

**SECTION 23 09 00
INSTRUMENTATION AND CONTROLS FOR HVAC**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Furnish and install a complete facility management system (BMS) for all mechanical systems and other facility systems as included in the contract documents. The system shall perform all sequences of operations stated within these specifications or shown on the drawings.

1.2 RELATED WORK SPECIFIED

- A. Section 230500, Common Work Results for HVAC
- B. Section 230553, Identification for HVAC Piping and Equipment
- C. Section 230593, Testing, Adjusting, and Balancing
- D. Section 233300, Air Duct Accessories
- E. Section 233600, Air Terminal Units
- F. Section 283111, Digital, Addressable Fire Alarm System

1.3 REFERENCES

- A. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers
 - 1. ASHRAE Chapter 62: Ventilation for Acceptable Indoor
- B. FCC: Federal Communications Commission
 - 1. FCC Part 15: Radio Frequency Devices
- C. ISO: International Organization for Standardization
 - 1. ISO 9001: Quality Management Systems - Requirements
- D. NEC: National Electric Code
- E. NEMA: National Electrical Manufacturers' Association
- F. UL: Underwriters Laboratories
- G. US EPA: US Environmental Protection Agency

1. Energy Star Building Recommendations

1.4 QUALITY ASSURANCE

A. General:

1. The BMS installer shall be a factory-owned branch office that is regularly engaged in the engineering, programming, installation, and service of BMSs of similar size and complexity.
2. The BMS, including all components and appurtenances, shall be configured and installed to yield a mean time between failures of at least 1,000 hours.

B. ISO-9001:

1. Provide documentation supporting compliance with ISO-9001 (Model of Quality Assurance in Design/ Development, Production, Installation, and Servicing). Product literature shall contain the ISO-9001 Certification Mark from the applicable registrar. For products that do not comply with the ISO-9001 certification requirement, provide the following information to assure that quality systems are in place which are equivalent to the ISO-9001 standard:
 - a. Marketing specification standards.
 - b. Design file standards.
 - c. Manufacturing test standards.
 - d. Calibration standards.
 - e. Quality system standards.
 - f. Quality system procedures.
 - g. Documented management commitment that all employees participate in quality programs.
 - h. Training procedures.
 - i. Methods by which corrective actions are taken for problems identified within the factory process.

C. FCC Regulation:

1. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

D. UL:

1. Components shall be UL listed or recognized under the appropriate standard. These standards may include:
 - a. UL 916 for energy management systems.
 - b. UL 864 for fire, smoke and process control systems, as required.
 - c. UL 873 for controllers and temperature indicating and regulating equipment.

1.5 SUBMITTALS

- A. For systems, equipment, and components specified herein, submit product/material data; certified shop drawings; installation, startup, and testing manuals; operation and maintenance data; as-constructed data; operation and maintenance manuals; and as-constructed drawings.
1. System Drawings and Schedules: Include the following:
 - a. For industrial applications provide direct digital control (DDC) panel physical layout and schematics.
 - b. One-line schematics and system flow diagrams showing the location of all control devices. Provide points list for each DDC controller, including tag, point type, system name, object name, expanded ID, controller type, address, cable destination, terminal ID, panel, reference drawing, and cable number.
 - c. Details of connections to power sources, including grounding.
 - d. Details of surge protection device installations.
 - e. Sequences of operation.
 - f. Complete diagrams of the related pneumatic and electric controls, including a written description of control sequences.
 - g. User interface (UI) functional outline. Include each display screen to be provided, data to be displayed, and links to other screens. The outline level hierarchy shall be:
 - 1) Site.
 - 2) Building.
 - 3) Floor.
 - 4) System.
 - h. Control Damper and Valve Schedules: Include code number, failure position, pipe or duct size, valve or damper size, damper seal, blade and bearing type, valve body configuration, CV, flow, pressure drop and close-off pressure.
 2. Prototype graphics for review prior to implementation of the full graphics package.
 3. Equipment Data: Include complete data for all materials, including field and system equipment. Data provided shall be marked to indicate which specific model or feature will be provided.
 4. Field Installation Handbook: Show all standard devices, networks, controllers, and enclosures with configurations, cable specifications, wiring and installation methods, termination details, agency listings, and controller specifications.
 5. Software Data: Provide complete descriptions of system, command, and applications software as specified. Include description of control sequences which are software based using detailed logic flow diagrams. Diagrams shall indicate logic used to achieve control sequence of calculation specified, and shall show relationship between control sequence and application software packages specified.
 6. Operation and Maintenance Manuals: Provide seven complete sets of manuals bound in loose-leaf binders within 30 days after completing acceptance tests. Identify each manual's contents on cover. Manuals shall include names,

addresses, and telephone numbers of each subcontractor installing equipment and systems, and of nearest service representatives for each item of equipment and each system. Place tab sheets at beginning of each chapter or section and at beginning of each appendix. Final copies delivered after completion of the acceptance tests shall include all modifications made during installation, checkout, and acceptance. Operation and maintenance manuals shall include the hardware manual, software manual, operations manual, and maintenance manual.

- a. Hardware Manual: Describe all equipment provided, including:
 - 1) General description and specifications.
 - 2) Field Installation Handbook: Show all standard devices, networks, controllers and enclosures with configurations, cable specifications, wiring and installation methods, termination details, agency listings and controller specifications.
 - 3) As-built system drawings and schedules.
 - 4) Alignment and calibration procedures.
 - b. Software Manual: Describe all furnished software. Include the following documentation in the DDC software manual:
 - 1) Sequence of operations.
 - 2) Program listing of software source code and flow chart diagrams of programming objects for all major systems.
 - 3) Printed listing of controller and operator workstation database files.
 - 4) Software point name abbreviation list. Include name, description, controller where located, point type and point ID.
 - 5) Input/output (I/O) point list. Include point name, controller location, point number, control device, range and span.
 - 6) Printouts of all reports, group listings, and alarm messages.
 - c. Operator's Manual: Provide all procedures and instructions for operation of the system, including:
 - 1) DDC panels and peripherals.
 - 2) System startup and shutdown procedures.
 - 3) Use of system, command, and applications software.
 - 4) Alarm presentation.
 - 5) Recovery and restart procedures.
 - 6) Report generation.
 - 7) System schematic graphics.
 - d. Maintenance Manual: Provide descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.
- B. For system, equipment, and components, submit commissioning plans and schedules; checkout, startup, operational, functional and final acceptance test plans, procedures, checklists, and reports; systems manuals; and operation and maintenance training plans.
1. Testing Submittals: Provide test plan and test procedures for approval. Explain in detail, step-by-step, actions and expected results to demonstrate compliance with the requirements of this specification and methods for simulating necessary

conditions of operation to demonstrate performance of the system. Test plan and test procedures shall demonstrate capability of system to monitor and control equipment and to accomplish control and monitoring specified.

1.6 COMMISSIONING AND TRAINING

- A. Systems, equipment and component checkout, startup, calibration, operational, functional and final acceptance testing:
 - 1. General: Provide all personnel, equipment, instrumentation, and supplies necessary to commission controls.
 - 2. Commissioning: Commission systems, equipment, and components in accordance with the requirements of the contract documents. Demonstrate compliance of completed control system. Checkout and test all physical, operational, and functional requirements of the controls and related equipment.
 - 3. Six and Twelve Month Callbacks: In addition to the requirements of the contract, the Port may request, at its discretion, a recheck or resetting of any equipment, device or control on two occasions within the first year of operation.
- B. Training:
 - 1. General: Conduct training courses for designated personnel in operation and maintenance of system. Training shall be oriented to specific system being installed. Training manuals shall be provided for each trainee, with two additional copies provided for archival at project site. Manuals shall include detailed description of the subject matter for each lesson. Copies of audiovisuals shall be delivered to the Port.
 - 2. Operator's Training: The course shall be taught at the work site for a period of one training day after completion of the Contractor's field testing. The course shall include instruction on specific hardware configuration of installed system and specific instructions for operating the installed system. Upon completion, each student shall be able to start system, operate the system, recover the system after failure, and describe the specific hardware architecture and operation of system. Repeat course if necessary to include all shift personnel.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. The architecture shall consist of the products of a manufacturer regularly engaged in the production of BMS, and shall be the manufacturer's latest standard of design. Controllers and DDC system components shall be current production products.
- B. All other equipment shall be the products of the manufacturer or of an approved manufacturer regularly engaged in production of specialized BMS materials or equipment.

