

SECTION 230900 – INSTRUMENTATION AND CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. All work of this Division shall be coordinated and provided by the single Building Management System (BMS) Sub-Contractor.
- B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 23 Sections for details.
- C. The work of this Division shall be as required by the Specifications, Drawings, Point Schedules and Division 230993.
- D. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

1.2 BMS DESCRIPTION

- A. Elyria City School temperature control requirements are as follows:
 - 1. Any software or components installed must NOT require administrator level or higher access to run. Administrator rights for installation is acceptable.
 - 2. Any software must NOT require JAVA to install or operate.
 - 3. Any software must run on Microsoft Windows 10 or Server 2016 or higher and must be compatible with all future upgrades released by Microsoft within three (3) months of the release.
 - 4. Any software must NOT require FLASH to install or operate.
- B. General: The control system shall consist of a peer-to-peer network of digital building control panels and Network Area Controller(s) (NAC) within each facility. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard web browsers, via the Internet and/or local area network. Each NAC shall be capable of communication with the OPEN BACNet controllers. The web browser shall provide users an interface with the system through dynamic color graphics of building areas and systems.
- C. The Facility Management and Control System (FMCS) shall be based on the Niagara 4 Framework™ (or “Gardiner KMC brand), a framework technology developed by Tridium and systems not developed based upon the Niagara 4 Framework™ technology are not acceptable.
- D. All control devices furnished within this section shall be programmed directly through the Niagara 4 workbench embedded toolset upon completion of the project.

- E. Approved manufacturers listed shall be required to provide programming and configuration tools for the BACNet controllers for the project. The use of proprietary configurable and programmable controllers that require additional software tools for post installation maintenance and programming shall not be acceptable.
- E. The Building Management System (BMS) shall be based for use with the enterprise IT systems. This functionality shall extend into the equipment rooms and be capable of providing an integrated solution enhancing the efficiency and life cycle cost through advanced analytics, technical support and service support. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN. This shall consist of control systems for:
- F. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BMS manufacturer for use as a building operation terminal. The primary point of interface on these PCs will be a standard Web Browser.
- G. Where necessary and as dictated elsewhere in these Specifications, Servers shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions. All data stored will be through the use of a standard data base platform: Microsoft Data Engine (MSDE).
- H. The work of the single BMS Sub-Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Point Sheets and Drawings, Division 230993 and the associated interfacing work as referenced in the related documents.
- I. The BMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.
- J. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.
- K. Manage and coordinate the BMS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.
- L. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:

1. Operator information, alarm management and control functions.
 2. Enterprise-level information and control access.
 3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
 4. Diagnostic monitoring and reporting of BMS functions.
 5. Offsite monitoring and management access.
 6. Energy management
 7. Standard applications for terminal HVAC systems.
 8. Indoor Air Quality monitoring and control
- M. Temperature controls contractor shall coordinate tie in of the auxiliary contacts from the control panel into the building automation system for monitoring and alarm of the lift station.

1.3 QUALITY ASSURANCE

A. General

1. The Building Management System Sub-Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems.
2. The term “manufacturer” when used to identify an automatic temperature control sub-contractor/supplier, shall mean the complete system of building energy management. Components of the completed system shall include but not being limited to, hardware equipment, engineering, wiring, installation, sequence of operations, network architecture, commissioning, training, software programming and warranty.
3. The BMS Sub-Contractor shall be a recognized national manufacturer, installer and service provider of BMS.
4. HVAC Contractors installing their own controls will not be accepted. **NO EXCEPTIONS.**
5. The BMS Sub-Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.

6. As evidence and assurance of the contractor's ability to support the Owner's system with service and parts, the contractor must have been in the BMS business for at least the last ten (10) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years.
7. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management System and shall be the manufacturer's latest standard of design at the time of bid.

B. Workplace Safety and Hazardous Materials

1. Provide a safety program in compliance with the Contract Documents.
2. The BMS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.
3. The Contractor and its employees and sub trades comply with federal, state and local safety regulations.
4. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA having jurisdiction for at least each topic listed in the Safety Certification Manual.
5. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.
6. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.
7. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.
8. The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the Authority Having Jurisdiction (AHJ) at the Project site.
9. The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

C. Quality Management Program

1. Designate a competent and experienced employee to provide BMS Project Management. The designated Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the BMS Contractor. At minimum, the Project Manager shall:
 - a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
 - b. Manage the financial aspects of the BMS Contract.
 - c. Coordinate as necessary with other trades.
 - d. Be responsible for the work and actions of the BMS workforce on site.

