignore select traffic.

* + - 1. CEA-709.1-C NETWORK HARDWARE

Retain this article for DDC systems using LON protocol.

* + - * 1. Routers:

Network routers, including routers configured as repeaters, shall comply with requirements of CEA-709.1-C and include connection between two or more CEA-709.3 TP/FT-10 channels or between two or more CEA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.

IP Routers:

Perform layer three routing of CEA-709.1-C packets over an IP network according to CEA-852-B.

Include appropriate connection to the IP network and connections to CEA-709.3 TP/FT-10 or TP/XF-1250 network.

Support the Dynamic Host Configuration Protocol for IP configuration and use of an CEA-852-B Configuration Server (for CEA-852-B configuration), but shall not rely on these services for configuration.

Capable of manual configuration via a console RS-232 port.

* + - * 1. Gateways:

Perform bidirectional protocol translation from one non-CEA-709.1-C protocol to CEA-709.1-C.

Incorporate a network connection to a TP/FT-10 network according to CEA-709.3 and a connection for a non-CEA-709.1-C network.

* + - 1. WIRELESS ROUTERS FOR OPERATOR INTERFACE

If wireless routers are required, retain single-band or dual-band router type, or both. If retaining both types, indicate on Drawings or in an application article describing application of each type on Project.

* + - * 1. Single-Band Wireless Routers:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Cisco Linksys.

D-Link Corporation/D-Link Systems, Inc.

NETGEAR Inc.

Approved equivalent.

Description: High-speed router with integral Ethernet ports.

Technology: IEEE 802.11n; [**2.4**] <**Insert number**>-GHz speed band.

Speed: Up to [**300**] <**Insert number**> Mbps.

Compatibility: IEEE 802.11n/g/b/a wireless devices.

Ethernet Ports: Four, gigabit (1000 Mbps).

Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 according to IEEE 802.11i.

* + - * 1. Dual-Band Wireless Routers:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Cisco Linksys.

D-Link Corporation/D-Link Systems, Inc.

NETGEAR Inc.

Approved equivalent.

Description: High-speed, dual-band router with integral Ethernet ports and USB port.

Technology: IEEE 802.11n; 2.4- and 5-GHz speed bands.

Speed: Up to [**300**] <**Insert number**> Mbps on 2.4-GHz band and up to [**450**] <**Insert number**> Mbps on 5-GHz band.

Compatibility: IEEE 802.11n/g/b/a wireless devices.

Ethernet Ports: Four, gigabit (1000 Mbps).

USB Port: One, USB 2.0 or 3.0.

Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 according to IEEE 802.11i.

* + - 1. DDC CONTROLLERS
				1. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.
				2. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.
				3. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
				4. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.
				5. Environment Requirements:

Controller hardware shall be suitable for the anticipated ambient conditions.

Controllers located in conditioned space shall be rated for operation at [**32 to 120 deg F**] <**Insert temperature range**>.

Controllers located outdoors shall be rated for operation at [**40 to 150 deg F**] <**Insert temperature range**>.

* + - * 1. Power and Noise Immunity:

Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.

Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

Retain "DDC Controller Spare Processing Capacity" paragraph below to require spare processing capacity for future growth.

* + - * 1. DDC Controller Spare Processing Capacity:

Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

Network Controllers: [**50**] [**60**] [**70**] <**Insert value**> percent.

Programmable Application Controllers: Not less than [**60**] [**70**] [**80**] <**Insert number**> percent.

Application-Specific Controllers: Not less than [**70**] [**80**] [**90**] <**Insert number**> percent.

Memory shall support DDC controller's operating system and database and shall include the following:

Monitoring and control.

Energy management, operation and optimization applications.

Alarm management.

Historical trend data of all connected I/O points.

Maintenance applications.

Operator interfaces.

Monitoring of manual overrides.

Retain "DDC Controller Spare I/O Point Capacity" paragraph below to require spare point capacity for future growth.

* + - * 1. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

Network Controllers:

[**10**] [**20**] <**Insert number**> percent of each AI, AO, BI, and BO point connected to controller.

Minimum Spare I/O Points per Controller:

AIs: [**Two**] [**Three**] <**Insert number**>.

AOs: [**Two**] [**Three**] <**Insert number**>.

BIs: [**Three**] [**Five**] <**Insert number**>.

BOs: [**Three**] [**Five**] <**Insert number**>.

Programmable Application Controllers:

[**10**] [**20**] <**Insert number**> percent of each AI, AO, BI, and BO point connected to controller.

Minimum Spare I/O Points per Controller:

AIs: [**Two**] [**Three**] <**Insert number**>.

AOs: [**Two**] [**Three**] <**Insert number**>.

BIs: [**Three**] [**Five**] <**Insert number**>.

BOs: [**Three**] [**Five**] <**Insert number**>.

Application-Specific Controllers:

[**10**] <**Insert number**> percent of each AI, AO, BI, and BO point connected to controller.

Minimum Spare I/O Points per Controller:

AIs: [**One**] [**Two**] <**Insert number**>.

AOs: [**One**] [**Two**] <**Insert number**>.

BIs: [**One**] [**Two**] <**Insert number**>.

BOs: [**One**] [**Two**] <**Insert number**>.

* + - * 1. Maintenance and Support: Include the following features to facilitate maintenance and support:

Mount microprocessor components on circuit cards for ease of removal and replacement.

Means to quickly and easily disconnect controller from network.

Means to quickly and easily access connect to field test equipment.

Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

* + - * 1. General Requirements for CEA-709.1-C DDC Controllers:

Controllers shall be LonMark certified.

Distinguishable and accessible switch, button, or pin, when pressed shall broadcast its 48-bit Node ID and Program ID over network.

TP/FT-10 transceiver according to CEA-709.3 and connections for TP/FT-10 control network wiring.

TP/XF-1250 transceiver according to CEA-709.3 and connections for TP/XF-1250 control network wiring.

Communicate using CEA-709.1-C protocol.

Controllers configured into subnets, as required, to comply with performance requirements indicated.

Network communication through LNS network management and database standard for CEA-709.1-C network devices.

Locally powered, not powered through network connection.

Functionality required to support applications indicated, including, but not limited to, the following:

Input and outputs indicated and as required to support sequence of operation and application in which it is used. SNVTs shall have meaningful names identifying the value represented by an SNVT. Unless an SNVT of an appropriate engineering type is unavailable, all network variables shall be of an SNVT with engineering units appropriate to value the variable represents.

Configurable through SCPTs defined in LonMark SCPT List, operator-defined UCPTs, network configuration inputs (NCIs) of an SNVT type defined in LonMark SNVT List, NCIs of an operator-defined network variable type, or hardware settings on controller itself for all settings and parameters used by application in which it is used.

Programmable controllers shall conform to LonMark Interoperability Guidelines and have LonMark certification.

* + - * 1. Input and Output Point Interface:

Hardwired input and output points shall connect to network, programmable application and application-specific controllers.

Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.

Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.

AIs:

AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.

AIs shall be compatible with, and field configurable to, sensor and transmitters installed.

Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of [**8**] [**12**] <**Insert value**> bits or better to comply with accuracy requirements indicated.

Signal conditioning including transient rejection shall be provided for each AI.

Capable of being individually calibrated for zero and span.

Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

AOs:

Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of [**8**] [**12**] <**Insert value**> bits or better to comply with accuracy requirements indicated.

Output signals shall have a range of [**4 to 20 mA dc**] [**or**] [**zero- to 10-V dc**] as required to include proper control of output device.

Capable of being individually calibrated for zero and span.

AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

BIs:

Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.

Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.

BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.

BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.

Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

BOs:

Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.

Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.

BOs shall be selectable for either normally open or normally closed operation.

Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.

Limit use of three-point floating devices to VAV terminal unit control applications, [**and other applications indicated on Drawings,**] <**Insert applications**>. Control algorithms shall operate actuator to one end of its stroke once every [**12**] [**24**] <**Insert time**> hours for verification of operator tracking.

* + - 1. NETWORK CONTROLLERS
				1. General Network Controller Requirements:

Include adequate number of controllers to achieve performance indicated.

System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.

Controller shall have enough memory to support its operating system, database, and programming requirements.

Data shall be shared between networked controllers and other network devices.

Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.

Controllers [**that perform scheduling**]shall have a real-time clock.

Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.

Controllers shall be fully programmable.

* + - * 1. Communication:

Network controllers shall communicate with other devices on DDC system [**Level one**] <**Insert level**> network.

Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

* + - * 1. Operator Interface:

Controller shall be equipped with a service communications port for connection to a portable operator's workstation[**or mobile device**].

Retain "Local Keypad and Display" subparagraph below to require a local keypad and display. Requirement adds cost and is unnecessary for most applications.

Local Keypad and Display:

Equip controller with local keypad and digital display for interrogating and editing data.

Use of keypad and display shall require security password.

* + - * 1. Serviceability:

Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.

Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

Controller shall maintain BIOS and programming information in event of a power loss for at least [**72**] [**96**] <**Insert number**> hours.

* + - 1. PROGRAMMABLE APPLICATION CONTROLLERS
				1. General Programmable Application Controller Requirements:

Include adequate number of controllers to achieve performance indicated.

Controller shall have enough memory to support its operating system, database, and programming requirements.

Data shall be shared between networked controllers and other network devices.

Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.

Controllers [**that perform scheduling**]shall have a real-time clock.

Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.

Controllers shall be fully programmable.

* + - * 1. Communication:

Programmable application controllers shall communicate with other devices on network.

* + - * 1. Operator Interface:

Controller shall be equipped with a service communications port for connection to a portable operator's workstation[**or mobile device**].

Retain "Local Keypad and Display" subparagraph below to require a local keypad and display. Requirement adds cost and is unnecessary for most applications.

Local Keypad and Display:

Equip controller with local keypad and digital display for interrogating and editing data.

Use of keypad and display shall require security password.

* + - * 1. Serviceability:

Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.

Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

* + - 1. APPLICATION-SPECIFIC CONTROLLERS
				1. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

Capable of standalone operation and shall continue to include control functions without being connected to network.

Data shall be shared between networked controllers and other network devices.

* + - * 1. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.
				2. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation.[**Connection shall extend to port on space temperature sensor that is connected to controller.**]
				3. Serviceability:

Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.

Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

* + - 1. CONTROLLER SOFTWARE
				1. General Controller Software Requirements:

Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.

I/O points shall be identified by up to [**30**] <**Insert number**>-character point name and up to [**16**] <**Insert number**>-character point descriptor. Same names shall be used at operator workstations.

Control functions shall be executed within controllers using DDC algorithms.

Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

* + - * 1. Security:

Operator access shall be secured using individual security passwords and user names.

Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.

Operator log-on and log-off attempts shall be recorded.

System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

* + - * 1. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

Weekly Schedule:

Include separate schedules for each day of week.

Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.

Each schedule may consist of up to 10 events.

When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

Exception Schedules:

Include ability for operator to designate any day of the year as an exception schedule.

Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

Holiday Schedules:

Include capability for operator to define up to 99 special or holiday schedules.

Schedules may be placed on scheduling calendar and will be repeated each year.

Operator shall be able to define length of each holiday period.

* + - * 1. System Coordination:

Include standard application for proper coordination of equipment.

Application shall include operator with a method of grouping together equipment based on function and location.

Group may then be used for scheduling and other applications.

* + - * 1. Binary Alarms:

Each binary point shall be set to alarm based on operator-specified state.

Include capability to automatically and manually disable alarming.

* + - * 1. Analog Alarms:

Each analog object shall have both high and low alarm limits.

Alarming shall be able to be automatically and manually disabled.

* + - * 1. Alarm Reporting:

Operator shall be able to determine action to be taken in event of an alarm.

Alarms shall be routed to appropriate operator workstations based on time and other conditions.

Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

* + - * 1. Remote Communication:

System shall have ability to dial out in the event of an alarm.

* + - * 1. Electric Power Demand Limiting:

Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.

Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.

Demand reduction shall be accomplished by the following means:

Reset air-handling unit supply temperature set points.

Reset space temperature set points.

De-energize equipment based on priority.

Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.

Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.

Include means operator to make the following changes online:

Addition and deletion of loads controlled.

Changes in demand intervals.

Changes in demand limit for meter(s).

Maximum shutoff time for equipment.

Minimum shutoff time for equipment.

Select rotational or sequential shedding and restoring.

Shed and restore priority.

Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:

Total electric consumption.

Peak demand.

Date and time of peak demand.

Daily peak demand.

* + - * 1. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
				2. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.
				3. Control Loops:

Support any of the following control loops, as applicable to control required:

Two-position (on/off, open/close, slow/fast) control.

Proportional control.