- C. Acceptable Manufacturer: Johnson Controls Group, Inc., Honeywell, Siemens, no substitutions.

2.2 SYSTEM DESCRIPTION

A. First-Tier Network:

1. The automation network shall be based on a personal computer (PC) industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off-the-shelf" products available through normal PC vendor channels.
2. The BMS shall network multiple UI clients, automation engines, system controllers and application-specific controllers (ASC). Provide application and data server(s) as required for systems operation.
 - a. All BMS devices on the automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
3. Network automation engines (NAE) shall reside on the automation network.
 - a. The automation network shall be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

B. Second-Tier Network:

1. NAE shall provide supervisory control over the control network and shall support all three of the following communication protocols:
 - a. BACnet Standard Master-Slave Token Passing (MS/TP) Bus Protocol ASHRAE SSPC-135, Clause 9.
 - 1) The NAE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - 2) The NAE shall be tested and certified as a BACnet Building Controller.
 - b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).
 - c. The Johnson Controls N2 Field Bus.
 - d. The Johnson Controls wireless field bus.
2. Control networks shall provide peer-to-peer, master-slave, or supervised token passing communications, and shall operate at a minimum communication speed of 9600 baud.
3. DDC Controllers shall reside on the control network.
4. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.
5. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each controller device, master or slave, which will communicate on the BACnet MS/TP Bus.

C. Integration Options:

1. Hardwired:

- a. Analog and digital signal values shall be passed from one system to another via hardwired connections.
 - b. There shall be one separate physical point on each system for each point to be integrated between the systems.
 - 2. Wireless:
 - a. Series Wireless Field Bus System: Series system shall employ ZigBee technology that creates a wireless mesh network to provide wireless connectivity for Metasys BACnet devices at multiple system levels. This includes communications from field equipment controller and VAV modular assembly (VMA) field controllers to sensors and from engines to these field controllers. Wireless devices shall co-exist on the same network with hardwired devices. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.
 - 3. Direct Protocol (Integrator Panel):
 - a. The BMS system shall include appropriate hardware equipment and software to allow bi-directional data communications between the BMS system and third-party manufacturers' control panels. The BMS shall receive, react to, and return information from multiple building systems, including but not limited to the chillers, boilers, variable frequency drives, power monitoring system, and medical gas.
 - b. All data required by the application shall be mapped into the NAE database, and shall be transparent to the operator.
 - c. Point inputs and outputs from the third-party controllers shall have real-time interoperability with BMS software features such as: control software, energy management, custom process programming, alarm management, historical data and trend analysis, totalization, and local area network communications.
 - 4. BACnet Protocol Integration – BACnet:
 - a. The neutral protocol used between systems shall be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2008.
 - b. A complete PICS shall be provided for all BACnet system devices.
 - c. Provide the ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems.
- D. Server/Web Browser/Operator Interfaces:
- 1. Dedicated Web-Based UI:
 - a. Where indicated on the drawings, provide a PC for command entry, information management, network alarm management, and database management functions. All real-time control functions including scheduling, history collection, and alarming shall be resident in the NAE to facilitate greater fault tolerance and reliability.
 - b. Dedicated UI Architecture: The architecture of the computer shall be implemented to conform to industry standards so that it can accommodate applications provided by the BMS, including but not limited to Microsoft Office applications. Specifically, it shall be implemented to conform to the following interface standards:
 - 1) Microsoft Internet Explorer for UI functions.

- 2) Microsoft Office Professional for creation, modification, and maintenance of reports, sequences, and other necessary building management functions.
 - 3) Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events and reports.
 - 4) Required network operating system for exchange of data and network functions such as printing of reports, trends, and specific system summaries.
 - c. PC Hardware: The PC(s) shall be configured as follows:
 - 1) Memory: 1 GB (512 MB minimum).
 - 2) CPU: Pentium 4 processor. 2.8 GHz clock speed (2.0 GHz minimum).
 - 3) Hard Drive: 80 GB free hard drive space (40 GB minimum)
 - 4) Hard Drive Backup System: CD/RW, DVD/RW, or network backup software provided by IT department.
 - 5) CD ROM Drive: 32X performance.
 - 6) Ports: 2 serial and 1 parallel, 2 USB ports.
 - 7) Keyboard: 101 keyboard and 2 button mouse.
 - 8) CRT Configuration: 1-2 CRTs as follows:
 - a) Each display shall be 17-inch flat panel monitor, 1280x1024 resolution minimum.
 - b) 16 bit or higher color resolution.
 - c) Display card with multiple monitor support.
 - 9) LAN Communication: Ethernet communications board. 3Comm, or equal.
 - d. Operating System Software shall be as follows:
 - 1) Windows 7 or 8 Professional.
 - 2) Where UI is not provided via browser, provide complete operator workstation software package including any hardware or software keys. Include the original installation disks and licenses for all included software, device drivers, and peripherals.
 - 3) Provide software registration cards for all included software.
 - e. Peripheral Hardware. Provide reports printer meeting the following requirements:
 - 1) Printer Make: Hewlett Packard DeskJet.
 - 2) Print Speed: 600 DPI black, 300 DPI color.
 - 3) Buffer: 64 K input print buffer.
 - 4) Color Printing: Include color kit.
2. Distributed Web-Based UI:
- a. All features and functions of the dedicated UI previously defined in this specification shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the automation network and conforming to the following:
 - 1) The software shall run on the Microsoft Internet Explorer (6.0 or higher) browser supporting the following functions:
 - a) Configuration.
 - b) Commissioning.

- c) Data archiving.
 - d) Monitoring.
 - e) Commanding.
 - f) System diagnostics.
 - 2) Minimum hardware requirements are as follows:
 - a) 1 GB RAM.
 - b) 2.0 GHz clock speed Pentium 4 microprocessor.
 - c) 100 GB hard drive.
 - d) 1 keyboard with 83 keys, minimum.
 - e) SVGA 1024x768 resolution display with 64K colors and 16 bit color depth.
 - f) Mouse or other pointing device.
- 3. Site Management UI Application Components:
 - a. Operator interface shall meet the following criteria:
 - 1) Integrated browser-based client applications.
 - 2) The system shall have event-driven rather than device polling methodology to dynamically capture and present new data to the user.
 - 3) All inputs, outputs, setpoints, and all other parameters as defined in Part 3 of this section, as shown on the drawings, or as required as part of the system software, shall be displayed for operator viewing and modifying from the operator interface software.
 - 4) UI software shall provide help menus and instructions for each operation and/or application.
 - 5) The system shall support customization of the UI configuration and a home page display for each operator.
 - 6) The system shall support user preferences in the following screen presentations:
 - a) Alarm.
 - b) Trend.
 - c) Display.
 - d) Applications.
 - 7) All controller software operating parameters shall be displayed for the operator to view/modify from the UI. These include, but are not limited to, setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, and schedules.
 - 8) The operator interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
 - a) User access for selective information retrieval and control command execution.
 - b) Monitoring and reporting.
 - c) Alarm, non-normal, and return to normal condition annunciation.
 - d) Selective operator override and other control actions.
 - e) Information archiving, manipulation, formatting, display, and reporting.
 - f) BMS internal performance supervision and diagnostics.
 - g) Online access to user Help menus.