1.4 REFERENCES

- A. All work shall conform to the following Codes and Standards, as applicable:
 1. National Fire Protection Association (NFPA) Standards.
 2. National Electric Code (NEC) and applicable local Electric Code.
 3. Underwriters Laboratories (UL) listing and labels.
 4. UL 864 UUKL Smoke Control
 5. UL 268 Smoke Detectors.
 6. UL 916 Energy Management
 7. NFPA 70 - National Electrical Code.
 8. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.
 9. American National Standards Institute (ANSI).
 10. National Electric Manufacturer's Association (NEMA).
 11. American Society of Mechanical Engineers (ASME).
 12. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and ASHRAE 62 IAQ as applicable.
 13. Air Movement and Control Association (AMCA).
 14. Institute of Electrical and Electronic Engineers (IEEE).

15. American Standard Code for Information Interchange (ASCII).
 16. Electronics Industries Association (EIA).
 17. Occupational Safety and Health Administration (OSHA).
 18. American Society for Testing and Materials (ASTM).
 19. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.
 20. Americans Disability Act (ADA)
 21. ANSI/ASHRAE Standard 195-2004 (BACnet)
- B. In the case of conflicts or discrepancies, the more stringent regulation shall apply.
- C. All work shall meet the approval of the Authorities Having Jurisdiction at the project site.

1.5 SUBMITTALS

- A. Shop Drawings, Product Data, and Samples
1. The BMS contractor shall submit a list of all shop drawings with submittals dates within 30 days of contract award.
 2. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.
 3. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BMS work.
 4. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.
 5. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
 6. The BMS Contractor shall correct any errors or omissions noted in the first review.
 7. At a minimum, submit the following:
 - a. BMS network architecture diagrams including all nodes and interconnections.

- b. Systems schematics, sequences and flow diagrams.
- c. Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
- d. Samples of Graphic Display screen types and associated menus.
- e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
- f. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
- g. Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
- h. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address and room thermostat specifics.
- i. Details of all BMS interfaces and connections to the work of other trades.
- j. Listing of all read and or write points derived via interfaces to mechanical system components as required per project specifications, sequences of operation, points list(s), and/or required for correct systems operation and functionality. Points shall be identified as to point type (AI, BI, AO, DO, AV, DV), point source (read, write, commandable), interface type (BACnet, N2, etc.) point ID in BMS and point ID in mechanical system, mechanical system source (VFD, RTU, Chiller, etc.), point (object) name (% speed, fan status, cws temp, etc.) and point description (speed of motor, fan on, chilled water supply temperature, etc.)
- k. Product data sheet section with an index identifying each product utilized in the installed BMS system and product data sheet(s) for each product. The index shall individually list each product with the associated numerically sequenced page number(s) of the product data sheets. For all products including software, provide product data sheet(s) or marked catalog pages that include part number, photo, complete specifications and numerically sequenced page number(s) referenced in the index.

1.6 RECORD DOCUMENTATION

A. Operation and Maintenance Manuals

- 1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:

- a. Table of contents.
 - b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
 - c. Manufacturer's product data sheets or catalog pages for all products including software.
 - d. System Operator's manuals.
 - e. Archive copy of all site-specific databases and sequences.
 - f. BMS network diagrams.
 - g. Interfaces to all third-party products and work by other trades.
2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

1.7 WARRANTY

A. Standard Material and Labor Warranty:

1. Provide a two- year labor and material warranty on the BMS.
2. If within twenty- four (24) months from the date of final payment, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Contractor at the cost of the BMS Contractor.
3. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BMS Contractor's normal business hours.