Proportional plus integral (PI) control.

Proportional plus integral plus derivative (PID) control.

Include PID algorithms with direct or reverse action and anti-windup.

Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.

Controlled variable, set point, and PID gains shall be operator-selectable.

Adaptive (automatic tuning).

* + - * 1. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.
				2. Energy Calculations:

Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.

Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).

Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

* + - * 1. Anti-Short Cycling:

BO points shall be protected from short cycling.

Feature shall allow minimum on-time and off-time to be selected.

* + - * 1. On and Off Control with Differential:

Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.

Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

* + - * 1. Run-Time Totalization:

Include software to totalize run-times for all BI [**and BO**]points.

A high run-time alarm shall be assigned, if required, by operator.

* + - 1. ENCLOSURES
				1. General Enclosure Requirements:

House each controller and associated control accessories in a [**single**]enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.

Do not house more than one controller in a single enclosure.

Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.

Retain first subparagraph below for windows in enclosure doors.

Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.

Retain any of first two subparagraphs below to restrict enclosure size.

Individual wall-mounted single-door enclosures shall not exceed [**36 inches** ] <**Insert dimension**> wide and [**48 inches** ] [**60 inches**] <**Insert dimension**> high.

Individual wall-mounted double-door enclosures shall not exceed [**60 inches** ] <**Insert dimension**> wide and [**36 inches** ] <**Insert dimension**> high.

Retain first subparagraph below to allow freestanding enclosures.

Freestanding enclosures shall not exceed [**48 inches**] <**Insert dimension**> wide and [**72 inches** ] <**Insert dimension**> high.

Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.

Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.[**For enclosures with windows, include pocket on bottom of enclosure.**]

* + - * 1. Internal Arrangement:

Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.

Arrange layout to group similar products together.

Include a barrier between line-voltage and low-voltage electrical and electronic products.

Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.

Terminate field cable and wire using heavy-duty terminal blocks.

Include spare terminals, equal to not less than [**10**] [**20**] <**Insert number**> percent of used terminals.

Include spade lugs for stranded cable and wire.

Install a maximum of two wires on each side of a terminal.

Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.

Retain first subparagraph below for enclosure-mounted receptacle.

Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.

Mount products within enclosure on removable internal panel(s).

Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch- high lettering.

Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.

Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.

Size enclosure internal panel to include at least [**25**] <**Insert number**> percent spare area on face of panel.

* + - * 1. Environmental Requirements:

Evaluate temperature and humidity requirements of each product to be installed within each enclosure.

Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.

Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.

Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.

Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.

Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

* + - * 1. Wall-Mounted, NEMA 250, Type 1:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Cooper B-line; brand of Eaton, Electrical Sector.

Hammond Mfg. Co. Inc.

Hoffman; brand of nVent Electrical PLC.

Saginaw Control and Engineering.

Approved equivalent.

Enclosure shall be NRTL listed according to UL 50 or UL 50E.

Construct enclosure of steel, not less than:

Enclosure size less than 24 in. : [**0.053 in.**] [**or**] [**0.067 in.**] thick.

Enclosure size 24 in. and larger: [**0.067 in.**] [**or**] [**0.093 in.**] thick.

Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Exterior color shall be [**white**] [**ANSI 61 gray**] [**selected by Architect**] [**manufacturer's standard**] <**Insert color**>.

Interior color shall be [**white**] [**ANSI 61 gray**] [**manufacturer's standard**].

Hinged door full size of front face of enclosure and supported using:

Enclosures sizes less than 36 in. tall: Multiple butt hinges.

Enclosures sizes 36 in. tall and larger: Continuous piano hinges.

Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Size less than 24 in. : [**Solid**] [**or**] [**Perforated**] steel, 0.053 in. thick.

Size 24 in. and larger: Solid [**aluminum, 0.10 in.**] [**or**] [**steel, 0.093 in.** ] thick.

Internal panel mounting hardware, grounding hardware and sealing washers.

Grounding stud on enclosure body.

Thermoplastic pocket on inside of door for record Drawings and Product Data.

* + - * 1. Wall Mounted NEMA 250, Types 4 and 12:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Cooper B-line; brand of Eaton, Electrical Sector.

Hammond Mfg. Co. Inc.

Hoffman; brand of nVent Electrical PLC.

Saginaw Control and Engineering.

Approved equivalent.

Enclosure shall be NRTL listed according to UL 508A.

Seam and joints are continuously welded and ground smooth.

Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.

Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.

Single-door enclosure sizes up to 60 inches tall by 36 inches wide.

Double-door enclosure sizes up to 36 inches tall by 60 inches wide.

Construct enclosure of steel, not less than the following:

Size Less Than 24 Inches: [**0.053 inch**] [**or**] [**0.067 inch**] thick.

Size 24 Inches and Larger: 0.067 inch thick.

Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Exterior color shall be [**white**] [**ANSI 61 gray**] [**as selected by Architect**] [**manufacturer's standard**] <**Insert color**>.

Interior color shall be [**white**] [**ANSI 61 gray**] [**manufacturer's standard**].

Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

Sizes through 24 Inches Tall: Two hinges.

Sizes between 24 Inches through 48 Inches Tall: Three hinges.

Sizes Larger 48 Inches Tall: Four hinges.

Double-door enclosures with overlapping door design to include unobstructed full-width access.

Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Size Less Than 24 Inches: [**Solid**] [**or**] [**perforated**] steel, 0.053 inch thick.

Size 24 Inches and Larger: Solid [**aluminum, 0.10 inch**] [**or**] [**steel, 0.093 inch** ] thick.

Internal panel mounting studs with hardware, grounding hardware, and sealing washers.

Grounding stud on enclosure body.

Thermoplastic pocket on inside of door for record Drawings and Product Data.

* + - * 1. Wall-Mounted, NEMA 250, Type 4X SS:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Crouse-Hinds; brand of Eaton, Electrical Sector.

Hammond Mfg. Co. Inc.

Hoffman; brand of nVent Electrical PLC.

Saginaw Control and Engineering.

Approved equivalent.

Enclosure shall be NRTL listed according to UL 508A.

Seam and joints are continuously welded and ground smooth.

Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.

Construct enclosure of [**Type 304**] [**Type 316L**] stainless steel, not less than the following:

Size Less Than 24 Inches: 0.053 inch thick.

Size 24 Inches and Larger: 0.067 inch thick.

Outside body and door of enclosure with brushed No. 4 finish.

Retain one of first two subparagraphs below for door hinge choices.

Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

Sizes through 24 Inches Tall: Two hinges.

Sizes between 24 Inches through 48 Inches Tall: Three hinges.

Sizes Larger 48 Inches Tall: Four hinges.

Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.

Retain first subparagraph below for upgraded door latching system.

Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquid-tight Type 316 stainless steel handle with integral locking mechanism.

Removable internal panel shall be 0.093-inch solid steel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Internal panel mounting studs and hardware, grounding hardware, and sealing washers.

Install corrosion-resistant polyester vent drain in a stainless steel sleeve at the bottom of enclosure.

Include enclosure with stainless steel mounting brackets.

* + - * 1. Freestanding, NEMA 250, Type 1:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Cooper B-line; brand of Eaton, Electrical Sector.

Hammond Mfg. Co. Inc.

Hoffman; brand of nVent Electrical PLC.

Saginaw Control and Engineering.

Approved equivalent.

Enclosure shall be NRTL listed according to UL 508A.

Seam and joints are continuously welded and ground smooth.

Externally formed body flange around perimeter of enclosure face.

Single-door enclosure sizes up to 84 inches tall by 36 inches wide.

Double-door enclosure sizes up to 84 inches tall by 72 inches wide.

Construct enclosure of steel, not less than 0.067 inch thick.

Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Exterior color shall be [**white**] [**ANSI 61 gray**] [**as selected by Architect**] [**manufacturer's standard**] <**Insert color**>.

Interior color shall be [**white**] [**ANSI 61 gray**] [**manufacturer's standard**].

Corner-formed flush door, full size of enclosure face, supported using four concealed hinges with easily removable hinge pins.

Double-door enclosures with overlapping door design to include unobstructed full-width access.

Doors with three-point (top, middle, and bottom) latch system with single heavy-duty handle and integral locking mechanism.

Removable back covers.

Removable solid steel internal panel, 0.093 inch thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Internal panel mounting studs with hardware, grounding hardware, and sealing washers.

Grounding stud on enclosure body.

Thermoplastic pocket on inside of door for record Drawings and Product Data.

Nominal 4-inch- tall integral lifting base, not less than 0.123 inch thick, with predrilled holes for attachment to mounting surface.

Each top end of enclosure fitted with lifting tabs, not less than 0.172 inch thick.

Internal rack-mount shelves and angles as required by application.

* + - * 1. Freestanding, NEMA 250, Types 4 and 12:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Cooper B-line; brand of Eaton, Electrical Sector.

Hammond Mfg. Co. Inc.

Hoffman; brand of nVent Electrical PLC.

Saginaw Control and Engineering.

Approved equivalent.

Enclosure shall be NRTL listed according to UL 508A.

Seam and joints are continuously welded and ground smooth.

Externally formed body flange around perimeter of enclosure face.

Type 12 Enclosure Sizes:

Single-door enclosure sizes up to 90 inches tall by 36 inches wide .

Double-door enclosure sizes up to 90 inches tall by 72 inches wide .

Type 4 Enclosure Sizes:

Single-door enclosure sizes up to 72 inches tall by 36 inches wide .

Construct enclosure of steel, not less than 0.093 inch thick.

Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Exterior color shall be [**white**] [**ANSI 61 gray**] [**as selected by Architect**] [**manufacturer's standard**] <**Insert color**>.

Interior color shall be [**white**] [**ANSI 61 gray**] [**manufacturer's standard**].

Corner-formed door with continuous perimeter oil-resistant gasket supported using continuous piano hinge full length of door.

Doors fitted with three-point (top, middle, and bottom) latch system with latching rod rollers and single, heavy-duty oil-tight handle with integral locking mechanism.

Removable solid steel internal panel, 0.093 inch thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

Internal panel mounting studs with hardware, grounding hardware, and sealing washers.

Grounding stud on enclosure body.

Thermoplastic pocket on inside of door for record Drawings and Product Data.

Top of enclosure fitted with no fewer than two lifting eyes.

Internal rack-mount shelves and angles as required by application.

* + - * 1. Accessories:

Electric Heater:

Aluminum housing with brushed finish.

Thermostatic control with adjustable set point from zero to 100 deg F.

Capacity: 100, 200, 400, and 800 W as required by application.

Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

Ventilation Fans, Filtered Intake and Exhaust Grilles:

Number and size of fans, filters and grilles as required by application.

Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.

Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.

Thermostatic control with adjustable set point from 32 to 140 deg F.

Airflow Capacity at Zero Pressure:

4-Inch Fan: 100 cfm.

6-Inch Fan: 240 cfm.

10-Inch Fan: 560 cfm .

Maximum operating temperature of 158 deg F .

4-inch fan thermally protected and provided with permanently lubricated ball-bearings.

6- and 10-inch fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.

Dynamically balanced impellers molded from polycarbonate material.

Fan furnished with power cord and polarized plug for power connection.

Fan brackets, finger guards and mounting hardware provided with fans to complete installation.

Removable Intake and Exhaust Grilles: [**ABS plastic**] [**or**] [**stainless steel**] of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.

Filters for NEMA 250, Type 1 Enclosures: Washable [**foam**] [**or**] [**aluminum**], of a size to match intake grille.

Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.

Air Conditioner:

Electric-powered, self-contained air-conditioning unit specially designed for electrical enclosures to maintain temperature inside enclosure below ambient temperature outside enclosure.

Thermostatic control with adjustable set point from 60 to 120 deg F .

Enclosure side or top mounting with unit capacity as required by application.

Designed for closed-loop cooling with continuous operation in ambient environments up to 125 deg F.

HFC refrigerant.

Reusable and washable air filter.

High-performance, industrial-grade, and high-efficiency fans.

Furnished with power cord and polarized plug for power connection.

Condensate management system with base pan side drain.

Mounting hardware, gaskets, mounting template and instruction manual furnished with unit.

Outdoor units equipped with head pressure control for low ambient operation, compressor heater, coated condenser coil and thermostat.

Thermoelectric Humidifier:

ABS plastic enclosure.

Capacity of 8 oz. of water per 24 hours.

Built-in drain captures moisture and plastic hose directs moisture to outside enclosure through a drain.

Controlled to maintain enclosure relative humidity at an adjustable set point.

Unit power supply shall be internally wired to enclosure electrical power source.

Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:

0.25-inch- thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.

Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.

Window kit shall be factory or shop installed before shipment to Project.

Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:

0.125-inch- thick, polycarbonate window mounted in enclosure door material.

Window attached to door with screw fasteners and continuous strip of high-strength double-sided tape around window perimeter.

Window kit shall be factory or shop installed before shipment to Project.

Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:

0.25-inch- thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.

Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.

Window kit shall be factory or shop installed before shipment to Project.

Bar handle with keyed cylinder lock set.

* + - 1. RELAYS
				1. General-Purpose Relays:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Allen Bradley; by Rockwell Automation.

Eaton.

IDEC Corporation.

Omron Americas.

Siemens Industry, Inc., Building Technologies Division.

Square D; Schneider Electric USA.

Approved equivalent.

Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.

Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.

Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.

Construct the contacts of either silver cadmium oxide or gold.

Enclose the relay in a clear transparent polycarbonate dust-tight cover.

Relays shall have LED indication and a manual reset and push-to-test button.

Performance:

Mechanical Life: At least 10 million cycles.

Electrical Life: At least 100,000 cycles at rated load.

Pickup Time: 15 ms or less.

Dropout Time: 10 ms or less.

Pull-in Voltage: 85 percent of rated voltage.

Dropout Voltage: 50 percent of nominal rated voltage.

Power Consumption: 2 VA.

Ambient Operating Temperatures: Minus 40 to 115 deg F .

Equip relays with coil transient suppression to limit transients to non-damaging levels.

Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.

Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

* + - * 1. Multifunction Time-Delay Relays:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Allen Bradley; by Rockwell Automation.

Eaton.

IDEC Corporation.

Omron Americas.

Siemens Industry, Inc., Building Technologies Division.

Square D; Schneider Electric USA.

Approved equivalent.

Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.

Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.

Use a plug-in-style relay with either an 8- or 11-pin octal plug.

Construct the contacts of either silver cadmium oxide or gold.

Enclose the relay in a dust-tight cover.

Include knob and dial scale for setting delay time.

Performance:

Mechanical Life: At least 10 million cycles.

Electrical Life: At least 100,000 cycles at rated load.

Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.

Repeatability: Within 2 percent.

Recycle Time: 45 ms.

Minimum Pulse Width Control: 50 ms.

Power Consumption: 5 VA or less at 120-V ac.

Ambient Operating Temperatures: Minus 40 to 115 deg F.

Equip relays with coil transient suppression to limit transients to non-damaging levels.

Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.

Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

* + - * 1. Latching Relays:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Allen Bradley; by Rockwell Automation.

Eaton.

IDEC Corporation.

Omron Americas.

Siemens Industry, Inc., Building Technologies Division.

Square D; Schneider Electric USA.

Approved equivalent.

Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.

Relays shall be either DPDT or three-pole double throw, depending on the control application.

Use a plug-in-style relay with a multibladed plug.

Construct the contacts of either silver cadmium oxide or gold.

Enclose the relay in a clear transparent polycarbonate dust-tight cover.

Performance:

Mechanical Life: At least 10 million cycles.

Electrical Life: At least 100,000 cycles at rated load.

Pickup Time: 15 ms or less.

Dropout Time: 10 ms or less.

Pull-in Voltage: 85 percent of rated voltage.

Dropout Voltage: 50 percent of nominal rated voltage.

Power Consumption: 2 VA.

Ambient Operating Temperatures: Minus 40 to 115 deg F .

Equip relays with coil transient suppression to limit transients to non-damaging levels.

Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.

Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

* + - * 1. Current Sensing Relay:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Eaton.

Functional Devices Inc.

NK Technologies.

Square D; Schneider Electric USA.

Approved equivalent.

Monitors ac current.

Independent adjustable controls for pickup and dropout current.

Energized when supply voltage is present and current is above pickup setting.

De-energizes when monitored current is below dropout current.

Dropout current is adjustable from 50 to 95 percent of pickup current.

Include a current transformer, if required for application.

House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

* + - * 1. Combination On-Off Status Sensor and On-Off Relay:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Functional Devices Inc.

Veris Industries.

Johnson Controls

Approved equivalent.

Description:

On-off control and status indication in a single device.

LED status indication of activated relay and current trigger.

Closed-Open-Auto override switch located on the load side of the relay.

Performance:

Ambient Temperature: Minus 30 to 140 deg F.

Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

Status Indication:

Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.

Current Sensor Range: As required by application.

Current Set Point: [**Fixed**] [**Adjustable**] [**Fixed or adjustable as required by application**].

Current Sensor Output:

Retain any of first four subparagraphs below as applicable to Project.

Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.

Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.

Analog, zero- to 5- or 10-V dc.

Analog, 4 to 20 mA, loop powered.

Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.

Enclosure: NEMA 250, Type 1 enclosure.

* + - 1. ELECTRICAL POWER DEVICES
				1. Transformers:

Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.

Transformer shall be at least [**40**] [**100**] <**Insert value**> VA.

Transformer shall have both primary and secondary fuses.

* + - * 1. Power-Line Conditioner:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Eaton.

Emerson Electric Co., Automation Solutions.

SolaHD; Emerson Electric Co., Automation Solutions.

Approved equivalent.

General Power-Line Conditioner Requirements:

Design to ensure maximum reliability, serviceability and performance.

Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient, and noise-free sinusoidal power to loads served.

Standards: NRTL listed per UL 1012.

Performance:

Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.

Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.

At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.

At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.

At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.

With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.

Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.

Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.

K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.

Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.

Attenuate load-generated odd current harmonics 23 dB at the input.

Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.

Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.

Common-mode noise attenuation of 140 dB.

Transverse-mode noise attenuation of 120 dB.

With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.

Reliability of 200,000 hours' MTBF.

At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.

Approximately 92 percent efficient at full load.

Transformer Construction:

Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.

Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.

Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.

Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.

Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.

Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.

Include interface terminals for output power hot, neutral and ground conductors.

Label leads, wires and terminals to correspond with circuit wiring diagram.

Vacuum impregnate transformer with epoxy resin.

Cabinet Construction:

Design for panel or floor mounting.

NEMA 250, Type 1, general-purpose, indoor enclosure.

Manufacture the cabinet from heavy gauge steel complying with UL 50.

Include a textured baked-on paint finish.

* + - * 1. Transient Voltage Suppression and High-Frequency Noise Filter Unit:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Current Technology Inc.

Microchip

Polyphaser Transtector

Approved equivalent.

The maximum continuous operating voltage shall be at least 125 percent.

The operating frequency range shall be 47 to 63 Hz.

Protection modes according to NEMA LS-1.

The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:

Line to Neutral: 45,000 A.

Neutral to Ground: 45,000 A.

Line to Ground: 45,000 A.

Per Phase: 90,000 A.

Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:

Line to Neutral: 360 V.

Line to Ground: 360 V.

Neutral to Ground: 360 V.

Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.

Line to Neutral:

100 kHz: 42 dB.

1 MHz: 25 dB.

10 MHz: 21 dB.

100 MHz: 36 dB.

Line to Ground:

100 kHz: 16 dB.

1 MHz: 55 dB.

10 MHz: 81 dB.

100 MHz: 80 dB.

Unit shall have LED status indicator that extinguishes to indicate a failure.

Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.

Unit shall not generate any appreciable magnetic field.

Unit shall not generate an audible noise.

* + - * 1. DC Power Supply:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Acopian Technical Company.

Emerson Electric Co., Automation Solutions.

IDEC Corporation.

Omron Americas.

Approved equivalent.

Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.

Enclose circuitry in a housing.

Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.

Performance:

Output voltage nominally 25-V dc within 5 percent.

Output current up to 100 mA.

Input voltage nominally 120-V ac, 60 Hz.

Load regulation within 0.5 percent from zero- to 100-mA load.

Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.

Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

* + - 1. UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS FOR WORKSTATIONS
				1. 250 through 1000 VA:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Oneac-Powervar Solutions; Powervar, Inc.

APC by Schneider Electric

Eaton

Approved equivalent.

UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.

Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

Larger-capacity units shall be provided for systems with larger connected loads.

UPS shall provide [**five**] <**Insert number**> minutes of battery power.

Performance:

Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.

Load Power Factor Range (Crest Factor): 0.65 to 1.0.

Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.

On Battery Output Voltage: Sine wave.

Inverter overload capacity shall be minimum 150 percent for 30 seconds.

Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.

Transfer Time: 6 ms.

Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

UPS shall be automatic during fault or overload conditions.

Unit with integral line-interactive, power condition topology to eliminate all power contaminants.

Include front panel with power switch and visual indication of power, battery, fault and temperature.

Unit shall include an audible alarm of faults and front panel silence feature.

Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.

UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure)[**and connect the points to the DDC system**].

Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.

Include tower models installed in ventilated cabinets to the particular installation location.

* + - * 1. 1000 through 3000 VA:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Toshiba International Corporation.

Easton

Static Power Inc.

Approved equivalent.

UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.

Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.

UPS shall provide [**five**] [**10**] <**Insert number**> minutes of battery power.

Performance:

Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.

Power Factor: Minimum 0.97 at full load.

Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.

Inverter overload capacity shall be minimum 150 percent for 30 seconds.

Recharge time shall be a maximum of eight hours to 90 percent capacity.

UPS bypass shall be automatic during fault or overload conditions.

UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure)[**and connect the points to the DDC system**].

Batteries shall be sealed lead-acid type and be maintenance free.

Include tower models installed in ventilated cabinets or rack models installed on matching racks, as applicable to the particular installation location and space availability/configuration.

* + - 1. PNEUMATIC AND PRESSURE INSTRUMENT SIGNAL AIR PIPING AND TUBING
				1. Products in this article are intended for use with the following:

Retain first subparagraph below if Project includes pneumatic products.

Main air and signal air to pneumatically controlled instruments, actuators, and other control devices and accessories.

Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.

* + - * 1. Copper Tubing:

Seamless phosphor deoxidized copper, soft annealed, or drawn tempered, with chemical and physical properties according to ASTM B75.

Performance, dimensions, weight, and tolerance according to ASTM B280.

Diameter, as required by application, not less than nominal 0.25 inch.

Wall thickness, as required by the application, but not less than 0.030 inch.

Copper Tubing Connectors and Fittings (for Pneumatic/Pressure Instrument Signal Air) - Brass, Compression Type:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

BrassCraft Manufacturing Co.; a Masco company.

DK-LOK USA.

Mid-America Fittings, LLC; A Midland Industries Company.

Parker (Parker Hannifin).

Approved equivalent.

Copper Tubing Connectors and Fittings (for Pneumatic/Pressure Instrument Signal Air) - Brass, Solder-Joint Type:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems.

NIBCO INC.

Paul Mueller Company.

Approved equivalent.

Retain "Galvanized-Steel Piping" paragraph if required by Project. Galvanized-steel pipe is not typically used on most projects.

* + - * 1. Galvanized-Steel Piping (for Pneumatic/Pressure Instrument Signal Air):

Galvanized pipe shall be ASTM A53, Schedule 40.

Fittings, galvanized malleable iron, ASME B16.3, Class 150.

* + - * 1. Polyethylene Tubing (for Pneumatic/Pressure Instrument Signal Air):

Fire-resistant black virgin polyethylene according to ASTM D1248, Type 1, Class C and Grade 5.

Tubing shall comply with stress crack test according to ASTM D1693.

Diameter, as required by application, of not less than nominal 0.25 inch.

Polyethylene Tubing Connectors and Fittings (for Pneumatic/Pressure Instrument Signal Air) - Brass, Barbered Fittings:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

BrassCraft Manufacturing Co.; a Masco company.

DK-LOK USA.

Mid-America Fittings, LLC; A Midland Industries Company.

Parker (Parker Hannifin).

Approved equivalent.

Polyethylene Tubing Connectors and Fittings (for Pneumatic/Pressure Instrument Signal Air) - Brass, Compression Type:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

BrassCraft Manufacturing Co.; a Masco company.

DK-LOK USA.

Mid-America Fittings, LLC; A Midland Industries Company.

Parker (Parker Hannifin).

Approved equivalent.

* + - 1. PROCESS TUBING
				1. Products in this article are intended for signals to instruments connected to liquid and steam systems.

Retain "Copper Tubing" or "Stainless Steel Tubing" subparagraph below, or both, as applicable to Project.

* + - * 1. Copper Tubing:

Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B75.

Performance, dimensions, weight and tolerance according to ASTM B280.

Diameter, as required by application, of not less than nominal 0.25 inch .

Wall thickness, as required by application, but not less than 0.030 inch.

Copper Tubing Connectors and Fittings (for Process Tubing) - Brass, Compression Type:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

BrassCraft Manufacturing Co.; a Masco company.

DK-LOK USA.

Mid-America Fittings, LLC; A Midland Industries Company.