- h) Online access to current BMS as-built records and documentation.
 - i) Means for the controlled reprogramming, reconfiguration of BMS operation, and for the manipulation of BMS database information in compliance with the prevailing codes, approvals, and regulations for individual BMS applications.
 - 9) The system shall support a list of applications programs configured by the users that are called up by the following means:
 - a) The Tools menu.
 - b) Hyperlinks within the graphics displays.
 - c) Key sequences.
 - 10) The operation of the control system shall be independent of the UI which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications will not be acceptable.
 - b. Navigation Trees:
 - 1) The system shall have the capability to display multiple navigation trees that aids the operator in navigating throughout all systems and points connected. At a minimum, provide a tree that identifies all systems on the networks.
 - 2) Provide the ability for the operator to add custom trees. The operator shall be able to define any logical grouping of systems or points and arrange them on the tree in any order. Groups shall be able to nest within other groups. Provide at minimum five levels of nesting.
 - 3) The navigation trees shall be "dockable" to other displays in the UI, such as graphics. The trees shall appear as part of the display but can be detached and then minimized to the Windows task bar. A simple keystroke shall reattach the navigation to the primary display of the UI.
 - c. Alarms:
 - 1) Alarms shall be routed directly from NAE to PCs and servers. Specific alarms from specific points shall be able to be routed to specific PCs and servers. The alarm management portion of the UI shall, at minimum, provide the following functions:
 - a) Log date and a time of alarm occurrence.
 - b) Generate a pop-up window, with audible alarm, informing a user that an alarm has been received.
 - c) Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
 - d) Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This shall be provided in addition to the pop-up window described in this section. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.
 - e) Configuration of which NAE offline alarms are seen by each user.

- f) Any attribute of any object in the system may be designated to report an alarm.
- 2) The BMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions.
- 3) The BMS shall allow a minimum of four categories of alarm sounds, customizable through user-defined .wav files.
- 4) The BMS shall annunciate application alarms at minimum, as required in Part 3 of this section.
- d. Reports and Summaries:
 - 1) Reports and summaries shall be generated and directed to the UI displays with subsequent assignment to printers, or disk. At a minimum, the system shall provide the following reports:
 - a) All points in the BMS.
 - b) All points in each BMS application.
 - c) All points in a specific controller
 - d) All points in a user-defined group of points
 - e) All points currently in alarm
 - f) All points locked out
 - g) All user defined and adjustable variables, schedules, interlocks, etc.
 - 2) Summaries and reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
 - 3) Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.
 - 4) Provide the capability to view, command, and modify large quantities of similar data in tailored summaries created online without the use of a secondary application, like a spreadsheet. Summary definition shall allow up to seven user defined columns describing attributes to be displayed, including custom column labels. At a minimum, 100 rows per summary shall be supported. Summary viewing shall be available over the network using a standard Web browser.
 - 5) Reports shall be selectable by day, time, area, and device. Each report shall include a color visual summary of essential energy information.
- e. Schedules:
 - 1) Provide a graphical display for time-of-day scheduling and override scheduling of building operations. At a minimum, the following functions shall be provided:
 - a) Weekly schedules.
 - b) Exception schedules.
 - c) Monthly calendars.
 - 2) Provide weekly schedules for each group of equipment with a specific time-use schedule.
 - 3) One or more exception schedules for each schedule, including references to calendars, shall be possible.

- 4) Provide monthly calendars that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard and shall automatically reschedule equipment operation as previously defined on the exception schedules.
 - 5) Changes to schedules made from the UI shall directly modify the NAE schedule database.
 - 6) Schedules and calendars shall comply with ASHRAE SP135/2008 BACnet Standard.
 - 7) The calendar object shall support an option to add a reference to another calendar object designated to be the master for the facility. Any supervisory and BAC calendars shall be able to be configured to reference a single master global calendar. Changes to the master global calendar shall automatically sync with all calendars that are referenced.
 - 8) Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.
 - 9) Provide software to configure and implement optimal start and stop programming based on existing indoor and outdoor environmental conditions as well as equipment operating history.
 - 10) The system solar clock shall support the scheduling and energy management functions. The solar clock shall calculate the sunrise, sunset, and sun angle values for a specified latitude and longitude. A time offset may also be specified. An example would be to use the solar clock object as a master to an interlock to turn lights on 30 minutes after sunset and off 30 minutes before sunrise.
- f. Security/Passwords:
- 1) Provide multiple-level password access protection via roles and permissions. The feature shall allow the system to base access on a user's job title or role and allow the user/manager access interface control, display, and database manipulation capabilities based on an assigned password.
 - 2) Roles may be copied and altered to meet specific roles and permissions based on the particular policies.
 - 3) Each user shall have the following: a (Metasys Local) user account name (with a maximum of 30 characters), a complex password or passphrase (with a min of 8 characters and a max of 50 characters), other user account policies (such as session timeout), timesheet access based on day of the week and time of day, and specific user view.
 - 4) The system shall allow each user to change his or her password at will.
 - 5) When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
 - 6) A maximum of 150 categories may be used to determine or assign areas of responsibilities to each user account. A maximum of 13 of

- the 150 named categories, shall be specifics such as, "No Access," "View," "Advanced Review," "Operate," "Intervene," "Diagnostic," "Manage Item Events," "Manage Every," and "Configure Items."
- 7) A minimum of 100 unique passwords shall be supported.
 - 8) Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
 - 9) Operators shall be further limited to only access, command, and modify those buildings, systems, and subsystems for which they have responsibility. Provide a minimum of 100 categories of systems to which individual operators may be assigned.
 - 10) The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including, but not limited to: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.
 - 11) The system shall have the ability to provide a Department of Defense specific warning banner for applicable sites that warns the user they are accessing a restricted site.
 - 12) After successful login to the Site Management Portal, the last time and date that user name was previously logged in shall be shown on the screen.
 - 13) Each login attempt shall be recorded in the system audit log with the option to record the IP address of the PC that made the login.
- g. Screen Manager:
- 1) The system shall allow a customized image on the login screen (i.e., organization name, logo).
 - 2) User view navigations may be displayed as either a set of tabs or a drop down list.
 - 3) Allow users a preference for assigning a background color for when an object is out of service which will enable the operator to quickly distinguish points that have been commanded to this state.
 - 4) Provide the UI with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of four active display windows plus a network or user defined navigation tree.
- h. Dynamic Color Graphics:
- 1) The graphics application program shall be supplied as an integral part of the UI. Browser or workstation applications that rely only upon HTML pages will not be acceptable.
 - 2) The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed. The graphics shall be able to display and

- provide animation based on real-time data that is acquired, derived, or entered.
- 3) Graphics Runtime Functions: A maximum of 16 graphic applications shall be able to execute at any one time on a UI or workstation, with 4 visible to the user. Each graphic application shall be capable of the following functions:
 - a) All graphics shall be fully scalable.
 - b) The graphics shall support a maintained aspect ratio.
 - c) Multiple fonts shall be supported.
 - d) Unique background shall be assignable on a per graphic basis.
 - e) The color of all animations and values on displays shall indicate the status of the object attribute.
 - f) Graphics that represent buildings or systems shall allow natural links and transitions between related detailed tabular views of data that complement the graphic.
 - 4) Operation from Graphics: Values (setpoints) and states shall be able to change in system controlled equipment directly from the graphic.
 - 5) Floor Plan Graphics: The UI shall provide graphic applications that summarize conditions on a floor. Floor plan graphics shall indicate thermal comfort using dynamic colors to represent zone temperature deviations from zone setpoint(s) and shall display overall metrics for each zone in the floor.
 - 6) Aliasing: Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, the value of a graphic display shall bind to aliases instead of the physical field tags.
 - 7) Graphic Editing Tool: A graphic editing tool shall allow for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, defining all runtime binding, and shall provide the following:
 - a) A library of standard HVAC equipment, floor plan, lighting, security, and network symbols.
 - b) For the creation and positioning of library symbols by dragging from tool bars or drop-downs and positioning, where required.
 - c) Ability to import AutoCAD drawings for use in the system.
 - d) Ability to add additional content to any graphic by importing images in the SVG, PNG, or JPG file formats.
 - i. Historical Trending and Data Collection:
 - 1) Each NAE shall store trend and point history data for all analog and digital inputs and outputs, as follows:
 - a) Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed: defined time interval or upon a change of value.
 - b) Capacity to store multiple samples for each physical point and software variable based upon available memory, including an

- individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.
- 2) Trend and change of value data shall be stored within the engine and upload to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time-scheduled basis.
 - 3) The system shall provide a configurable data storage subsystem for the collection of historical data. Data can be stored in SQL database format.
 - 4) The system shall provide data to enable optimization capabilities including fault detection and diagnostics, advanced analytics, and central plant optimization without the need of a gateway or additional hardware.
- j. Trend Data Viewing and Analysis:
- 1) Provide a trend viewing utility that shall have access to all database points.
 - 2) Retrieving any historical database point for use in displays and reports shall be possible by specifying the point name and associated trend name.
 - 3) The trend viewing utility shall have the capability to define trend study displays to include multiple trends.
 - 4) Displays shall be single or stacked graphs with online selectable display characteristics such as ranging, color, and plot style.
 - 5) Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collecting data. This shall be a zoom capability.
 - 6) Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
 - 7) The display shall support the user's ability to change colors, sample sizes, and types of markers.
- k. Database Management:
- 1) Where a separate SQL database is utilized for information storage, the system shall provide a database manager that separates the database monitoring and managing functions by supporting two separate windows.
 - 2) Database secure access shall be accomplished using standard SQL authentication, including the ability to access data for use outside of the building automation application.
 - 3) The database managing function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
 - a) Backup.
 - b) Purge.
 - c) Restore.
 - 4) The database manager shall support four tabs:

- a) Statistics. Display database server information and trend, alarm (event), and audit information on the Metasys databases.
 - b) Maintenance. Provide an easy method of purging records from the Metasys server trend, alarm (event), and audit databases by supporting separate screens for creating a backup prior to purging, selecting the database, and allowing for the retention of a selected number of day's data.
 - c) Backup. Provide the means to create a database backup file and select a storage location.
 - d) Restore. Provide a restricted means of restoring a database by requiring the user to log into an expert mode in order to view the restore screen.
- 5) The status bar shall appear at the bottom of all Metasys database manager tabs and shall provide information on the current database activity. The following icons shall be provided:
- a) Ready.
 - b) Purging record from a database.
 - c) Action failed.
 - d) Refreshing statistics.
 - e) Restoring database.
 - f) Shrinking a database.
 - g) Backing up a database.
 - h) Resetting internet information services.
 - i) Starting the Metasys device manager.
 - j) Shutting down the Metasys device manager.
 - k) Action successful.
- 6) Access the database manager monitoring functions through the monitoring settings window and continuously read database information once the user has logged in.
- 7) The system shall provide user notification via taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.
- 8) The monitoring settings window shall have the following sections:
- a) General. Allows the user to set and review scan intervals and start times.
 - b) Email. Allows the user to create and review e-mail and phone text messages to be delivered when a warning or alarm is generated.
 - c) Warning. Allows the user to define the warning limit parameters, set the reminder frequency, and link the e-mail message.
 - d) Alarm. Allows the user to define the alarm limit parameters, set the reminder frequency, and link the e-mail message.
 - e) Database login. Protects the system from unauthorized database manipulation by creating a read access and a write access for each trend, alarm (event), and audit database as well as an expert mode required to restore a database.

- 9) The monitoring settings taskbar shall provide the following informational icons:
 - a) Normal. Indicates by color and size that all databases are within their limits.
 - b) Warning. Indicates by color and size that one or more databases have exceeded their warning limit.
 - c) Alarm. Indicates by color and size that one or more databases have exceeded their alarm limit.
 - 10) The system shall provide user notification via taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.
- I. Demand Limiting and Load Rolling:
- 1) The system shall provide a demand limiting and load rolling program for the purpose of limiting peak energy usage and reducing overall energy consumption.
 - 2) The system shall support both sliding window and fixed window methods of predicting demand.
 - 3) The system shall support three levels of sensitivity in the sliding window demand calculations for fine tuning the system.
 - a) Low setting. Sheds loads later and over the shortest amount of time. Maximizes the time the equipment is on.
 - b) Medium setting. Sheds loads earlier over a longer amount of time than the low setting. Increases the time the equipment is on and decreases the probability of exceeding the tariff target over the low setting.
 - c) High Setting. Sheds loads earlier over a longer amount of time than the medium setting. Minimizes the probability of exceeding the tariff target.
 - 4) The system shall have a "Shed" mode and a "Monitor Only" mode of operation.
 - a) When the shed mode is engaged, the system shall actively control the demand.
 - b) When the monitor mode is engaged, the system shall simulate the shedding action but shall not take any action.
 - 5) The demand limiting program shall monitor the energy consumption rate and compare it to a user-defined tariff target. The system shall maintain consumption below the target by selectively shedding loads based upon a user-defined strategy.
 - 6) The demand limiting program shall be capable of supporting a minimum of 10 separate load priorities. Each load shall be user assigned to a load priority.
 - 7) The demand limiting program shall be capable of supporting a minimum of 12 separate tariff targets defining the maximum allowed average power during the current interval.
 - 8) The system shall support a maximum shed time for each load as determined by the user. The system shall restore the load before the maximum shed time has expired.

- 9) The system shall support a minimum shed time for each load as determined by the user. The system shall not restore the load sooner than the minimum shed time has expired.
- 10) The system shall support a minimum release time for each load as determined by the user. The system shall not shed the load until it has been off for the minimum release time.
- 11) The system shall support three user-defined options if the meter goes unreliable.
 - a) Shedding. The currently shed loads shall be released as their maximum shed times expire.
 - b) Maintain the current shed rate. The system shall use the demand limiting shed rate that was present when the meter went unreliable.
 - c) Use unreliable meter shed rate. The system shall control to a user-defined unreliable shed rate target.
- 12) The load rolling program shall sum the loads currently shed and compare it to a user-defined load rolling target. The system shall maintain consumption below the target by selectively shedding loads based upon a user-defined load priority.
- 13) The load rolling program shall be capable of supporting a minimum of 10 separate load priorities. Each load shall be user assigned to a load priority.
- 14) The load rolling program shall be capable of supporting a minimum of 12 separate tariff targets defining the amount of power by which the demand shall be reduced.
- 15) The system shall provide the user with a load tab that displays all of the demand limiting and load rolling parameters for any selected load.
- 16) The system shall provide the user with a load summary that displays all of the loads associated with the demand limiting and load rolling programs. Status icons for each load shall indicate:
 - a) Load is offline.
 - b) Load is disabled.
 - c) Load is shed.
 - d) Load is locked.
 - e) Load is comfort override.
- 17) The load summary shall include a load summary runtime view listing the following load conditions:
 - a) Load priority.
 - b) Shed strategy.
 - c) Load rating.
 - d) Present value.
 - e) Ineligibility status.
 - f) Active timer.
 - g) Time remaining.
 - h) Last shed time.