I. OWNERSHIP OF PROPRIETARY MATERIAL

- A. All project-developed hardware and software shall become the property of the Owner. These items include but are not limited to:
 1. Project graphic images
 2. Record drawings
 3. Project database
 4. Project-specific application programming code

5. All documentation
6. All programming tools shall be provided to the owner on a laptop computer or embedded within the Niagara system control system.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

- A. The Building Management System (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 owner provided networks.
- B. The Building Management System shall consist of the following:
 1. Standalone Network Automation Engine(s)
 2. Field Equipment Controller(s)
 3. Input/Output Module(s)
 4. Local Display Device(s)
 5. Distributed User Interface(s)
 6. Network processing, data storage and communications equipment
 8. Other components required for a complete and working BMS
- C. 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 re-using existing controls equipment.
- D. 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.
- E. Acceptable Manufacturers
 1. KMC - Gardiner
 2. Johnson Controls Metasys – Cleveland Branch Office
 3. Siemens Apogee– (Cleveland Branch Office)
 4. Honeywell - (Cleveland Branch Office)
 5. Trane (Cleveland Branch Office)
 6. Schneider Electric – EcoStruxure – (Wadsworth)

2.2. BMS Architecture

- A. Automation Network

1. 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.
2. The BMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.
3. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
4. Network Automation Engines (NAE) shall reside on the automation network.
5. The automation network will 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. Control Network

1. Network Automation Engines shall provide supervisory control over the control network and shall support the following communication protocol:
 - a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
2. Control networks shall provide either “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 shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.
6. The Conformance Statements shall be submitted 10 day prior to bidding.

C. Integration

1. BACnet Protocol Integration – BACnet
 - a. The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2003.

- b. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.
- c. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.
- d. Additional integration protocols can be added

2.3 USER INTERFACE

A. Dedicated Web Based User Interface

- 1. The BMS Contractor shall provide and install a personal computer 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 BMS Network Automation Engines to facilitate greater fault tolerance and reliability.
- 2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third- party applications suppliers, including but not limited to Microsoft Office Applications if required by the BAS manufacturer. Specifically, it must be implemented to conform to the following interface standards.
 - a. Microsoft Internet Explorer for user interface functions
 - b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions
 - c. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports.
 - d. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.
- 3. PC Hardware – One (1) personal computer shall have minimum configuration as follows:
 - a. Memory – 1 GB (512 MB Minimum)
 - b. CPU– Pentium 4 processor. 2.8 Hz Clock Speed (2.0 GHz minimum)
 - c. Hard Drive – 80 GB free hard drive space (40GB minimum)

- d. Hard drive backup system – CD/RW, DVD/RW or network backup software provided by IT department
 - e. CD ROM Drive – 32X performance
 - f. Ports – (2) Serial and (1) parallel, (2) USB ports
 - g. Keyboard – 101 Keyboard and 2 Button Mouse
 - h. CRT configuration – 1-2 CRTs as follows:
 - 1. Each Display – 17” Flat Panel Monitor 1280 x 1024 resolution minimum.
 - 2. 16 bit or higher color resolution
 - 3. Display card with multiple monitor support
 - i. LAN communications – Ethernet communications board; 3Comm or equal.
 - j. Furnish one (1) laptop computers with full BMS functionality for maintenance purposes.
 - k. The Owner will provide information from its IT group regarding the specifications for computers, laptops and servers.
4. Operating System Software
- a. Windows 10 or newer.
 - b. Where user interface 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.
 - c. Provide software registration cards to the Owner for all included software.
5. Peripheral Hardware
- a. Reports printer:
 - 1. Printer Make – Hewlett Packard DeskJet or equivalent
 - 2. Print Speed – 600 DPI Black, 300 DPI Color
 - 3. Buffer – 64 K Input Print Buffer

4. Color Printing – Include Color Kit

B. Distributed Web Based User Interface

1. All features and functions of the dedicated user interface previously defined in this document 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 specifications.
2. The software shall run on the Microsoft Internet Explorer (6.0 or higher) or equivalent browser.
3. Minimum hardware requirements:
 1. 256 MB RAM
 2. 2.0 GHz Clock Speed Pentium 4 Microprocessor.
 3. 40.0 GB Hard Drive.
 4. Keyboard with 83 keys (minimum).
 5. SVGA 1024x768 resolution display with 64K colors and 16 bit color depth.
 6. Mouse or other pointing device

C. User Interface Application Components

1. Operator Interface
 - a. An integrated browser based client application shall be used as the user operator interface program.
 - b. All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.
 - c. The user interface software shall provide help menus and instructions for each operation and/or application.
 - d. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.