Parker (Parker Hannifin).

Approved equivalent.

Copper Tubing Connectors and Fittings (for Process Tubing) - Brass, Solder-Joint Type:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

BrassCraft Manufacturing Co.; a Masco company.

Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems.

NIBCO INC.

Approved equivalent.

* + - * 1. Stainless Steel Tubing (for Process Tubing):

Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.

Chemical and physical properties according to ASTM A269.

Diameter, as required by application, of not less than nominal 0.25 inch .

Wall thickness, as required by application, but not less than 0.035 inch.

Furnish stainless steel tubing in [**20-foot**] straight random lengths.

* + - * 1. Stainless Steel Tubing Connectors and Fittings (for Process Tubing):

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

DK-LOK USA.

Parker (Parker Hannifin).

Sizto Tech Corporation (STC).

Approved equivalent.

Connectors and fittings shall be stainless steel, with stainless steel collets, flareless type.

Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.

* + - 1. CONTROL WIRE AND CABLE
				1. Wire: Single conductor control wiring above 24 V.

Wire size shall be at least [**No. 18**] [**No. 16**] [**No. 14**] <**Insert value**> AWG.

Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.

Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.

Conductor colors shall be black (hot), white (neutral), and green (ground).

Furnish wire on spools.

* + - * 1. Single Twisted Shielded Instrumentation Cable above 24 V:

Wire size shall be a minimum [**No. 18**] [**No. 20**] [**No. 22**] <**Insert value**> AWG.

Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.

Conductor insulation shall have a Type THHN/THWN or Type TFN rating.

Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.

Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.

For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.

Furnish wire on spools.

* + - * 1. Single Twisted Shielded Instrumentation Cable 24 V and Less:

Wire size shall be a minimum [**No. 18**] [**No. 20**] [**No. 22**] <**Insert value**> AWG.

Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.

Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.

Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.

Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.

For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.

Furnish wire on spools.

* + - * 1. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

Cable shall be balanced twisted pair.

Comply with the following requirements and for balanced twisted pair cable described in [**Section 260523 "Control-Voltage Electrical Power Cables."**]

Cable shall be plenum rated.

Cable shall have a unique color that is different from other cables used on Project.

* + - 1. RACEWAYS
				1. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.
			2. ACCESSORIES
				1. Pneumatic Pressure Gauges:

Pressure gauges shall a 1.5-inch- diameter face for pressures up through 30 psig and 2.5-inch- diameter face for greater pressures.

Include separate gauges for branch pressure and main pressure lines.

White dial face with black printing.

Include 1-psig increment for scale ranges through 30 psig and 2-psig increment for larger ranges.

Accuracy: Within 1 percent of full-scale range.

* + - * 1. Pressure Electric Switches:

Diaphragm-operated snap acting switch.

Set point adjustable from 3 to 20 psig.

Differential adjustable from 2 to 6 psig.

Rated for resistance loads at 120-V ac.

Body and switch housing shall be metal.

* + - * 1. Damper Blade Limit Switches:

Sense positive open and/or closed position of the damper blades.

NEMA 250, Type 13, oil-tight construction.

Arrange for the mounting application.

Additional waterproof enclosure when required by its environment.

Arrange to prevent "over-center" operation.

* + - * 1. I/P and E/P Transducers:

Commercial Grade:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

ControlAir, Inc.

Dwyer Instruments, Inc.

KMC Controls, Inc.

MAMAC Systems, Inc.

Approved equivalent.

The transducer shall convert an AO signal to a stepped pneumatic signal. Unless otherwise required by the operating sequence, use a 3- to 15-psig pneumatic signal for pneumatic actuation.

Construct the entire assembly so that shock and vibration will neither harm the transducer nor affect its accuracy.

Transducer shall have auto/manual output switch, manual output control and an output pressure gauge.

Accuracy: Within 1.0 percent of the output span.

Linearity: Within 0.5 percent of the output span.

Output Capacity: Not less than 550 scim at 15 psig.

Transducer shall have separate zero and span calibration adjustments.

The transducer shall withstand up to 40 psig of supply pressure without damage.

For use on only modulating pneumatic outputs that are associated with terminal units, including fan-coil units, VAV units, unit heaters and <**Insert equipment**>.

Industrial Grade:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

ControlAir, Inc.

Fischer; Emerson Electric Co., Automation Solutions.

Marsh Bellofram.

Approved equivalent.

The transducer shall convert an AO signal to a proportional pneumatic signal. Unless otherwise required by the operating sequence, use a 3- to 15-psig pneumatic signal for pneumatic actuation. A stepped pneumatic signal is unacceptable.

Construct the entire assembly so that shock and vibration will neither harm the transducer nor affect its accuracy.

Suitable for operation in an ambient temperature range of minus 40 to 150 deg F.

Accuracy: Within 0.5 percent of the output span.

Linearity: Within 0.5 percent of the output span.

Output Capacity: Not less than 5 scfm.

Transducer shall have zero and span calibration adjustments.

The transducer shall withstand up to 50 psig of supply pressure without damage.

For use on all modulating pneumatic outputs, not requiring a commercial-grade transducer.

* + - * 1. E/P Switch:

Construct the body of cast aluminum or brass; three pipe body (common, normally open, and normally closed).

Internal construction of steel, copper or brass.

Air Connections: Barb.

Rating of 30 psig when installed in systems below 25 psig and of 150 psig when installed in systems above 25 psig.

Include coil transient suppression.

* + - * 1. Instrument Enclosures:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Hammond Mfg. Co. Inc.

Hoffman; brand of nVent Electrical PLC.

Saginaw Control and Engineering.

Approved equivalent.

Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.

NRTL listed and labeled to UL 50.

Sized to include at least 25 percent spare area on subpanel.

Instrument(s) mounted within enclosure on internal subpanel(s).

Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.

Enclosures housing pneumatic instruments shall include main pressure gauge and a branch pressure gauge for each pneumatic device, installed inside.

Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.

Enclosures larger than [**12 inches**] <**Insert dimension**> shall have a hinged full-size face cover.

Retain subparagraph below for applications requiring additional security.

Equip enclosure with lock and common key.

* + - * 1. Manual Valves:

Needle Type:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Dwyer

Parker Hannifin Corporation.

Swagelok

Approved equivalent.

PTFE packing.

Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless steel tubing.

Aluminum T-bar handle.

Include tubing connections.

Ball Type:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Apollo Valves; a part of Aalberts Integrated Piping Systems.

Milwaukee Valve Company.

NIBCO INC.

Approved equivalent.

Body: Bronze ASTM B62 or ASTM B61.

Ball: Type 316 stainless steel.

Stem: Type 316 stainless steel.

Seats: Reinforced PTFE.

Packing Ring: Reinforced PTFE.

Lever: Stainless steel with a vinyl grip.

600 WOG.

Threaded end connections.

* + - * 1. Wall-Mounted Portable Workstation Cabinet:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

AtlasIED.

Ergotron

Lowell Manufacturing Co.

Approved equiv.

Surface-mounted wall cabinet for tilt-out operation of laptop computers and large-format mobile devices.

Cabinet shall have a load limit of 50 lb.

Cabinet shall include the following:

Oil-filled dampers for controlled lowering of equipment to operational position.

3RU EIA mounting rails.

Removable laptop shelf.

Separate top compartment with mounting area, hinged rail and security lock.

Front ventilation slots.

Knockouts for conduit connections on top and bottom of cabinet.

Cabinet shall be constructed of steel and painted with a powder-coat epoxy.

Inside center of backbox shall have provision to mount a field-furnished and -installed, single gang electrical outlet box.

* + - 1. IDENTIFICATION
				1. Instrument Air Pipe and Tubing:

Engraved tag shall bear the following information:

Service (Example): "Instrument Air."

Pressure Range (Example): 0 to 30 psig.

Letter size shall be a minimum of [**0.25 inch** ] <**Insert dimension**> high.

Tag shall consist of white lettering on blue background.

Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded blue with contrasting white center exposed by engraving through outer layer.

Include tag with a brass grommet, chain and S-hook.

* + - * 1. Control Equipment, Instruments, and Control Devices:

[**Self-adhesive label**] [**Laminated acrylic or melamine plastic sign**] bearing unique identification.

Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

Letter size shall be as follows:

First 12 subparagraphs below are examples only.

Operator Workstations: Minimum of [**0.5 inch**] <**Insert dimension**> high.

Servers: Minimum of [**0.5 inch**] <**Insert dimension**> high.

Printers: Minimum of [**0.5 inch** ] <**Insert dimension**> high.

DDC Controllers: Minimum of [**0.5 inch** ] <**Insert dimension**> high.

Gateways: Minimum of [**0.5 inch**] <**Insert dimension**> high.

Repeaters: Minimum of [**0.5 inch** ] <**Insert dimension**> high.

Enclosures: Minimum of [**0.5 inch** ] <**Insert dimension**> high.

Electrical Power Devices: Minimum of [**0.25 inch** ] <**Insert dimension**> high.

UPS units: Minimum of [**0.5 inch**] <**Insert dimension**> high.

Accessories: Minimum of [**0.25 inch** ] <**Insert dimension**> high.

Instruments: Minimum of [**0.25 inch**] <**Insert dimension**> high.

Control Damper and Valve Actuators: Minimum of [**0.25 inch** ] <**Insert dimension**> high.

Legend shall consist of white lettering on black background.

Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer and shall be fastened with drive pins.

Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

* + - * 1. Valve Tags:

Brass tags and brass chains attached to valve.

Tags shall be at least [**1.5 inches**] <**Insert dimension**> in diameter.

Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.

Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

* + - * 1. Raceway and Boxes:

Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.

Retain first subparagraph below if Project includes pneumatic products.

For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."

For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

* + - * 1. Equipment Warning Labels:

Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.

Lettering size shall be at least 14-point type with white lettering on red background.

Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."

Lettering shall be enclosed in a white line border. Edge of label shall extend at least [**0.25 inch**] <**Insert dimension**>beyond white border.

* + - 1. SOURCE QUALITY CONTROL

This article covers tests and inspections performed at the source to verify that products and materials comply with requirements specified.

Retain "Testing Agency" paragraph below if retaining "DDC System Reliability" paragraph in "Performance Requirements" Article and to require independent evaluation. Independent evaluation may be required whether "DDC System Reliability" is required. Independent certification may be acceptable to authorities having jurisdiction without further monitoring of plant's quality-control and testing program by Director’s Representative .

* + - * 1. Testing Agency: [Director’s Representative **will engage**] [**Engage**] a qualified testing agency to evaluate the following according to industry standards for each product, and to verify DDC system reliability specified in performance requirements:

DDC controllers.

Gateways.

Routers.

Operator workstations.

<**Insert product**>.

* + - * 1. Product(s) [**and**] [**material(s)**] will be considered defective if [**it does**] [**they do**] not pass tests and inspections.
				2. Prepare test and inspection reports.
1. EXECUTION
	* + 1. EXAMINATION
				1. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

Verify compatibility with and suitability of substrates.

* + - * 1. Examine roughing-in for products to verify actual locations of connections before installation.

Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

* + - * 1. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
				2. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
				3. Proceed with installation only after unsatisfactory conditions have been corrected.
			1. DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

Retain "Communication Interface to Equipment with Integral Controls" paragraph below to require DDC system to monitor or control equipment through a communication link.

* + - * 1. Communication Interface to Equipment with Integral Controls:

DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.

Retain "Equipment to Be Connected" subparagraph below to require equipment to be connected to DDC system through a communication interface; delete if equipment to be connected is indicated on Drawings. Coordinate with Drawings.

Equipment to Be Connected:

Retain applicable subparagraphs below. Coordinate specific interface requirements in Sections specifying equipment.

Domestic water booster pumps specified in Section 221123.13 "Domestic-Water Packaged Booster Pumps."

Air-terminal units specified in Section 233600 "Air Terminal Units."

Kitchen hoods specified in Section 233813 "Commercial-Kitchen Hoods."

Boilers specified in Section 235213 "Electric Boilers."

Boilers specified in Section 235216 "Condensing Boilers."

Boilers specified in Section 235223 "Cast-Iron Boilers."

Boilers specified in Section 235233 "Water-Tube Boilers."

Boilers specified in Section 235239 "Fire-Tube Boilers."

Feedwater equipment specified in Section 235313 "Boiler Feedwater Pumps."

Deaerators specified in Section 235316 "Deaerators."

Chillers specified in Section 236413.13 "Direct-Fired Absorption Water Chillers."

Chillers specified in Section 236413.16 "Indirect-Fired Absorption Water Chillers."

Chillers specified in Section 236416 "Centrifugal Water Chillers."