4. Portable Operator Terminal:

- a. For systems that do not provide full access to system configuration and definition via the browser-based UI, provide a portable operator terminal for programming purposes. The terminal shall be configured as follows:
 - 1) Personal laptop computer manufacturer: Dell, Compaq, or HP.
 - 2) 1 GB RAM, 256 MB minimum. Microsoft Windows 7 or 8 Professional.
 - 3) 1.8 GHz clock speed Pentium 4 microprocessor, 800 MHz minimum.
 - 4) 40 GB Hard Drive, 40 GB minimum.
 - 5) 1 CD-ROM Drive, 32 x speeds.
 - 6) 1 serial, 1 parallel, 2 USB ports.
 - 7) 1 keyboard with 83 keys, minimum.
 - 8) Integral 2 button track point or track ball.
 - 9) 10-inch SVGA 1024x768 resolution color display.
 - 10) 2 PCMCIA Type II or 1 Type III card slot.
 - 11) Complete operator workstation software package including any hardware or software.
 - 12) Original printed manuals for all software and peripherals.
 - 13) Original installation disks or CD for all software, device drivers, and peripherals.
 - 14) Software registration cards for all included software.
 - 15) Carrying case.
 - 16) Spare battery.
 - 17) External power supply/battery charge.
 - b. Proprietary Portable Terminal: Submit technical data sheets for the terminal and all associated software and hardware.
 - c. Software:
 - 1) Portable operator terminals shall support all controllers within the system on a direct-connect communications basis.
 - 2) When used to access first or second tier controllers, the portable operator terminal shall utilize the standard operator workstation software, as defined in this section.
 - 3) When used to access application specific controllers, the portable operator terminal shall utilize either the standard operator workstation software, as defined in this section, or controller-specific utility software.
5. Metasys UI:
- a. Provide all computer hardware and software required for the purpose of configuration and consolidation of information and programs required for the delivery of a task focused, web based portal to the BMS. The Metasys UI shall provide a natural, complementary extension to the Metasys site management UI previously described in this section.
 - b. The UI architecture shall be implemented to conform to industry standards, accommodating the required applications and communicating information to and from any size control system.
 - c. The exact same UI shall be accessible from any type of PC or mobile device running any type of operating system (i.e., iOS, Android, Windows).

- d. The interface shall automatically adapt and optimize the information displayed to fit the screen size of the client device and shall also be touch friendly.
 - e. The UI shall organize and display information using customer-specific locations and spaces. At a minimum, the UI shall provide:
 - 1) Organization of all space, equipment, and point information in a familiar way, reducing the need for extensive training prior to use.
 - 2) A navigation mechanism for users to select the specific location or space to display information for, but only spaces and locations in the navigation tree.
 - 3) The ability to search for and/or bookmark any location or space by name for quick access to critical or troublesome areas.
 - 4) The same navigation mechanisms apply across any client device (i.e., smartphone, tablet, PC) for consistency and ease of use.
 - 5) Plug-ins and special native application software (i.e., downloaded and installed from an app store) shall not be required to conduct daily operations of buildings and equipment.
 - f. The UI shall clearly display equipment relationships without custom graphic generation.
 - g. The UI shall provide a single display of all potential issues in a facility including items currently in alarm, warning, override, out-of-service, and offline.
 - h. The UI shall provide a single display of all activity related to a specific piece of equipment including user changes, discarded user changes, pending alarms, discarded alarms, and acknowledged alarms.
 - i. The UI shall provide support for up to 100 concurrent users from an unlimited number of individuals with defined password access to the system.
 - j. Provide the capability to view, command, and modify large quantities of similar data in tailored summaries without the use of a secondary application, such as a spreadsheet. These summaries shall be automatically generated or user-defined. User-defined summaries shall allow up to seven user-defined columns describing attributes to be displayed, including custom column labels. Up to 100 rows per summary shall be supported.
6. Ready Access Portal UI:
- a. Provide all computer hardware and software required for the purpose of configuration and consolidation of information and programs required for the delivery of a task focused, web-based portal to the BMS. The ready access portal shall provide a natural, complementary extension to the Metasys site management UI, as described in this section.
 - b. Ready Access Portal Architecture: Implement to conform to industry standards, so that it may accommodate the required applications provided as well as communicate information to and from the Metasys system site director.
 - c. PC Hardware: The PC(s) shall be configured as follows:
 - 1) Memory: 2 GB, 1 GB Minimum.

- 2) CPU Pentium 4 processor. 2.8 Hz clock speed, 2.0 GHz minimum.
 - 3) Hard Drive: 200 GB free hard drive space, 80 GB minimum.
 - 4) Hard Drive Backup System: CD/RW, DVD/RW or network backup software provided by IT department.
 - 5) DVD ROM Drive: 16X performance.
 - 6) Ports: 1 Serial and 2 USB ports.
 - 7) Keyboard: 101 keyboard and 2-button mouse.
 - 8) CRT configuration.
 - 9) 17-inch flat panel monitor, 1280 x 1024 resolution minimum.
 - 10) 16 bit or higher color resolution.
 - 11) LAN Communications: Ethernet communications board, 100 Mbps minimum.
- d. Operating System Software:
- 1) Windows 7 or 8 Professional, IIS Version 5.1, .Net Version 2.0, SQL server 2005 express software with SP2 or Microsoft Windows Server 2003 OS with SP2, IIS Version 6.0, .Net version 2.0 and SQL Server 2005 with SP2.
 - 2) Provide software and hardware required for integration of computing hardware on enterprise IT network.
 - 3) Provide software registration cards for all included software.
- e. UI Application Components:
- 1) The ready access portal shall provide an intuitive UI to key Metasys functions and tasks via web browser.
 - 2) Plug-ins or special software shall not be required for access to alarm, summary, schedule, or trend data.
 - 3) The portal shall include the ability to view full graphical representations of systems and equipment on PC platforms.
 - 4) The control system shall provide secure sockets level and active directory service support. If the active directory service and single sign-on features are enabled and the user is logged in to the Windows desktop, access to the system shall be automatic and the login screen shall not appear.
 - 5) Provide a common tool for graphics creation, schedule creation, custom programming, user access, and hardware definition.
 - 6) Information shall be accessible on both PC and handheld device platforms as follows:
 - a) PCs. Internet Explorer Version 7.0, recommended.
 - b) Handheld Devices. Internet Explorer for Window Mobile Version 5.0 or 6.0, recommended, as well as Apple i-Phone, i-Touch, or i-Pad. UI shall be optimized for devices with a 240x320 pixel screen size (QVGA).
- f. Operator Interface:
- 1) Password access shall be as described in this section for management portal UI
 - 2) Once logged in, the system shall display a pre-selected screen tailored to the task requirements of the individual user.

- 3) The UI shall utilize an intuitive navigation and display method designed for operators accessing the system for casual information and control or on an infrequent basis. It shall feature three basic components:
 - a) Radio buttons for selecting the type of information to be displayed including alerts, summary, schedules, and diagnostics.
 - b) Navigation tree for selection of the specific data to be displayed on screen for the selected type. The navigation tree may be hidden and expanded by the operator to optimize the display of information.
 - c) A display window that provides the selected information by type in a pre-configured tabular format.
- 4) The UI software shall provide help menus and instructions for each operation and/or application.
- 5) The system shall provide support for up to 100 concurrent users from an unlimited universe individuals with defined password access to the system.
- 6) The system shall utilize secure sockets level support as required to allow the ready access portal to communicate across a network in a way designed to prevent eavesdropping, tampering, and message forgery. It provides endpoint authentication and communications privacy over the network using cryptography.
- 7) The system shall have the capability to display multiple navigation trees that correspond to the user views configured in the management portal UI.
- 8) The alert summary of the ready access portal shall, at the minimum, provide the following information:
 - a) Alert or alarm type.
 - b) Date and time of alert occurrence.
 - c) Priority color coded to level.
 - d) Item name.
 - e) Item value, if applicable.
 - f) Message.
 - g) Any attribute of any object in the system may be designated to report an alarm.
- 9) A standard summary on the ready access portal shall, at minimum, provide the following information:
 - a) Point type graphic icon.
 - b) Item name.
 - c) Item value.
 - d) Item status.
 - e) Access to the change value window, if applicable, for the purpose of setting, holding, or releasing an item value.
- 10) A custom summary on the ready access portal shall display user-specified summaries of key data sets that can be quickly filtered and sorted. Items within these custom summaries may be commanded.