- e. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
 - 1. User access for selective information retrieval and control command execution
 - 2. Monitoring and reporting
 - 3. Alarm, non-normal, and return to normal condition annunciation
 - 4. Selective operator override and other control actions
 - 5. Information archiving, manipulation, formatting, display and reporting
 - 6. BMS internal performance supervision and diagnostics
 - 7. On-line access to user HELP menus
 - 8. On-line access to current BMS as-built records and documentation
 - 9. Means for the controlled re-programming, re-configuration of BMS operation and for the manipulation of BMS database information in compliance with the prevailing codes, approvals and regulations for individual BMS applications.
- f. The operation of the control system shall be independent of the user interface, 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 shall not be acceptable.

2. Navigation Trees

- a. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.
- b. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.
- c. The navigation trees shall be “dockable” to other displays in the user interface such as graphics. This means that the trees will appear as part of the display but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.

3. Alarms

- a. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
 - 1. Log date and time of alarm occurrence.
 - 2. Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.
 - 3. Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
 - 4. Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
 - 5. Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.
 - 6. Any attribute of any object in the system may be designated to report an alarm.
- b. The BMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions
- c. The BMS shall annunciate application alarms at minimum, as required by Part 3.

4. Reports and Summaries

- a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:
 - 1. All points in the BMS
 - 2. All points in each BMS application
 - 3. All points in a specific controller
 - 4. All points in a user-defined group of points
 - 5. All points currently in alarm
 - 6. All points locked out
 - 7. All BMS schedules

8. All user defined and adjustable variables, schedules, interlocks and the like.
 - b. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
 - c. 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.
 - d. The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.
5. Schedules
- a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
 1. Weekly schedules
 2. Exception Schedules
 3. Monthly calendars.
 - b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
 - c. It shall be possible to define one or more exception schedules for each schedule including references to calendars
 - d. Monthly calendars shall be provided 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.
 - e. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.
Schedules and Calendars shall comply with ASHRAE SP135/2003 BACnet Standard.
 - f. 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.
6. Password
- a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.

- b. Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.
 - c. The system shall allow each user to change his or her password at will.
 - d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
 - e. A minimum of five levels of access shall be supported individually or in any combination as follows:
 - 1. Level 1 = View Data
 - 2. Level 2 = Command
 - 3. Level 3 = Operator Overrides
 - 4. Level 4 = Database Modification
 - 5. Level 5 = Database Configuration
 - 6. Level 6 = All privileges, including Password Add/Modify
 - f. A minimum of 100 unique passwords shall be supported.
 - g. 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.
 - h. 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; modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.
7. Screen Manager - The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.
8. Dynamic Color Graphics
- a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
 - b. 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.
 - c. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
 - 1. All graphics shall be fully scalable

2. The graphics shall support a maintained aspect ratio.
 3. Multiple fonts shall be supported.
 4. Unique background shall be assignable on a per graphic basis.
 5. The color of all animations and values on displays shall indicate if the status of the object attribute.
 - d. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device
 - e. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations and defining all runtime binding.
 1. The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
 2. In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.
 - f. 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, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.
9. Historical trending and data collection
- a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
 1. Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:
 - Defined time interval
 - Upon a change of value
 2. Each Automation Engine shall have the capability 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.
 - b. Trend and change of value data shall be stored within the engine and uploaded 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.
 - c. The system shall provide a configurable data storage subsystem for the collection of historical data. Data can be stored in either Microsoft Access or SQL database format.

10. Trend data viewing and analysis
 - a. Provide a trend viewing utility that shall have access to all database points.
 - b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
 - c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
 - d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
 - e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
 - f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
 - g. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

2.4 NETWORK AUTOMATION ENGINES (NAE)

A. Network Automation Engine

1. The Network Automation Engine (NAE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.
2. Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.
3. User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
 - a. The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
 - b. The NAE shall support up a minimum of four (4) concurrent users.
 - c. The web based user shall have the capability to access all system data through one NAE.