Chillers specified in Section 236423.13 "Air-Cooled, Scroll Water Chillers."

Chillers specified in Section 236423.16 "Water-Cooled, Scroll Water Chillers."

Chillers specified in Section 236426.13 "Air-Cooled, Rotary-Screw Water Chillers."

Chillers specified in Section 236426.16 "Water-Cooled, Rotary-Screw Water Chillers."

Cooling towers specified in Section 236513.13 "Open-Circuit, Forced-Draft Cooling Towers."

Cooling towers specified in Section 236513.16 "Closed-Circuit, Forced-Draft Cooling Towers."

Cooling towers specified in Section 236514.13 "Open-Circuit, Induced-Draft, Counterflow Cooling Towers."

Cooling towers specified in Section 236514.14 "Open-Circuit, Induced-Draft, Crossflow Cooling Towers."

Cooling towers specified in Section 236514.16 "Closed-Circuit, Induced-Draft, Counterflow Cooling Towers."

Cooling towers specified in Section 236514.17 "Closed-Circuit, Induced-Draft, Combined-Flow Cooling Towers."

Roof-top units specified in Section 237413 "Packaged, Outdoor, Central-Station Air-Handling Units."

Dedicated outdoor-air units specified in Section 237433 "Dedicated Outdoor-Air Units."

Packaged terminal air-conditioners specified in Section 238113.11 "Packaged Terminal Air-Conditioners, Through-Wall Units."

Packaged terminal air-conditioners specified in Section 238113.12 "Packaged Terminal Air-Conditioners, Freestanding Units."

Packaged terminal air-conditioners specified in Section 238113.13 "Packaged Terminal Air-Conditioners, Outdoor, Wall-Mounted Units."

Computer-room air-conditioning units specified in Section 238123.11 "Small-Capacity (6 Tons (21 kW) and Smaller), Computer-Room Air-Conditioners, Floor-Mounted Units."

Computer-room air-conditioning units specified in Section 238123.12 "Large-Capacity (7 Tons (25 kW) and Larger), Computer-Room Air-Conditioners, Floor-Mounted Units."

Computer-room air-conditioning units specified in Section 238123.13 "Computer-Room Air Conditioners, Ceiling-Mounted Units."

Computer-room air-conditioning units specified in Section 238123.14 "Computer-Room Air Conditioners, Console Units."

Computer-room, rack-mounted cooling equipment specified in Section 238123.18 "Computer-Room, Rack-Cooling Equipment."

Fan-coil units specified in Section 238219 "Fan Coil Units."

Unit ventilators specified in Section 238223 "Unit Ventilators."

Wetted-element humidifiers specified in Section 238413.16 "Wetted-Element Humidifiers."

Atomizing humidifiers specified in Section 238413.19 "Atomizing Humidifiers."

Direct-steam-injection humidifiers specified in Section 238413.23 "Direct-Steam-Injection Humidifiers."

Self-contained steam humidifiers specified in Section 238413.29 "Self-Contained Steam Humidifiers."

Heat exchanger humidifiers specified in Section 238413.36 "Heat Exchanger Humidifiers."

Motor-control centers specified in Section 262419 "Motor-Control Centers."

Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."

Diesel emergency engine generators specified in Section 263213.13 "Diesel-Engine-Driven Generator Sets."

Gaseous emergency engine generators specified in Section 263213.16 "Gas-Engine-Driven Generator Sets."

UPS specified in Section 263353 "Static Uninterruptible Power Supply."

Refrigerant monitoring.

<**Insert equipment and Section number and title**>.

Retain "Communication Interface to Other Building Systems" paragraph below to require DDC system to interface with systems through a communication link.

* + - * 1. Communication Interface to Other Building Systems:

DDC system shall have a communication interface with systems having a communication interface.

Retain "Systems to Be Connected" subparagraph below to indicate systems to be connected; delete if systems to be connected are indicated on Drawings. Coordinate with Drawings.

Systems to Be Connected:

Coordinate specific interface requirements in the Sections retained in remaining subparagraphs below.

Elevators specified in Section 142000 " Elevators."

Elevators specified in Section 142111 "Elevator Hoisting Equipment – Gearless Electric."

Elevators specified in Section 142112 "Elevator Hoisting Equipment – Geared Electric."

Elevators specified in Section 142411 “Elevator Hoisting Equipment - Hydraulic."

Automated water treatment systems specified in Section 232500 "HVAC Water Treatment."

Automated water treatment systems specified in Section 232516 "Water Treatment for Open-Loop Hydronic Systems."

Automated water treatment systems specified in Section 232519 "Water Treatment for Steam System Feedwater."

Power monitoring specified in Section 260913 "Electrical Power Monitoring and Control."

Lighting controls specified in Section 260943.16 "Addressable-Luminaire Lighting Controls."

Lighting controls specified in Section 260943.23 "Relay-Based Lighting Controls."

Select from subparagraphs below based upon project requirements

Fire-alarm system specified in Section 283101 "Protected Premises Fire Alarm System not for DCS."

Fire-alarm system specified in Section 283101 "Protected Premises Fire Alarm System for DCS."

Fire-alarm system specified in Section 283102 "Protected Premises Fire Alarm/Emergency Communication System not for NYC."

Fire-alarm system specified in Section 283102 "Protected Premises Fire Alarm/Emergency Communication System for NYC."

Fire-alarm system specified in Section 283103 “Integrated Protected Premises/Proprietary Fire Alarm System."

Fire-alarm system specified in Section 283105 "Modifications to Fire Alarm System."

<**Insert system and Section number and title**>.

* + - 1. DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

Retain "Interface with Existing Systems" paragraph below to require DDC system to be connected to existing systems. Include special instructions in Document 002213 "Supplementary Instructions to Bidders" to instruct bidders to visit Project to become familiar with systems to be connected and available interface requirements and to report findings with bids. An allowance may be required. Coordinate with OGS Spec Section 012100.

* + - * 1. Interface with Existing Systems:

DDC systems shall interface existing systems to achieve integration.

Retain "Monitoring and Control of DDC System by Existing Control System" subparagraph below when DDC system being installed is to integrate with existing system.

Monitoring and Control of DDC System by Existing Control System:

DDC system performance requirements shall be satisfied when monitoring and controlling DDC system by existing control system.

Operator of existing system shall be able to upload, download, monitor, trend, control and program every input and output point in DDC system from existing control system using existing control system software and operator workstations.

Remote monitoring and control from existing control system shall not require operators of existing control system to learn new software.

Interface of DDC system into existing control system shall be transparent to operators of existing control system and allow operators to [**program, monitor, and control**] [**monitor and control**] DDC system from any operator workstation connected to existing control system.

<**Insert requirements**>.

Retain "Integration of Existing Control System into DDC System" subparagraph below to require existing system to be integrated into DDC system.

Integration of Existing Control System into DDC System:

Existing control system performance requirements shall be satisfied when monitoring and controlling existing control system through DDC system.

Operator shall be able to upload, download, monitor, alarm, report, trend, control and program every input and output point in existing system from DDC system using operator workstations and software provided. The combined systems shall share one database.

Interface of existing control system I/O points into DDC system shall be transparent to operators. All operational capabilities shall be identical regardless of whether I/O already exists or I/O is being installed.

<**Insert requirements**>.

Retain "Integration with Existing Enterprise System" paragraph below where required to connect to existing enterprise system.

* + - * 1. Integration with Existing Enterprise System:

DDC system shall interface with an existing enterprise system to adhere to Director’s Representative standards already in-place and to achieve integration.

Retain one of first two subparagraphs below where required to connect to existing enterprise system that requires services of Director’s Representative's existing control system integrator.

Director’s Representative's control system integrator will provide the following services:

Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.

Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.

Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.

Engage Director’s Representative's control system integrator to provide the following services:

Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.

Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.

Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.

Control System Integrator Contact Information:

Company: <**Insert name**>.

Company Street Address: <**Insert address**>.

Company Contact: <**Insert name**>.

Phone Number: <**Insert phone number**>.

E-mail Address: <**Insert e-mail address**>.

Attend meetings with control system integrator to integrate DDC system.

* + - 1. CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

Coordinate requirements in this article with requirements in Sections specifying the identified equipment and systems. This article includes examples of requirements but is not all-inclusive. Requirements must be revised to comply with specific Project requirements.

* + - * 1. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

Both paragraphs below are examples only. Retain and revise as applicable.

* + - * 1. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

DDC control dampers, which are specified in Section 230923.12 "Control Dampers."

Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."

Pressure sensors, which are specified in Section 230923.23 "Pressure Instruments."

<**Insert additional control devices**>.

* + - * 1. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

DDC control valves, which are specified in Section 230923.11 "Control Valves."

Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."

Pipe-mounted sensors, switches, and transmitters. Flow meters are specified in Section 230923.14 "Flow Instruments."

Tank-mounted sensors, switches, and transmitters. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."

Liquid[**and steam**] temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."

Pipe- and tank-mounted thermowells. Liquid[**and steam**] thermowells are specified in Section 230923.27 "Temperature Instruments."

<**Insert additional control devices**>.

* + - 1. CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

Paragraphs in this article are examples only. Retain and revise as applicable.

* + - * 1. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer[**and supervise installation for compliance with requirements**].

[**Programmable application**] [**or**] [**application-specific**] controller.

Unit-mounted DDC control dampers and actuators, which are specified in Section 230923.12 "Control Dampers."

Unit-mounted airflow sensors, switches, and transmitters, which are specified in Section 230923.14 "Flow Instruments."

Unit-mounted gas sensors, and transmitters, which are specified in Section 230923.16 "Gas Instruments."

Unit-mounted leak-detection switches, which are specified in Section 230923.18 "Leak Detection Instruments."

Unit-mounted pressure sensors, switches, and transmitters, which are specified in Section 230923.23 "Pressure Instruments."

Unit-mounted speed sensors, switches, and transmitters, which are specified in Section 230923.24 "Speed Instruments."

Unit-mounted temperature sensors, switches, and transmitters. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."

Relays.

<**Insert additional control devices**>.

* + - * 1. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.

[**Programmable application**] [**or**] [**application-specific**] controller.

Electric damper actuator. Damper actuators are specified in Section 230923.12 "Control Dampers."

Unit-mounted flow and pressure sensors, transmitters, and transducers. Flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."

Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."

Relays.

<**Insert additional control devices**>.

* + - * 1. Deliver the following to fan-coil unit manufacturer for factory installation. Include installation instructions to fan-coil unit manufacturer.

[**Programmable application**] [**or**] [**application-specific**] controller.

Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."

Flow and pressure switches. Air and liquid flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."

Leak-detection switches, which are specified in Section 230923.18 "Leak Detection Instruments."

Relays.

<**Insert additional control devices**>.

* + - 1. GENERAL INSTALLATION REQUIREMENTS
				1. Install products to satisfy more stringent of all requirements indicated.
				2. Install products level, plumb, parallel, and perpendicular with building construction.
				3. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a <**Insert value**> force.
				4. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
				5. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
				6. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."
				7. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."
				8. Welding Requirements:

Restrict welding and burning to supports and bracing.

No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.

Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.

If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

* + - * 1. Fastening Hardware:

Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.

Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

* + - * 1. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.
				2. Corrosive Environments:

Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:

Laboratory exhaust-air streams.

Process exhaust-air streams.

When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

* + - 1. WORKSTATION INSTALLATION
				1. Desktop Workstations Installation:

If multiple desktop workstations with different requirements are required, revise subparagraphs below to match requirements in "Desktop Workstations" Article.

Install workstation(s) at location(s) directed by Director’s Representative.

Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.

Install software on workstation(s) and verify software functions properly.

Develop Project-specific graphics, trends, reports, logs and historical database.

Power [**each**]workstation through a [**dedicated**]UPS unit. Locate UPS adjacent to workstation.

* + - * 1. Portable Workstations Installation:

If multiple portable operator workstations with different requirements are required, revise subparagraphs below to match requirements in "Portable Workstations" Article.

Turn over portable workstations to Director’s Representative at Substantial Completion.

Install software on workstation(s) and verify software functions properly.

* + - * 1. Color Graphics Application:

Use system schematics indicated as starting point to create graphics.

Develop Project-specific library of symbols for representing system equipment and products.

Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.

Submit sketch of graphic layout with description of all text for each graphic for Director’s Representative's[**and Architect's**] review before creating graphic using graphics software.

Seek Director’s Representative input in graphics development once using graphics software.

Final editing shall be done on-site with Director’s Representative's[**and Architect's**] review and feedback.

Refine graphics as necessary for Director’s Representative acceptance.