- 11) A graphic view on the ready access portal shall display, as describe in this section for management portal UI.
- 12) The schedule detail summary of the ready access portal shall, at minimum, provide the following information:
 - a) Scheduled occurrences including time and value.
 - b) Scheduled overrides including start time, end time, and value.
 - c) A list of all scheduled items including name and attribute, value, status, and priority.
 - d) Access to the “add temporary override” window for the purpose of adding a temporary override to the schedule.
- 13) The diagnostic (trend) summary of the ready access portal, as viewed on a personal computing device, shall provide the following information:
 - a) Item name.
 - b) Item status.
 - c) Trend name.
 - d) Trend status.
 - e) Full path name.
 - f) Access to a detailed summary including trended value, time, and date arranged in a user-selectable format of 1, 12, 24, 48, or 72 hours.

E. BMS Architecture:

1. The BMS shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using “off the shelf,” industry standard technology compatible with other Port-provided networks.
2. The BMS system shall consist of the following:
 - a. Standalone NAE.
 - b. Field equipment controller(s).
 - c. Input/output module(s) (IOM).
 - d. Local display device(s).
 - e. Portable operator's terminal(s).
 - f. Distributed UI(s).
 - g. Network processing, data storage, and communications equipment.
 - h. Other components required for a complete and working BMS.
3. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers, and operator devices, while reusing existing controls equipment.
4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
5. Automation Network:

- a. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard “off-the-shelf” products available through normal PC vendor channels.
 - b. The BMS shall network multiple UI clients, automation engines, system controllers, and ASC. Provide application and data server(s) as required for systems operation.
 - c. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
 - d. NAE shall reside on the automation network.
 - e. The automation network shall be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.
6. Control Network:
- a. NAE shall provide supervisory control over the control network.
 - b. BACnet Protocol Integration, BACnet.
 - 1) The neutral protocol used between systems shall be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2008.
 - 2) A complete PICS shall be provided for all BACnet system devices.
 - 3) Provide the ability to command, share point object data, COS data and schedules between the host and BACnet systems.
- F. Environmental Conditions: The DDC panels and all other field equipment shall be rated for continuous operation under ambient environmental conditions of 35°F to 120°F dry bulb and 10 percent to 95 percent relative humidity, noncondensing. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installation.
- G. System Accuracy and Display:
- 1. The DDC system shall control space temperature with a range of 50°F to 85°F $\pm 1^\circ\text{F}$ for conditioned space (display to nearest 0.5°F); 30°F to 130° $\pm 1^\circ\text{F}$ for unconditioned space (display to nearest 0.5°F). Return air humidity shall be controlled to 20 percent RH to 35 percent RH ± 3 percent RH.
 - 2. The DDC system shall control duct temperature with a range of 40°F to 140°F $\pm 1^\circ\text{F}$ (display to nearest 0.5°F).
 - 3. Water temperature shall be displayed with a range of 30°F to 100°F $\pm 1^\circ\text{F}$ (display to nearest 0.5°F); the range of 100°F to 300°F $\pm 2^\circ\text{F}$ (display to nearest 0.5°F); and water temperatures for the purpose of performing BTU calculations using differential temperatures to $\pm 0.5^\circ\text{F}$ using matched sensors (display to nearest 0.5°F).
 - 4. Pressure shall be displayed with a range for the specific application ± 5 percent of range.
 - 5. Airflow or differential airflow shall be displayed with a range for the specific application of ± 4 percent of range (display to nearest 1.0 CFM).

2.3 MATERIALS AND EQUIPMENT

A. Controls and Power Wiring:

1. General: Electric equipment and wiring shall be in accordance with Division 26. Manual or automatic control and protective or signal devices required for operation specified, and any control wiring required for controls and devices, shall be provided hereunder. Run all control wiring in conduit.
2. Wiring:
 - a. Field and Subfield Panels: Voltage in panels shall not exceed 120 volts. Where devices are wired to higher voltages, mount in suitable individual enclosures or group in separate control panel. Coordinate electrical power supply with Division 26. Provide conduit and wiring required to spare breakers in accordance with Division 26.
 - b. Motor Control Centers: Ensure correct voltage of holding coils and starter wiring in pre-wired motor control centers to interface with automatic controls.
 - c. Wiring for the primary peer-to-peer communications network shall be two conductor minimum 18-gauge foil-shielded, stranded twisted pair cable rated at 100 Vdc or more at 80°C.
 - d. Cable types shall be of a different color coding for easy identification and troubleshooting. Recommended color coding:
 - 1) Analog Input Cable – Yellow
 - 2) Analog Output Cable – Tan
 - 3) Binary Input Cable – Orange
 - 4) Binary Output Cable – Violet
 - 5) 24 Vac Cable – Gray
 - 6) General Purpose Cable – Natural
 - e. Wiring for secondary network shall be three-conductor minimum 22-gauge telephone type wire. If LON works communications are used, provide two-conductor cable.
3. Communications Links Surge Protection: Protect all communications equipment against surges induced on communications link. All cables and conductors which serve as communications links shall have surge protection circuits installed that meet the requirements of REA PE-60d.
4. Communications Links Overvoltage Protection: Protect communications equipment against overvoltage on communications link conductors. Cables and conductors which serve as communications links shall have overvoltage protection for voltages up to 480 VAC rms, 60 Hz installed. Instrument fuses or fusible resistors will be accepted for this application.

B. Control Panels:

1. Wall-mounted control panels shall be provided as required to contain all relays, terminal strips, power supplies and other equipment in the building control system.
2. Panels shall be UL listed, minimum NEMA 1, minimum 14-gauge steel with stiffeners, continuous hinge doors, locking handles, single point latch.

Alternately, panels may be constructed of structural plastic meeting UL and NEMA requirements.

2.4 CONTROL DEVICES

A. Input:

1. Temperature Instruments:

- a. Room Temperature Sensors: Platinum or nickel RTD type with accuracy of $\pm 0.5^{\circ}\text{F}$ at 70°F ; operating range 50 to 90°F ; linear to DDC system; single point sensing element in wall-mounted ventilated enclosure with insulating back plate or ceiling pendant mount. Acceptable manufacturers are JCI, Veris, or pre-bid approved equal. Combination temperature, humidity, and/or carbon dioxide sensors may be used. Sensors shall have:
 - 1) No digital readout display.
 - 2) User adjustment based on DDC programmed offset.
 - 3) A room occupancy sensor installed as shown on the drawings.
 - 4) Wireless capability as shown on the drawings.
- b. Duct Temperature Sensors: Platinum or nickel RTD element with accuracy of $\pm 0.5^{\circ}\text{F}$ at 65°F , averaging type consisting of array of single point sensing elements, securely mounted in duct or plenum; operating range 30 to 100°F ; linear signal; 20-foot element.
- c. Outside Air Temperature Sensor: Platinum or nickel RTD element with accuracy of $\pm 0.5^{\circ}\text{F}$ at 32°F ; Range -50 to 250°F , single element, linear, with weather and sun shield for exterior mounting.
- d. Low Temperature Limit Thermostat: Minimum 1-foot capillary sensing element for 1 square foot of air flow area, triggering on low temperature as sensed by any 6-inch segment; snap acting, normally open contacts, manual reset, line voltage.
- e. Liquid Immersion Temperature Sensor: Platinum or nickel RTD element, with accuracy of $\pm 0.65^{\circ}\text{F}$ at 70°F , stainless steel well and assembly, range -50 to 220°F .