- d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.
 - e. Systems that require the user to address more than one NAE to access all system information are not acceptable.
 - f. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.
 - g. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
 - h. The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:
 - 1. Configuration
 - 2. Commissioning
 - 3. Data Archiving
 - 4. Monitoring
 - 5. Commanding
 - 6. System Diagnostics
 - i. Systems that require workstation software or modified web browsers are not acceptable.
 - j. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
4. Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.
5. Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
6. Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.
7. The NAE shall include troubleshooting LED indicators to identify the following conditions:
- a. Power - On/Off
 - b. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
 - c. Ethernet Connection Speed – 10 Mbps/100 Mbps
 - d. FC Bus A – Normal Communications/No Field Communications

- e. FC Bus B – Normal Communications/No Field Communications
 - f. Peer Communication – Data Traffic Between NAE Devices
 - g. Run – NAE Running/NAE In Startup/NAE Shutting Down/Software Not Running
 - h. Bat Fault – Battery Defective, Data Protection Battery Not Installed
 - i. 24 VAC – 24 VAC Present/Loss Of 24VAC
 - j. Fault – General Fault
8. Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
- a. Two (2) USB port
 - b. Two (2) URS-232 serial data communication port
 - c. Two (2) RS-485 port
 - d. One (1) Ethernet port
9. Diagnostics – The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
10. Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.
- a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
 - b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.
11. Certification – The NAE shall be listed by Underwriters Laboratories (UL).
12. Controller network – The NAE shall support the following communication protocols on the controller network:

- a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
 1. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.
 2. The Conformance Statements shall be submitted 10 day prior to bidding.
 3. The NAE shall support a minimum of 100 control devices.

2.5 DDC SYSTEM CONTROLLERS

A. Field Equipment Controller

1. The Field Equipment Controller (FEC) with display shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.
2. The FEC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
3. Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.
4. The FEC shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
5. The FEC shall include a removable base to allow pre-wiring without the controller.
6. The FEC shall include troubleshooting LED indicators to identify the following conditions:
 - a. Power On
 - b. Power Off
 - c. Download or Startup in progress, not ready for normal operation
 - d. No Faults

- e. Device Fault
 - f. Field Controller Bus - Normal Data Transmission
 - g. Field Controller Bus - No Data Transmission
 - h. Field Controller Bus - No Communication
 - i. Sensor-Actuator Bus - Normal Data Transmission
 - j. Sensor-Actuator Bus - No Data Transmission
 - k. Sensor-Actuator Bus - No Communication
7. The FEC shall accommodate the direct wiring of analog and binary I/O field points.
8. The FEC shall support the following types of inputs and outputs:
- a. Universal Inputs - shall be configured to monitor any of the following:
 - 1. Analog Input, Voltage Mode
 - 2. Analog Input, Current Mode
 - 3. Analog Input, Resistive Mode
 - 4. Binary Input, Dry Contact Maintained Mode
 - 5. Binary Input, Pulse Counter Mode
 - b. Binary Inputs - shall be configured to monitor either of the following:
 - 1. Dry Contact Maintained Mode
 - 2. Pulse Counter Mode
 - c. Analog Outputs - shall be configured to output either of the following:
 - 1. Analog Output, Voltage Mode
 - 2. Analog Output, current Mode
 - d. Binary Outputs - shall output the following:
 - 1. 24 VAC Triac
 - e. Configurable Outputs - shall be capable of the following:
 - 1. Analog Output, Voltage Mode

2. Binary Output Mode

9. The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).
 - a. The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
 - b. The FC Bus shall support communications between the FECs and the NAE.
 - c. The FC Bus shall also support Input/Output Module (IOM) communications with the FEC and with the NAE.
 - d. The FC Bus shall support a minimum of 100 IOMs and FEC in any combination.
 - e. The FC Bus shall operate at a maximum distance of 15, 00 Ft. between the FEC and the furthest connected device.
10. The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).
 - a. The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
 - b. The SA Bus shall support a minimum of 10 devices per trunk.
 - c. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.
11. The FEC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.
12. The FEC shall support, but not be limited to, the following:
 - a. Rooftop units for special application
 - b. Terminal units
 - c. Special programs as required for systems control
13. Hand–Off–Auto Override Switches shall be included on all control outputs that are associated with all the primary HVAC System equipment. These switches shall be hardwired such that no BAS system communications will be required. Overrides shall be physical and not through software or graphical screens. Overrides shall be for binary, analog and triac outputs.