On receiving Director’s Representative acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

Retain "Wall-Mounted Portable Operator's Workstation Cabinet Installation" paragraph below for applications requiring a cabinet to house and support portable operator workstations.

* + - * 1. Wall-Mounted Portable Operator's Workstation Cabinet Installation:

Retain one of first two subparagraphs below.

Install wall-mounted portable operator's workstation cabinet(s) at location(s) indicated on Drawings.

Install wall-mounted portable operator's workstation cabinet(s) at following location(s) and at locations directed by Director’s Representative:

Each mechanical room.

Chiller room.

Boiler room.

<**Insert location**>.

Connect each cabinet to [**120-V, single-phase, 60Hz**] <**Insert power requirements**> field power source, and install single gang electrical box with [**NEMA WD 6, Type 20R duplex**] <**Insert receptacle type**> receptacle and metal cover plate in cabinet. Comply with requirements in Section 262726 "Wiring Devices."

Connect each cabinet to Ethernet network and install an Ethernet network port for connection to portable operator workstation Ethernet cable.

Retain "POT Installation" Article below if operator access is provided at multiple locations and a portable operator workstation is not provided. Portable operator workstation is preferred because it provides operator with more capabilities.

* + - 1. POT INSTALLATION

Retain first paragraph below unless indicated on Drawings.

* + - * 1. Install [**one**] [**two**] <**Insert quantity**> portable operator terminal(s).
				2. Turn over POTs to Director’s Representative at Substantial Completion.
				3. Install software on each POT and verify that software functions properly.
			1. SERVER INSTALLATION

Retain one of first two paragraphs below if servers are not indicated on Drawings.

* + - * 1. Install [**one**] [**two**] <**Insert quantity**> server(s) at location(s) directed by Director’s Representative.
				2. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed location in Shop Drawings.
				3. Install software indicated on server(s) and verify that software functions properly.
				4. Develop Project-specific graphics, trends, reports, logs, and historical database.
				5. Power servers through [**dedicated**]UPS unit. Locate UPS adjacent to server.
			1. PRINTER INSTALLATION
				1. Provide the following printer(s) at location(s) directed by Director’s Representative:

Retain list of printer types in four subparagraphs below if printers are not indicated on Drawings.

Black and White Laser: Quantity, [**one**] [**one per desktop workstation**] <**Insert quantity**>.

Color Laser: Quantity, [**one**] [**one per desktop workstation**] <**Insert quantity**>.

Color Inkjet: Quantity, [**one**] [**one per desktop workstation**] <**Insert quantity**>.

Dot Matrix: Quantity, [**one**] [**one per desktop workstation**] <**Insert quantity**>.

* + - * 1. Install printer software on workstations and verify that software functions properly.
			1. GATEWAY INSTALLATION

Design of each gateway should include an interoperability schedule showing each point or event with interface requirements defined for each.

For BACnet DDC systems, include an interoperability schedule showing each point or event on non-BACnet side that BACnet "client" will read, and each parameter that BACnet network will write to for BACnet services, or BIBBs defined in ASHRAE 135, Annex K.

* + - * 1. Install gateways if required for DDC system communication interface requirements indicated.

Install gateway(s) required to suit indicated requirements.

<**Insert requirements**>.

* + - * 1. Test gateway to verify that communication interface functions properly.
			1. ROUTER INSTALLATION
				1. Install routers if required for DDC system communication interface requirements indicated.

Install router(s) required to suit indicated requirements.

<**Insert requirements**>.

* + - * 1. Test router to verify that communication interface functions properly.
			1. CONTROLLER INSTALLATION
				1. Install controllers in enclosures to comply with indicated requirements.
				2. Connect controllers to field power supply[**and to UPS units where indicated**].
				3. Install controller with latest version of applicable software and configure to execute requirements indicated.
				4. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
				5. Installation of Network Controllers:

Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.

Install controllers in a protected location that is easily accessible by operators.

Top of controller shall be within [**72 inches** ] [**84 inches**] <**Insert dimension**> of finished floor.

* + - * 1. Installation of Programmable Application Controllers:

Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.

Install controllers in a protected location that is easily accessible by operators.

Top of controller shall be within [**72 inches** ] [**84 inches**] <**Insert dimension**> of finished floor.

* + - * 1. Application-Specific Controllers:

Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.

For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

* + - 1. INSTALLATION OF WIRELESS ROUTERS FOR OPERATOR INTERFACE
				1. Install wireless routers to achieve optimum performance and best possible coverage.
				2. Mount wireless routers in a protected location that is within 60 inches of floor and easily accessible by operators.
				3. Connect wireless routers to field power supply and to UPS units if network controllers are powered through UPS units.
				4. Install wireless router with latest version of applicable software and configure wireless router with WPA2 security and password protection. Create access password with not less than 12 characters consisting of letters and numbers and at least one special character. Document password in operations and maintenance manuals for reference by operators.
				5. Test and adjust wireless routers for proper operation with portable workstation and other wireless devices intended for use by operators.
			2. ENCLOSURES INSTALLATION
				1. Install the following items in enclosures, to comply with indicated requirements:

Retain applicable devices in subparagraphs below.

Gateways.

Routers.

Controllers.

Electrical power devices.

UPS units.

Relays.

Accessories.

Instruments.

Actuators

<**Insert devices**>.

* + - * 1. Attach wall-mounted enclosures to wall using the following types of steel struts:

For NEMA 250, [**Type 1**] <**Insert type**> Enclosures: Use [**painted steel**] [**galvanized-steel**] [**corrosion-resistant-coated steel**] strut and hardware.

For NEMA 250, [**Type 4**] [**Type 4X**] <**Insert type**> Enclosures and Enclosures Located Outdoors: Use stainless steel strut and hardware.

Install plastic caps on exposed cut edges of strut.

* + - * 1. Align [**top**] [**or**] [**bottom**] of adjacent enclosures[**of like size**].
				2. Install floor-mounted enclosures located [**in mechanical equipment rooms**]on concrete housekeeping pads. Attach enclosure legs using [**galvanized-**] [**or**] [**stainless**]steel anchors.

Retain paragraph below to require wireways to connect between adjacent enclosures. Wireways provide a neat and easily accessible alternative to conduit, but they may come at a higher cost for specific installation.

* + - * 1. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.
			1. ELECTRIC POWER CONNECTIONS
				1. Connect electrical power to DDC system products requiring electrical power connections.
				2. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.
				3. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.
				4. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.
				5. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.
			2. IDENTIFICATION
				1. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

Products in first paragraph below are described in Section 260553 "Identification for Electrical Systems."

* + - * 1. Install [**self-adhesive labels**] [**laminated acrylic or melamine plastic signs**] with unique identification on face for each of the following:

Operator workstation.

Server.

Printer.

Gateway.

Router.

Protocol analyzer.

DDC controller.

Enclosure.

Electrical power device.

UPS unit.

Accessory.

* + - * 1. Install unique instrument identification on face of each instrument connected to a DDC controller.
				2. Install unique identification on face of each control [**damper**] [**and**] [**valve**] actuator connected to a DDC controller.

Retain first two paragraphs below to enhance locating products installed above ceilings.

* + - * 1. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.
				2. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.
				3. Warning Labels and Signs:

Shall be permanently attached to equipment that can be automatically started by DDC control system.

Shall be located in highly visible location near power service entry points.

* + - 1. NETWORK INSTALLATION

Retain first paragraph below to require optical fiber cable when connecting networks across large distance.

* + - * 1. Install optical fiber cable when connecting between the following network devices and when located in different buildings on campus, or when distance between devices exceeds <**Insert distance**>:

Operator workstations.

Operator workstations and network controllers.

Network controllers.

<**Insert network device**>.

* + - * 1. Install balanced twisted pair [**or optical fiber**]cable when connecting between the following network devices[**located in same building**]:

Operator workstations.

Operator workstations and network controllers.

Network controllers.

<**Insert network device**>.

* + - * 1. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:

Gateways.

Gateways and network controllers or programmable application controllers.

Routers.

Routers and network controllers or programmable application controllers.

Network controllers and programmable application controllers.

Programmable application controllers.

Programmable application controllers and application-specific controllers.

Application-specific controllers.

<**Insert network device**>.

* + - * 1. Install cable in continuous raceway.

Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

* + - 1. NETWORK NAMING AND NUMBERING
				1. Coordinate with Director’s Representative and provide unique naming and addressing for networks and devices.

Retain "ASHRAE 135 Networks" paragraph below for unique requirements to ASHRAE 135 networks.

* + - * 1. ASHRAE 135 Networks:

MAC Address:

Every network device shall have an assigned and documented MAC address unique to its network.

Ethernet Networks: Document MAC address assigned at its creation.

ARCNET or MS/TP networks: Assign from 00 to 64.

Network Numbering:

Assign unique numbers to each new network.

Provide ability for changing network number through device switches or operator interface.

DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

Device Object Identifier Property Number:

Assign unique device object identifier property numbers or device instances for each device network.

Provide for future modification of device instance number by device switches or operator interface.

LAN shall support up to 4,194,302 unique devices.

Device Object Name Property Text:

Device object name property field shall support 32 minimum printable characters.

Assign unique device "Object Name" property names with plain-English descriptive names for each device.

Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."

Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

Object Name Property Text for Other Than Device Objects:

Object name property field shall support 32 minimum printable characters.

Assign object name properties with plain-English names descriptive of application.

Example 1: "Zone 1 Temperature."

Example 2 "Fan Start and Stop."

Object Identifier Property Number for Other Than Device Objects:

Assign object identifier property numbers according to [**Drawings**] [**or**] [**tables**] indicated.

If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Director’s Representative in advance, be documented and be unique for like object types within device.

* + - 1. INSTALLATION OF PNEUMATIC AND AIR SIGNAL PIPING AND TUBING
				1. Above-Grade Pneumatic and Air Signal Piping and Tubing Installation:

Material Application:

Retain one of first two subparagraphs below. Retain first subparagraph for projects not requiring galvanized-steel pipe.

Install copper tubing, except as follows:

Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing.

Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when [**concealed behind accessible ceilings**] [**and**] [**concealed in walls and connecting wall-mounted instruments with recessed connections**].

Install copper tubing for sizes up through [**NPS 1**] <**Insert size**> and install galvanized-steel pipe for larger sizes, except as follows:

Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing where exposed to view.

Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when [**concealed behind accessible ceilings**] [**and**] [**concealed in walls and connecting wall-mounted instruments with recessed connections**].

Install copper tubing[**, unless other accessible materials are indicated,**] for pneumatic main and control signals to instruments including, but not limited to, the following:

Pneumatic actuators.

I/P transducers.

Sensors.

Switches.

Transmitters.

<**Insert instrument**>.

Install copper tubing[**, unless other accessible materials are indicated,**] for air signals to instruments including, but not limited to, the following:

Sensors.

Switches.

Transmitters.

<**Insert instrument**>.

Install drawn-temper copper tubing, except within 36 inches of device terminations tubing shall be annealed-tempered copper tubing.

Install compression fittings to connect copper tubing to instruments, control devices, and accessories.

Install [**barbed**] [**or**] [**compression**] fittings to connect polyethylene tubing to instruments, control devices, and accessories.

Routing:

Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, offices, and conference rooms, unless expressly approved in writing by Architect. Tubing may be exposed in areas without ceilings.

Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in wall, above ceiling or behind architectural enclosures or covers.

Install piping and tubing plumb and parallel to and at right angles with building construction.

Install multiple runs of tubing or piping in equally spaced parallel lines.

Piping and tubing shall not interfere with access to valves, equipment, duct and equipment access doors, or obstruct personnel access and passageways of any kind.

Coordinate with other trades before installation to prevent proposed piping and tubing from interfering with pipe, duct, terminal equipment, light fixtures, conduit and cable tray space. If changes to Shop Drawings are necessary due to field coordination, document changes on record Drawings.

Install vibration loops in copper tubing when connecting to instrument and actuators that vibrate.

Support:

According to MSS SP-69, Table 3, except support spacing shall not exceed 60 inches.

Support copper tubing with copper hangers, clips, and tube trays.

Do not use tape for support or dielectric isolation.

Install supports at each change in direction and at each branch take off.

Attached supports to building structure independent of work of other trades. Support from ducts, pipes, cable trays, and conduits is prohibited.

Attached support from building structure with threaded rods, structural shapes, or channel strut.

Install and brace supports to carry static load plus a safety margin, which will allow tubing to be serviced.

Brace supports to prevent lateral movement.

Paint steel support members that are not galvanized or zinc coated.

Support polyethylene tubing same as copper tubing.

Do not attach piping and tubing to equipment that may be removed frequently for maintenance or that may impart vibration and expansion from temperature change.