2. Humidity Instruments:

- a. Space Humidity Sensors: Operating range 10 to 95 percent relative humidity, accuracy $\pm 5\%$, surface mounted ventilated enclosure for wall mounting, Acceptable manufacturers are JCI, Veris, or pre-bid approved equal. Combination temperature, humidity, and/or carbon dioxide sensors may be used. Sensors shall have:
 - 1) No digital readout display.
 - 2) No user adjustment based on DDC programmed offset.
 - 3) Wireless capability as shown on the drawings.
- b. Duct Humidity Transmitter: Capacitive type sensor and transmitter, linear output signal, automatic temperature compensating, air filter, $\pm 2\%$ RH accuracy from 0 to 100% RH, industrial quality.

3. Occupancy Sensors: Sensors shall have a manual override button and wireless capability. Acceptable Manufacturers: Johnson WRZ, or pre-bid approved equal.

4. Airflow Measuring Station (Fan Inlet):
 - a. Acceptable Manufacturers: Ebtron, Air Monitor, Paragon, Johnson, or pre-bid approved equal.
 - b. Electronic air measuring system consisting of thermistor based sensor probe assemblies and a single microprocessor based transmitter. Each sensor probe assembly shall contain one or more independently wired sensor housings. The airflow and temperature readings calculated for each sensor housing shall be equally weighted and averaged by the transmitter prior to output.
 - c. Fan inlet airflow traverse probe with two bead-in-glass thermistor probes, mounted on 304 stainless steel blocks and feet with adjustable mounting rods.
 - d. Microprocessor and Electronics: Solid state microprocessor, permanent non-volatile memory, regulated power supply, software-based system. 0-5 Vdc, 0-10 Vdc, or 4-20 mA signals, linear flow and temperature outputs, line surge, and transient protection.
 - e. Performance: ± 2 percent of reading, +20 FPM across total calibrated range of 0 to 5,000 FPM, for duct mounted, 0-10,000 FPM for fan inlet mounted repeatability better than ± 0.4 percent of reading. Pressure drop shall not exceed 0.005 in. WG at 2000 FPM.
 - f. Probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors with an accuracy of 3 percent of actual flow over a fan operating range of 6 to 1 capacity turndown.
5. Air Flow Station (Duct-Mounted):
 - a. Acceptable Manufacturers: Ebtron, Kurz, Johnson, or pre-bid approved equal.
 - b. Electronic air measuring system consisting of thermistor based sensor grid and microprocessor based electronics.
 - c. Sensor Probes: Thermistors probes and linear IC's, aluminum casing, duct-mounted, wiring Teflon or kynar coated and encased, 20°F to 160°F operating range, weather resistant finish, flanged welded aluminum frame.
 - d. Microprocessor and Electronics: Solid state microprocessor, permanent non-volatile memory, regulated power supply, software based system, 0-5 Vdc, 0-10 Vdc, or 4-20 mA signals, linear flow and temperature outputs, line surge and transient protection.
 - e. Performance: ± 2 percent, +20 FPM across total calibrated range of 0 to 5000 FPM, for duct mounted, 0-10,000 FPM for fan inlet mounted, repeatability better than ± 0.4 percent of reading. Pressure drop shall not exceed 0.005 inches W.G. at 2000 FPM.
6. Airflow Transmitters: Provide transmitter with 4-20 mA output signal, 16 character alpha-numeric display capable of displaying airflow, temperature, system status, configuration setting, and diagnostics. Pressure transducers accurate to + 0.25 percent for full range, range selected based on the actual flow element and expected velocity pressure, and linear output on velocity turndown of 10 to 1. Acceptable manufacturers are Ebtron GTA 116, Setra Model C264, or pre-bid approved equal. Provide a calibration certificate for each unit.

7. Air Differential Pressure Switch: Required for filter status. Setpoint shall be adjustable with operating range of 0.05 to 5 inches W.G. Contactor shall close when set pressure differential is met or exceeded.
8. Air Duct Static Pressure Transmitter: Operating range 0 to 5 inches WC for duct-mounted transmitter and 0 to 12 inches WC for fan high limit transmitters. Sensors shall be diaphragm or rigid element bellows, electronic type. Each transmitter shall be provided with stop cock, and tubing for attaching portable pressure gauge. Sensing tube shall be securely mounted in duct with appropriate fitting.
9. Damper Position Indication: Where called for in the sequence of operations or on the drawings, provide a means of indicating damper position. Where two-position electric direct-coupled actuators are used, provide two auxiliary switches with SPDT contacts to indicate the fully open or fully closed positions as required. Where pneumatic or other types of actuators are used, provide an encapsulated mercury switch mated to a damper crank arm, which can be mounted on the damper control shaft to indicate the open or closed position.
10. Leak Detection:
 - a. Provide addressable water leak detection system that utilizes water sensing cable to detect the presence of water at any point along its length.
 - b. Detection cable shall each be 40 feet minimum in length and consist of two parallel conductors with a supervised end of line resistor circuit. The conductors shall be individually insulated with a protective outer covering of braided rayon.
 - c. Leak detection shall interface with the DDC system.
11. Duct-Mounted Carbon Dioxide Sensors: Self-sufficient CO₂ sampling station with pump to ensure proper air flow to sensing chamber. Solid state sensor, accuracy of ± 2 percent of span, maximum span of 0-2500 ppm. Provide single calibration kit with calibration gas, connecting hoses, and fittings. Acceptable manufacturers are Vulcain, Veris, Johnson Controls, or pre-bid approved equal.
12. Wall-Mounted Carbon Dioxide Sensors: Infrared sensing, microprocessor controlled digital transmitting carbon dioxide gas monitor suitable for wall mounting. Sensors shall be hard wired, unless drawings indicate sensor to be wireless. Combination temperature, humidity, and/or carbon dioxide sensors may be used.

Detection Range:	0-2000 ppm, *0-2% OR *0-5%
Accuracy:	+/- 13%
Response Time:	<60 seconds (for 90% of the reading)
Outputs:	4-20mA (optional: SPDT Relay rated 5A)
Relay Output Rating:	5A, 30 Vdc or 250 Vac (resistive load)
Power Requirement:	17-27 Vac or 24-38 Vdc, 200 mA
Operating Temperature Range:	32°F to 100°F (0°C to 40°C)
Operating Humidity Range:	0% - 95% RH, Non-Condensing
Display:	Sensor shall not be provided with digital display.
Acceptable Manufacturers:	Vulcain Series, Veris, Johnson Controls, or pre-bid approved equal.

13. Current Sensing Switches:
 - a. The current sensing switch shall be self-powered with solid state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
 - b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
 - c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
 - d. Acceptable manufacturers: Veris Industries or pre-bid approved equal.
 14. Air Pressure Safety Switches:
 - a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120 Vac.
 - b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
 - c. Acceptable Manufacturers: Johnson Controls, Cleveland Controls, Dwyer, or pre-bid approved equal.
- B. Output:
1. Motorized control valves, pressure independent type, for use in variable flow heating and chilled water systems:
 - a. Acceptable Manufacturers: Flow Control, Inc. Delta P Valve, or pre-bid approved equal.
 - b. Description:
 - 1) Pressure independent control valves shall be dynamic, modulating two-way, control device for use in variable flow chilled water and heating water systems.
 - 2) Dynamic control valve shall accurately control flow, independent of system pressure fluctuation, from 0 to 100 percent full rated flow.
 - 3) Test ports shall be furnished with valve.
 - c. Valve Actuator:
 - 1) Valve actuator shall be factory-mounted and calibrated to provide full design flow at end of stroke and 100 percent control signal.
 - 2) Actuator shall accept 2-10 Vdc, 4-20mA or 3-point floating electric signal and shall include resistor to facilitate any of these signals.
 - 3) Actuator shall be capable of providing 4-20mA or 2-10 Vdc feedback signal to the control system.
 - 4) Actuator shall be capable of control between maximum and minimum signal. End stroke of actuator at full design shall be factory set at design flow indicated on the drawings from performance curves furnished with valves. For example, 100 percent control signal would control 100 percent design flow, 50 percent signal would control 50 percent design flow.