14. Hand-Off-Auto Override Switches shall be monitored through the BAS system. Any output placed in the hand position shall be annunciated through the BAS system software so that the operator is aware of the condition

2.6 FIELD DEVICES

A. Input/Output Module (IOM X710)

1. The Input/Output Module (IOM) provides additional inputs and outputs for use in the FEC.
2. The IOM shall communicate with the FEC over either the FC Bus or the SA Bus using BACnet Standard protocol SSPC-135, Clause 9.
3. The IOM shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
4. The IOM shall have a minimum of 4 points to a maximum of 17 points.
5. The IOM shall support the following types of inputs and outputs:
 - a. Universal Inputs - shall be configured to monitor any of the following:
 1. Analog Input, Voltage Mode
 2. Analog Input, Current Mode
 3. Analog Input, Resistive Mode
 4. Binary Input, Dry Contact Maintained Mode
 5. Binary Input, Pulse Counter Mode
 - b. Binary Inputs - shall be configured to monitor either of the following:
 1. Dry Contact Maintained Mode
 2. Pulse Counter Mode
 - c. Analog Outputs - shall be configured to output either of the following:
 1. Analog Output, Voltage Mode
 2. Analog Output, Current Mode
 - d. Binary Outputs - shall output the following:
 1. 24 VAC Triac

- e. Configurable Outputs - shall be capable of the following:
 - 1. Analog Output, Voltage Mode
 - 2. Binary Output Mode
- 6. The IOM shall include troubleshooting LED indicators to identify the following conditions:
 - a. Power On
 - b. Power Off
 - c. Download or Startup in progress, not ready for normal operation
 - d. No Faults
 - e. Device Fault
 - f. Normal Data Transmission
 - g. No Data Transmission
 - h. No Communication
- B. Network Sensors
 - 1. The Network Sensors (NS) shall have the ability to monitor the following variables as required by the systems sequence of operations:
 - a. Zone Temperature
 - b. Zone humidity
 - c. Zone setpoint
 - 2. The NS shall transmit the zone information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135, Clause 9.
 - 3. The Network Sensors shall include the following items:
 - a. A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint.
 - b. An LED to indicate the status of the Override feature.
 - c. A button to toggle the temperature display between Fahrenheit and Celsius.

- d. A button to initiate a timed override command
- 4. The NS shall be available with either screw terminals or phone jack.
- 5. The NS shall be available in either surface mount or wall mount styles.

2.7 INPUT DEVICES

A. General Requirements

- 1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Temperature Sensors

1. General Requirements:

- a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
- b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
- c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Room Temp	$\pm .5^{\circ}\text{F.}$
Duct Temperature	$\pm .5^{\circ}\text{F.}$
All Others	$\pm .75^{\circ}\text{F.}$

2. Room Temperature Sensors

- a. Room sensors shall be constructed for either surface or wall box mounting.
- b. Room sensors shall have the following options when specified:
 - 1. Setpoint reset slide switch providing a ± 3 Degree (adjustable) range.
 - 2. Individual heating/cooling setpoint slide switches.

3. A momentary override request push button for activation of after-hours operation.
 4. Analog thermometer.
3. Room Temperature Sensors with Integral Display
 - a. Room sensors shall be constructed for either surface or wall box mounting.
 - b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:
 1. Display room and outside air temperatures.
 2. Display and adjust room comfort setpoint.
 3. Display and adjust fan operation status.
 4. Timed override request push button with LED status for activation of after hours operation.
 5. Display controller mode.

Password selectable adjustment of setpoint and override modes.
4. Blank Control Sensor
 - a. For use in common space transient areas such as corridors
 - b. No manual temperature adjustment shall be available. All adjustability shall be from the BAS system.
 - c. Shall be mounted at a height above the locker height and temperature offset to represent the temperature reading at normal mounting height.
5. Outside Air Sensors
 - a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
 - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
 - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
6. Duct Mount Sensors

- a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
- b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
- c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

7. Averaging Sensors

- a. For ductwork greater in any dimension than 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.
- b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
- c. Capillary supports at the sides of the duct shall be provided to support the sensing string.

8. Humidity Sensors

- a. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
- b. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
- c. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
- d. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with seal-tite fittings and stainless- steel bushings.
- i. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
- j. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
- k. Acceptable Manufacturers: Johnson Controls, Veris Industries, and Mamac.