Retain first subparagraph below for additional protection.

Protect exposed tubing in mechanical equipment rooms from mechanical damage within [**76 inches**] [**84 inches**] [**96 inches**] <**Insert dimension**> above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.

Joining and Makeup:

Where joining and mating dissimilar metals where galvanic action could occur, install dielectric isolation.

Install a dirt leg with an isolation valve and threaded plug at each main air, connection to a panel, pneumatic pilot positioner and PRV station.

Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on other end.

Make tubing bends with a tube-bending tool. Hard bends, wrinkled or flattened bends are unacceptable.

Install tube fittings according to manufacturer's written instructions.

Do not make tubing connections to a fitting before completing makeup of the connection.

Align tubing with the fitting. Avoid springing tube into position, as this may result in excessive stress on both tubing and fitting with possible resulting leaks.

Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.

Check tubing for correct diameter and wall thickness.

Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.

Thread pipe on a threading machine. Ream inner edges of pipe ends, file and grind to remove burrs.

Wrap pipe threads of fittings on pneumatic lines with a single wrap of PTFE tape.

Protect piping and tubing from entrance of foreign matter.

Conduit in which nonmetallic tubing is installed shall not exceed 50 percent fill. Support conduit according to NFPA 70 unless otherwise indicated.

* + - * 1. Below-Grade Pneumatic and Air Signal Piping and Tubing Installation:

Install tubing below grade in a continuous 4-inch, Schedule 80, PVC conduit.

Install at a depth of at least 24 inches below finished grade.

Install tubing in raceways dedicated to tubing. Do not combine electrical conductors and tubing in raceways.

* + - * 1. Identify piping and tubing as follows:

Every 50 feet of straight run.

At least once for each branch within 36 inches of main tee.

At each change in direction.

Within 36 inches of each ceiling, floor, roof and wall penetration.

Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.

At each valve.

Mark each instrument tube connection with a number-coded identification. Each unique tube shall have same unique number at instrument connection and termination at opposite end of tube.

* + - * 1. Pneumatic and Air Signal Piping Isolation Valves Installation:

Install valves full size of piping and tubing.

Install at the following locations:

At each branch.

Before and after each PRV.

Before and after each air dryer.

At each control device.

Valves shall be located to be readily accessible from floor.

* + - 1. INSTALLATION OF PROCESS TUBING
				1. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:

Meters.

Sensors.

Switches.

Transmitters.

* + - * 1. Support tubing according to MSS SP-69, Table 3, but at intervals no less than 60 inches.
				2. Install NPS 1/2 process tubing for industrial-grade sensors, transmitters, and switches. Install stainless steel bushings where required.
				3. Make tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.
				4. Support tubing independent of other trades.
				5. Route tubing parallel to and at right angles to building construction.
				6. Install tubing concealed in areas with ceilings.
				7. Install a dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.
				8. Insulate process piping connected to hot water and steam systems for personnel protection if the surface temperature exceeds 120 deg F. Only insulate piping within maintenance personnel reach from floor, platform, or catwalk.
				9. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F with a single wrap of PTFE tape.
				10. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F with pipe compound before being made up to reduce the possibility of galling.
				11. Do not make tubing connections to a fitting before completing makeup of the connection.
				12. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.
				13. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
				14. Align tubing with fitting when installed. Avoid springing tube into position.
				15. Install tubing with extreme care exercised to keep foreign matter out of system. Open tubing ends shall be kept plugged to keep out dust, dirt and moisture.
				16. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.

Retain paragraph below for additional protection.

* + - * 1. Protect exposed tubing in mechanical equipment rooms from inadvertent mechanical damage within [**76 inches**] [**84 inches**] [**96 inches**] <**Insert dimension**> above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.
				2. Process Tubing Isolation Valves Installation:

Install valves full size of piping and tubing.

Install isolation valves at the following locations:

Process connection.

Inlet to each instrument including, sensors, transmitters, switches, gauges, and other control devices.

Locate valves to be readily accessible from floor.

* + - 1. CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION
				1. Comply with NECA 1.
				2. Wire and Cable Installation:

Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."

Requirements below are in addition to those specified in the Division 26 and 27 cabling sections.

Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

Provide shielding to prevent interference and distortion from adjacent cables and equipment.

Terminate wiring in a junction box.

Clamp cable over jacket in junction box.

Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.

Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.

Use shielded cable to transmitters.

Use shielded cable to temperature sensors.

Perform continuity and meager testing on wire and cable after installation.

* + - * 1. Conduit Installation:

Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.

* + - 1. OPTICAL FIBER CABLE SYSTEM INSTALLATION
				1. Comply with installation requirements in Section 271525 "Optical Fiber Cables – FAS & DDC"
			2. FIELD QUALITY CONTROL

Retain "Testing Agency," "Manufacturer's Field Service," and "Perform the following tests and inspections" paragraphs below to identify who shall perform tests and inspections. If retaining second option in "Testing Agency" paragraph or if retaining "Manufacturer's Field Service" or "Perform the following tests and inspections" paragraph, retain "Field quality-control reports" paragraph in "Informational Submittals" Article.

* + - * 1. Testing Agency: [**Director’s Representative will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

Retain "Manufacturer's Field Service" paragraph below to require a factory-authorized service representative to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a company field advisor to test and inspect components, assemblies, and installations, including connections.

Retain "Perform the following tests and inspections" paragraph below to require Contractor to perform tests and inspections.

* + - * 1. Perform the following tests and inspections[**with the assistance of a company field advisor**]:

Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

Testing of Pneumatic and Air-Signal Tubing:

Test for leaks and obstructions.

Disconnect each pipe and tubing line before a test is performed, and blowout dust, dirt, trash, condensate and other foreign materials with compressed air. Use commercially pure compressed air or nitrogen as distributed in gas cylinders. Air from an oil-free compressor with an air dryer is an acceptable alternative for the test.

After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.

Connect a pressure source to near end of run with a needle valve between air supply and tubing run.

Connect a pressure gauge accurate to within 0.5 percent of test between the shutoff needle valve and tubing run under test.

For system pressures above 30 psig, apply a pressure of 1.5 times operating pressure. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 1 psig.

For system pressures 30 psig and below, apply a pressure of 2.0 times operating pressure to piping and tubing run. Record pressure in tubing run every 5 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 0.5 psig.

* + - * 1. Testing:

Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.

Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.

In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.

Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.

Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.

Test Results: Record test results and submit copy of test results for Project record.

* + - 1. DDC SYSTEM I/O CHECKOUT PROCEDURES
				1. Check installed products before continuity tests, leak tests and calibration.
				2. Check instruments for proper location and accessibility.
				3. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
				4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.
				5. For pneumatic products, verify that air supply for each product is properly installed.
				6. Control Damper Checkout:

For pneumatic dampers, verify that pressure gauges are provided in each air line to damper actuator and positioner.

Verify that control dampers are installed correctly for flow direction.

Verify that proper blade alignment, either parallel or opposed, has been provided.

Verify that damper frame attachment is properly secured and sealed.

Verify that damper actuator and linkage attachment is secure.

Verify that actuator wiring is complete, enclosed and connected to correct power source.

Verify that damper blade travel is unobstructed.

* + - * 1. Control Valve Checkout:

For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.

Verify that control valves are installed correctly for flow direction.

Verify that valve body attachment is properly secured and sealed.

Verify that valve actuator and linkage attachment is secure.

Verify that actuator wiring is complete, enclosed and connected to correct power source.

Verify that valve ball, disc or plug travel is unobstructed.

After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

* + - * 1. Instrument Checkout:

Verify that instrument is correctly installed for location, orientation, direction and operating clearances.

Verify that attachment is properly secured and sealed.

Verify that conduit connections are properly secured and sealed.

Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.

Inspect instrument tag against approved submittal.

For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.

For flow instruments, verify that recommended upstream and downstream distances have been maintained.

For temperature instruments:

Verify sensing element type and proper material.

Verify length and insertion.

* + - 1. DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:
				1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
				2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
				3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
				4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
				5. Provide diagnostic and test equipment for calibration and adjustment.
				6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
				7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
				8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
				9. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
				10. Analog Signals:

Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.

Check analog current signals using a precision current meter at zero, 50, and 100 percent.

Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

* + - * 1. Digital Signals:

Check digital signals using a jumper wire.

Check digital signals using an ohmmeter to test for contact making or breaking.

* + - * 1. Control Dampers:

Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.

Check and document open and close cycle times for applications with a cycle time less than 30 seconds.

For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

* + - * 1. Control Valves:

Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.

Check and document open and close cycle times for applications with a cycle time less than 30 seconds.

For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

* + - * 1. Meters: Check sensors at zero, 50, and 100 percent of Project design values.
				2. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
				3. Switches: Calibrate switches to make or break contact at set points indicated.
				4. Transmitters:

Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

* + - 1. DDC SYSTEM CONTROLLER CHECKOUT
				1. Verify power supply.

Verify voltage, phase and hertz.

Verify that protection from power surges is installed and functioning.

Verify that ground fault protection is installed.

If applicable, verify if connected to UPS unit.

If applicable, verify if connected to a backup power source.

If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

* + - * 1. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.
				2. Verify that spare I/O capacity is provided.
			1. DDC CONTROLLER I/O CONTROL LOOP TESTS
				1. Testing:

Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.

Test every I/O point throughout its full operating range.

Test every control loop to verify operation is stable and accurate.

Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.

Test and adjust every control loop for proper operation according to sequence of operation.

Test software and hardware interlocks for proper operation. Correct deficiencies.

Operate each analog point at the following:

Upper quarter of range.

Lower quarter of range.

At midpoint of range.

Exercise each binary point.

For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.

Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

* + - 1. DDC SYSTEM VALIDATION TESTS
				1. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
				2. After approval of Test Plan, execute all tests and procedures indicated in plan.
				3. After testing is complete, submit completed test checklist.
				4. Pretest Checklist: Submit the following list with items checked off once verified:

Detailed explanation for any items that are not completed or verified.

Required mechanical installation work is successfully completed and HVAC equipment is working correctly.

HVAC equipment motors operate below full-load amperage ratings.

Required DDC system components, wiring, and accessories are installed.

Installed DDC system architecture matches approved Drawings.

Control electric power circuits operate at proper voltage and are free from faults.

Required surge protection is installed.

DDC system network communications function properly, including uploading and downloading programming changes.

Retain first subparagraph below if applicable to Project.

Using BACnet protocol analyzer, verify that communications are error free.

Each controller's programming is backed up.

Equipment, products, tubing, wiring cable, and conduits are properly labeled.

All I/O points are programmed into controllers.

Testing, adjusting, and balancing work affecting controls is complete.

Dampers and actuators zero and span adjustments are set properly.

Each control damper and actuator goes to failed position on loss of power.

Valves and actuators zero and span adjustments are set properly.

Each control valve and actuator goes to failed position on loss of power.

Meter, sensor and transmitter readings are accurate and calibrated.

Control loops are tuned for smooth and stable operation.

View trend data where applicable.

Each controller works properly in standalone mode.

Safety controls and devices function properly.

Interfaces with fire-alarm system function properly.

Electrical interlocks function properly.

Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.

Record Drawings are completed.

* + - * 1. Test Plan:

Prepare and submit a validation test plan including test procedures for performance validation tests.

Test plan shall address all specified functions of DDC system and sequences of operation.

Explain detailed actions and expected results to demonstrate compliance with requirements indicated.

Explain method for simulating necessary conditions of operation used to demonstrate performance.

Include a test checklist to be used to check and initial that each test has been successfully completed.

Submit test plan documentation [**10**] [**20**] <**Insert number**> business days before start of tests.

* + - * 1. Validation Test:

Verify operating performance of each I/O point in DDC system.

Verify analog I/O points at operating value.

Make adjustments to out-of-tolerance I/O points.

Identify I/O points for future reference.

Simulate abnormal conditions to demonstrate proper function of safety devices.

Replace instruments and controllers that cannot maintain performance indicated after adjustments.

Simulate conditions to demonstrate proper sequence of control.

Readjust settings to design values and observe ability of DDC system to establish desired conditions.

After 24 Hours following Initial Validation Test:

Re-check I/O points that required corrections during initial test.

Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

After 24 Hours of Second Validation Test:

Re-check I/O points that required corrections during second test.

Continue validation testing until I/O point is normal on two consecutive tests.

Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.

After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

* + - * 1. DDC System Response Time Test:

Simulate HLC.

Heavy load shall be an occurrence of [**50**] <**Insert number**> percent of total connected binary COV, one-half of which represent an "alarm" condition, and [**50**] <**Insert number**> percent of total connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.

Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.

Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.