- 5) Actuators shall power valve to either open or closed position from any position in case of power failure.
 - 6) External LED read-out of current valve position and maximum valve position setting shall be available.
 - 7) Provide current limiting for stalled actuators.
 - 8) Actuators shall be sized to provide the required close off torque and be able to open a valve in 200 seconds or less.
 - d. Valve Body:
 - 1) Valves 1/2 inch to 2 inches shall be constructed of brass, rated at 150 psi working pressure.
 - 2) Valves 3 inches and greater shall be constructed of ductile iron, rated at 150 psi working pressure.
 - e. Flow Regulation Unit: Flow regulation unit shall be capable of controlling flow within ± 5 percent of rated flow, due to system pressure fluctuations.
2. Motorized control valves, pressure dependent type, for use in constant flow heating systems: Equip with modulating plug or V-port inner valve with composition disc for tight shutoff. Two-position valves shall be line size, modulating water valves shall be sized at 3 psi drop or as shown on the drawings. Screwed ends except 2 1/2-inch and larger valves with flanged ends. Select valves to modulate smoothly at all system pressures and flows. Select valves with close-off ratings and spring ranges designed to operate at the maximum flows and maximum available pump heads scheduled without leakage or spring range shift. Bubble tight butterfly valves acceptable on 2 1/2-inch lines and above for two-position action only. Use pressure dependent, two position, motorized valves for controlling water flow to cabinet unit heaters and unit heaters in variable flow heating water systems.
3. Electronic Valve and Damper Operators:
 - a. Electronic modulating type with low voltage DC or current positioning signal or low voltage AC motive power.
 - 1) Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
 - 2) Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator size shall be based on the valve manufacturer's recommendations for flow and pressure differential. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
 - 3) Modulating actuators shall accept 24 VAC or Vdc power supply and be UL listed. The control signal shall be 2-10 Vdc or 4-20 mA. Where required by sequence, the actuator shall provide a clamp position feedback signal of 2-10 Vdc. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a

terminal strip in the control panel for troubleshooting purposes. Use 120 Vac as shown on the drawings.

- 4) Two-position or open/closed actuators shall accept 24 Vac power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller. Use 120 Vac as shown on the drawings.

2.5 LOCAL CONTROL PANELS

- A. All control panels shall be factory constructed, incorporating the BMS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed, as an assembly, and carry a UL 508 label listing compliance. Control panels shall be fully enclosed with perforated sub-panel, hinged door, and slotted flush latch.
- B. General: The control panels shall consist of the DDC controller(s), display module as shown on the drawings, and I/O devices such as relays, transducers, etc., that are not required to be located external to the control panel due to function. The display module shall be flush mounted in the panel face where specified.
- C. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
- D. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service, and provide adequate clearance for field wiring. All wiring shall be neatly installed in plastic trays or tie-wrapped.
- E. Provide a 120 volt convenience outlet, fused on/off power switch, and required transformers in each enclosure.
- F. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75 percent of the rated capacity of the power supply. An appropriately sized fuse and fuse block shall be provided and located next to the power supply. A power disconnect switch shall be provided next to the power supply.
 1. Input: 120 Vac +10%, 60Hz.
 2. Output: 24 Vdc.
 3. Line Regulation: +0.05% for 10% line change.
 4. Load Regulation: +0.05% for 50% load change.
 5. Ripple and Noise: 1 mV rms, 5 mV peak to peak.

2.6 INPUT/OUTPUT (I/O) FUNCTIONS

- A. Analog Inputs (AI): The AI function shall monitor each analog input, perform A-to-D conversion, and hold the digital value in a buffer for interrogation. Provide signal

conditioning for each analog input. Individually calibrate all analog inputs for zero and span, in hardware or in software.

- B. Analog Outputs (AO): The AO function shall accept digital data, perform D-to-A conversion, and output a signal compatible with the operator. Individually calibrate all analog outputs for zero and span. Provide short circuit protection.
- C. Digital Inputs (DI): The DI function shall accept on/off, open/close, or other COS (two-state data) indications. Provide isolation and protection against input voltage up to 180 Vac peak.
- D. Digital Outputs (DO): The DO function shall provide contact closures for momentary and maintained operation of output devices. Closures shall have a minimum duration of 0.1 second.

PART 3 - EXECUTION

3.1 INSTALLATION PRACTICES

- A. Mounting Panels: Locate panels where shown on the drawings or near item of equipment to be controlled, but not on equipment itself.
- B. DDC Field Panels: Locations shown on the drawings are recommended locations and do not indicate actual quantity or location. Provide number of panels required to accommodate all DI, DO, AI, and AO points and all hardware and software to accomplish specified control sequences. Locate all panels in mechanical or electrical rooms. Submit proposed locations for approval prior to preparing control drawings.
- C. Electrical:
 - 1. Provide control wiring for all control devices and control panels.
 - 2. Provide power wiring for all control devices and control panels. Obtain power from spare circuits in emergency power panels.
 - 3. All wiring, including low voltage wiring, shall be installed in minimum 3/4-inch conduit in mechanical rooms or other locations susceptible to damage. Plenum rated cable shall be used in other locations.
 - 4. Grounding: Instrumentation and communication grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.
 - 5. Control voltage shall be limited to a maximum of 120 volts.
 - 6. Where relay coil is connected to load side of motor starter to energize with motor operation, external control circuit shall be properly fused with fuse block located in respective starter enclosure.
 - 7. Where relays are used to control single phase motors directly, provide contacts rated for not less than horsepower rating of largest motor switched by relay.
 - 8. UPS: Provide UPS systems to power all NCM panels. Provide UPS systems to power all combination fire/smoke dampers.

- D. Identification: Provide engraved nameplates identifying all switches, lights and starters, and each control device where control function is not readily apparent.
- E. Room Sensors: Mount at height of 4 feet for wall-mounted sensor and thermostats with adjustment on face. Mount at height of 5 feet for all wall-mounted thermostats and sensors which do not have adjustment face. Provide insulating back on thermostats mounted on exterior walls. Provide one sensor for each zone of temperature control.
- F. Carbon Dioxide Sensors and Oxygen Detectors:
 - 1. Mount at 5 feet above finished floor, or as shown on the drawings.
 - 2. Provide quantity as required by coverage rating (20-foot radius, maximum), or as shown on the drawings.
 - 3. Carbon dioxide sensor shall alarm above 850 PPM.
 - 4. Oxygen detector operating system to maintain 19.5 percent. Alarm if levels exceed 23 percent for longer than 15 minutes.
 - 5. See Sequence of Operations Article in this section for more information.
- G. Airflow Station (Duct-Mounted): Install grid array in ductwork where shown. Provide gasket between frame and duct. Mount electronic components in nearest temperature control panel. Install in accordance with the manufacturer's instructions.
- H. Airflow Station (Fan Inlet): Install in fan inlet bell in accordance with the manufacturer's instructions.
- I. Water Flow Meters: Install devices in accordance with the manufacturer's recommendations, with sufficient upstream and downstream straight pipe to obtain accurate readings.

END OF DOCUMENT 230900

CDH Partners, Inc.
21077.00

Estoria Urgent Care Center

GHS-FD Q2025027
Atlanta, Georgia

THIS PAGE INTENTIONALLY LEFT BLANK