9. Duct Shielded Static Pressure Probe
 - a. Probes shall be complete with mounting bracket, noise suppression chamber and brass compression connector.
10. Differential Pressure Transmitters
 - a. Air type: Transmitter shall be provided in a NEMA enclosure with barbed fittings for connection of signal lines. Wiring terminations shall be short circuit and reverse polarity protected. Accuracy shall be +/- 1 % full scale with an over pressure rating of 10 psi. Transmitter shall be temperature compensated from 25 to 150 deg. F. with an operating range of 0 to 175 deg. F. Output shall be 4 to 20 ma.
 - b. Wet type: Shall be enclosed in a NEMA enclosure with a 5 valve bypass assembly. Transmitter shall have an over pressure rating of at least 200 psi on either port without permanent damage. Transmitter shall have externally accessible zero and span adjustments. Transmitter shall have a static error band of +/- .5% full scale including linearity, hysteresis and repeatability. Output of transmitter shall be 4 to 20 ma.
 - c. Industrial Grade: Shall use silicon strain gauge technology and a two-wire d/p Cell transmitter to measure the difference between two pressures and transmit a proportional (or square root) 4-20 mA output signal. Differential pressure transmitters shall be used in conjunction with Venturi Flow Stations and shall be as manufactured by Foxboro, Rosemount or approved equal with the following specification requirements:

Zero Suppression: To upper range limit minus the span
Ambient Temperature Effect: Total effect for a 100 DEGF change within Normal Operating Conditions limits is + or - (0.2% of URL +0.1% of span)
Accuracy (Includes linearity, Hysteresis, and Repeatability): + or - 0.20% of calibration span for spans less than 6.7% of URL
Over range Limit (DP) and Maximum Static Pressure: 25 Mpa, 3625 psi, 250 bar or kg/ (cm*cm). Either side may be higher pressure during over range.
11. Flow Monitoring – Supply, Return Fan and Toilet Exhaust
 - a. Air Flow Monitoring
 1. Fan Inlet Air Flow Measuring Stations
 1. At the inlet of each fan and near the exit of the inlet sound trap, airflow traverse probes shall be provided that shall continuously monitor the fan air volumes and system velocity pressure.
 2. Each traverse probe shall be of a dual manifolded, cylindrical, type 3003 extruded aluminum configuration, having an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching airflow. The manifold should not have forward projecting sensors into the air

stream. The static pressure manifold shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as $\pm 20^\circ$ in the approaching air stream.

3. The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Each airflow-measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.
4. Airflow measuring stations shall be manufactured by Air Monitor Corp., Tek-Air Systems, Inc., Ebtron, or Dietrich Standard.

2. Single Probe Air Flow Measuring Sensor

1. The single probe airflow-measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a hot wire anemometer and utilize two temperature sensors and a heater element temperature. The other sensor shall measure the downstream air temperature. The temperature differential shall be directly related to airflow velocity.

3. Duct Air Flow Measuring Stations

1. Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.
2. Airflow measuring stations shall be fabricated of 14-gauge galvanized steel welded casing with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 6000 feet per minute. This air directionalizer and parallel cell honeycomb suppressor shall provide 98% free area, equalize the velocity profile, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.
3. The total pressure measurement side (high side) will be designed and spaced to the Industrial Ventilation Manual 16th Edition, Page 9-5. The self-averaging manifold will be manufactured of brass and copper components.

4. The static pressure sensing probes (low side) shall be bullet-nosed shaped, per detailed radius, as illustrated in Industrial Ventilation Manual 16th Edition, Page 9-5.
5. The main take-off point from both the total pressure and the static pressure manifolds must be symmetrical.
6. Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.

Installation Considerations

- a. The maximum allowable pressure loss through the Flow and Static Pressure elements shall not exceed .065" w.c. at 1000 feet per minute, or .23" w.c. at 2000 feet per minute. Each unit shall measure the airflow rate within an accuracy of plus 2% as determined by U.S. – GSA certification tests and shall contain a minimum of one total pressure sensor per 36 square inches of unit measuring area.
 - b. The units shall have a self-generated sound rating of less than NC40, and the sound level within the duct shall not be amplified nor shall additional sound be generated.
 - c. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
 - d. Where control dampers are shown as part of the airflow measuring station, opposed blade precision controlled volume dampers integral to the station and complete with actuator, pilot positioner, and linkage shall be provided.
 - e. Stations shall be installed in strict accordance with the manufacturer's published requirements, and in accordance with ASME Guidelines affecting non-standard approach conditions.
 7. Acceptable manufacturers: Air Monitor Corp., Tek-Air, Ebtron, and Dietrich Standard.
4. Static Pressure Traverse Probe
- a. Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple

static pressure sensors located along exterior surface of the cylindrical probe.

b. Acceptable manufacturers: Cleveland Controls

5. Shielded Static Air Probe

a. A shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.