Purpose of test is to demonstrate DDC system, as follows:

Reaction to COV and alarm conditions during HLC.

Ability to update DDC system database during HLC.

Passing test is contingent on the following:

Alarm reporting at printer beginning no more than [**two**] <**Insert number**> seconds after the initiation (time zero) of HLC.

All alarms, both binary and analog, are reported and printed; none are lost.

Compliance with response times specified.

Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

* + - * 1. DDC System Network Bandwidth Test:

Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.

To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

* + - 1. DDC SYSTEM WIRELESS NETWORK VERIFICATION
				1. DDC system Installer shall design wireless DDC system networks to comply with performance requirements indicated.
				2. Installer shall verify wireless network performance through field testing and shall document results in a field test report.
				3. Testing and verification of all wireless devices shall include, but not be limited to, the following:

Speed.

Online status.

Signal strength.

* + - 1. FINAL REVIEW
				1. Submit written request to Director’s Representative when DDC system is ready for final review. Written request shall state the following:

DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.

DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.

DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.

DDC system is complete and ready for final review.

* + - * 1. Review by [**Architect**] [**and**] [**Construction Manager**] shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
				2. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.
				3. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.
				4. Prepare and submit closeout submittals[**and begin procedures indicated in "Extended Operation Test" Article**] when no deficiencies are reported.
				5. A part of DDC system final review shall include a demonstration to parties participating in final review.

Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.

Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.

Demonstration shall include, but not be limited to, the following:

Subparagraphs below are examples only and must be revised to suit Project.

Accuracy and calibration of [**10**] [**20**] <**Insert number**> I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.

HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to [**10**] [**20**] <**Insert number**> I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.

Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.

Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.

Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.

Trends, summaries, logs and reports set-up for Project.

For up to [**three**] <**Insert number**> HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.

Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.

Software's ability to edit control programs off-line.

Data entry to show Project-specific customizing capability including parameter changes.

Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

Execution of digital and analog commands in graphic mode.

Spreadsheet and curve plot software and its integration with database.

Online user guide and help functions.

Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.

System speed of response compared to requirements indicated.

For Each [**Network**] [**and**] [**Programmable Application**] Controller:

Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.

Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.

Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.

Electric Power: Ability to disconnect any controller safely from its power source.

Wiring Labels: Match control drawings.

Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.

Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.

For Each Operator Workstation:

I/O points lists agree with naming conventions.

Graphics are complete.

UPS unit, if applicable, operates.

Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management.[**Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability.**] Requirements must be met even if only one manufacturer's equipment is installed.

Data Presentation: On each operator workstation, demonstrate graphic display capabilities.

Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.

Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated.[**Modifications are made with messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.**]

Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.

Alarm and Event Management: Alarms and events are installed and prioritized according to Director’s Representative. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.

Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.

Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.

Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.

Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.

Device and Network Management:

Display of network device status.

Display of BACnet Object Information.

Silencing devices transmitting erroneous data.

Time synchronization.

Remote device re-initialization.

Backup and restore network device programming and master database(s).

Configuration management of routers.

<**Insert additional requirements**>.

* + - 1. EXTENDED OPERATION TEST

Retain this article when documentation of proper DDC system operation over an extended operating period is required. Consult Director’s Representative to confirm if test is applicable due to added cost.

* + - * 1. Extended operation test is intended to simulate normal operation of DDC system by Director’s Representative.
				2. Operate DDC system for an operating period of [**14**] [**21**] [**28**] <**Insert number**> consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Director’s Representative.
				3. Provide an operator familiar with DDC system installed to man an operator workstation [**while on-site**]during eight hours of each normal business day occurring during operating period.
				4. During operating period, DDC system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.

Correct defects of hardware and software when it occurs.

* + - * 1. Definition of Failures and Downtime during Operating Period:

Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.

Downtime is when any I/O point in DDC system is unable to fulfill its' required function.

Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.

Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation shall be 0.5 hours.

Downtime shall be logged in hours to nearest 0.1 hour.

Power outages shall not count as downtime, but shall suspend test hours unless systems are provided with UPS and served through a backup power source.

Hardware or software failures caused by power outages shall count as downtime.

* + - * 1. During operating period, log downtime and operational problems are encountered.

Identify source of problem.

Provide written description of corrective action taken.

Record duration of downtime.

Maintain log showing the following:

Time of occurrence.

Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.

Downtime for each failed I/O point.

Running total of downtime and total time of I/O point after each problem has been restored.

Log shall be available to Director’s Representative for review at any time.

* + - * 1. For DDC system to pass extended operation test, total downtime shall not exceed [**1**] [**2**] <**Insert number**> percent of total point-hours during operating period.

Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until DDC system passes requirement.

* + - * 1. Evaluation of DDC system passing test shall be based on the following calculation:

Downtime shall be counted on a point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.

One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.

Example Calculation: Maximum allowable downtime for 30-day test when DDC system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

* + - * 1. Prepare test and inspection reports.
			1. ADJUSTING
				1. Occupancy Adjustments: When requested within [**12**] <**Insert number**> months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [**two**] <**Insert number**> visits to Project during other-than-normal occupancy hours for this purpose.
			2. MAINTENANCE SERVICE

Verify with Director’s Representative that maintenance service is required for Project.

* + - * 1. Maintenance Service: In addition to the contractors 1-year project warranty requirements, beginning at Substantial Completion, maintenance service shall include [**three**] [**six**] [**nine**] [**12**] <**Insert number**> months' full maintenance by DDC system manufacturer's authorized service representative. Include [**monthly**] [**quarterly**] [**semiannual**] [**annual**] preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
			1. SOFTWARE SERVICE AGREEMENT

Services in this article may not be allowed for publicly funded projects.

* + - * 1. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for [**one**] [**two**] <**Insert number**> year(s).
				2. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within [**one**] [**two**] <**Insert number**> year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

Upgrade Notice: At least [**30**] <**Insert number**> days to allow Director’s Representative to schedule and access system and to upgrade computer equipment if necessary.

* + - 1. DEMONSTRATION

Revise this article to suit scope of DDC system for Project. Not all requirements indicated may be applicable.

* + - * 1. Engage a company field advisor with complete knowledge of Project-specific system installed to train Director’s Representative's maintenance personnel to adjust, operate, and maintain DDC system.
				2. Extent of Training:

Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.

Inform Director’s Representative of anticipated training requirements if more than minimum training requirements are indicated.

Minimum Training Requirements:

Revise subparagraphs below to suit unique requirements of DDC system and other Project requirements. Consult Director’s Representative for assistance in establishing minimum requirements.

Provide not less than [**five**] [**10**] [**15**] <**Insert number**> days of training total.

Stagger training over multiple training classes to accommodate Director’s Representative's requirements. All training shall occur before end of warranty period.

Total days of training shall be broken into not more than [**two**] [**three**] [**four**] <**Insert number**> separate training classes.

Each training class shall be not less than [**one**] [**two**] [**three**] <**Insert number**> consecutive day(s).

* + - * 1. Training Schedule:

Schedule training with Director’s Representative [**20**] <**Insert number**> business days before expected Substantial Completion.

Schedule training to provide Director’s Representative with at least [**10**] [**15**] [**20**] <**Insert number**> business days of notice in advance of training.

Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with [**15**] [**30**] <**Insert number**>-minute break between sessions. Morning and afternoon sessions shall be separated by [**30**] [**60**] <**Insert number**>-minute lunch period. Training, including breaks and excluding lunch period, shall not exceed [**eight**] <**Insert number**> hours per day.

Provide staggered training schedule as requested by Director’s Representative.

* + - * 1. Training Attendee List and Sign-in Sheet:

Request from Director’s Representative in advance of training a proposed attendee list with name, phone number and e-mail address.

Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.

Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.

Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.

At end of each training day, send Director’s Representative an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

* + - * 1. Training Attendee Headcount:

Plan in advance of training for [**two**] [**three**] [**five**] <**Insert number**> attendees.

Make allowance for Director’s Representative to add up to [**one**] [**two**] <**Insert number**> attendee(s) at time of training.

Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

* + - * 1. Training Attendee Prior Knowledge: For guidance in planning required training and instruction, assume attendees have the following:

Revise subparagraphs below to suit Director’s Representative personnel being trained. Consult Director’s Representative for assistance.

[**High school**] [**High school and technical school**] [**High school and four-year college**] <**Insert level**> education and degree.

[**Basic**] [**Intermediate**] [**Advanced**] user knowledge of computers and office applications.

[**Basic**] [**Intermediate**] [**Advanced**] knowledge of HVAC systems.

[**Basic**] [**Intermediate**] [**Advanced**] knowledge of DDC systems.

[**Basic**] [**Intermediate**] [**Advanced**] knowledge of DDC system and products installed.

* + - * 1. Attendee Training Manuals:

Provide each attendee with a color hard copy of all training materials and visual presentations.

Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.

In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

* + - * 1. Instructor Requirements:

One or multiple qualified instructors, as required, to provide training.

Instructors shall have not less than [**five**] <**Insert number**> years of providing instructional training on not less than [**five**] <**Insert number**> past projects with similar DDC system scope and complexity to DDC system installed.

* + - * 1. Organization of Training Sessions:

Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:

Daily operators.

Advanced operators.

System managers and administrators.

Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

* + - * 1. Training Outline:

Submit training outline for Director’s Representative review at least [**10**] <**Insert number**> business day before scheduling training.

Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

* + - * 1. On-Site Training:

Director’s Representative will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.

Instructor shall provide training materials, projector and other audiovisual equipment used in training.

Provide as much of training located on-site as deemed feasible and practical by Director’s Representative.

On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.

Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

* + - * 1. Off-Site Training:

Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power and data connectivity for each attendee.

Retain first subparagraph below only if DDC system is capable of remote access.

Provide capability to remotely access to Project DDC system for use in training.

Provide a workstation for use by each attendee.

* + - * 1. Training Content for Daily Operators:

Subparagraphs below are examples only and must be revised to suit Project.

Basic operation of system.

Understanding DDC system architecture and configuration.

Understanding each unique product type installed including performance and service requirements for each.

Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.

Operating operator workstations, printers and other peripherals.

Logging on and off system.

Accessing graphics, reports and alarms.

Adjusting and changing set points and time schedules.

Recognizing DDC system malfunctions.

Understanding content of operation and maintenance manuals including control drawings.

Understanding physical location and placement of DDC controllers and I/O hardware.

Accessing data from DDC controllers.

Operating portable operator workstations.

Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.

Running each specified report and log.

Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.

Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.

Executing digital and analog commands in graphic mode.

Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.

Demonstrating DDC system performance through trend logs and command tracing.

Demonstrating scan, update, and alarm responsiveness.

Demonstrating spreadsheet and curve plot software, and its integration with database.

Demonstrating on-line user guide, and help function and mail facility.

Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.

Demonstrating the following for HVAC systems and equipment controlled by DDC system:

Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.

For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.

Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.

Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.

Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.

Each control loop responds to set point adjustment and stabilizes within time period indicated.

Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

<**Insert requirement**>.

* + - * 1. Training Content for Advanced Operators:

Subparagraphs below are examples only and must be revised to suit Project.

Making and changing workstation graphics.

Creating, deleting and modifying alarms including annunciation and routing.

Creating, deleting and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.

Creating, deleting and modifying reports.

Creating, deleting and modifying points.

Creating, deleting and modifying programming including ability to edit control programs off-line.

Creating, deleting and modifying system graphics and other types of displays.

Adding DDC controllers and other network communication devices such as gateways and routers.

Adding operator workstations.

Performing DDC system checkout and diagnostic procedures.

Performing DDC controllers operation and maintenance procedures.

Performing operator workstation operation and maintenance procedures.

Configuring DDC system hardware including controllers, workstations, communication devices and I/O points.

Maintaining, calibrating, troubleshooting, diagnosing and repairing hardware.

Adjusting, calibrating and replacing DDC system components.

<**Insert requirement**>.

* + - * 1. Training Content for System Managers and Administrators:

Subparagraphs below are examples only and must be revised to suit Project.

DDC system software maintenance and backups.

Uploading, downloading and off-line archiving of all DDC system software and databases.

Interface with Project-specific, third-party operator software.

Understanding password and security procedures.

Adding new operators and making modifications to existing operators.

Operator password assignments and modification.

Operator authority assignment and modification.

Workstation data segregation and modification.

<**Insert requirement**>.

* + - * 1. Video of Training Sessions:

Provide a digital video and audio recording of each training session. Create a separate recording file for each session.

Stamp each recording file with training session number, session name and date.

Provide Director’s Representative with [**two**] <**Insert number**> copies of digital files on DVDs or flash drives for later reference and for use in future training.

Director’s Representative retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 230923