2. Water Flow Monitoring

1. Water flow meters shall be electromagnetic type with integral microprocessor-Based electronics. The meter shall have an accuracy of 0.25%.
2. Acceptable manufacturers: Onicon

C. Smoke Detectors

1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 26 for installation under Division 23. All wiring for air duct detectors shall be provided under Division 26, Fire Alarm System.

D. Status and Safety Switches

1. General Requirements

- a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. 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

3. Low Temperature Limit Switches

- a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
- b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
- c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
- d. The low temperature limit switch shall be equal to Johnson Controls A70.

4. Differential Pressure Switches

- a. Air type: Shall be diaphragm actuated type with a single-pole, double-throw, snap-acting switch. Motion of the diaphragm shall be restrained by a calibrated spring that can be adjusted to set the exact pressure differential at which the electrical switch will be actuated. Motion of the diaphragm shall be transmitted to the switch button by means of a direct mechanical linkage. Electrical rating shall be 6.0 amps at 120 VAC. Pressure range and temperature limits shall be suitable for the application. Switch shall be utilized in conjunction with static pressure probes when utilized across filters, and a static pressure probe on the low side and a velocity probe on the high side when utilized across a fan.
- b. Water type: Shall be diaphragm-actuated type with a single-pole, double-throw snap-acting switch. Motion of the diaphragm shall be restrained by a calibrated spring that can be adjusted to set the exact pressure differential at which the electrical switch will be actuated. Switch shall be utilized in conjunction with shut off valves on the low and high sides of the switch to allow for ease of service.

2.8 OUTPUT DEVICES

A. Actuators

1. General Requirements

- a. Damper and valve actuators shall be electronic, as specified in the System Description section.

2. Electronic Damper Actuators
 - a. Electronic damper actuators shall be direct shaft mount.
 - b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
 - c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and 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 one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
 - d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, 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 associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

B. Control Dampers

1. The BMS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor or as specifically indicated on the Drawings.
2. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.
3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.
5. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g. Acceptable manufacturers are Johnson Controls D-7250 D-1250 or D-1300, Ruskin CD50, and Vent Products 5650.
6. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800.
7. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

C. Control Relays

1. Control Pilot Relays
 - a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
 - b. Mounting Bases shall be snap-mount.
 - c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
 - d. Contacts shall be rated for 10 amps at 120VAC.
 - e. Relays shall have an integral indicator light and check button.
 - f. Acceptable manufacturers: Johnson Controls, Potter and Brumfield, RIB

2.9 MISCELLANEOUS DEVICES

A. Local Control Panels

1. 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.
2. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
3. All panel wiring shall be to and from terminal strips. The use of wire nuts for connection of wiring to or from a common point is not acceptable.
4. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
5. 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.
6. All wiring shall be neatly installed in plastic trays or tie-wrapped.
7. All wiring shall be identified.
8. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

B. Power Supplies

1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
2. Input: 120 VAC +10%, 60Hz.
3. Output: 24 VDC.
4. Line Regulation: +0.05% for 10% line change.
5. Load Regulation: +0.05% for 50% load change.
6. Ripple and Noise: 1 mV rms, 5 mV peak to peak.
7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.

8. A power disconnect switch shall be provided next to the power supply.

C. Thermostats

1. Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

D. Lexan Thermostat Guards

1. All thermostats located in public and non-supervised areas shall be fitted with tamperproof Lexan guards.

E. CO2 Sensors

1. Where shown on the drawings, CO2 sensors shall have the following features:
 - a. Jumper selectable: 0-20mA, 4-20mA & 0-10VDC output
 - b. Liquid Crystal Display
2. The CO2 sensors shall have the ability to monitor and output the following variables as required by the systems sequence of operations:
 - a. Zone carbon-dioxide
3. The CO2 shall transmit the information back to the controller via jumper selectable 0-20mA, 4-20mA & 0-10VDC output signals.
 - a. The CO2 sensors shall provide a maximum output current of 25mA; Maximum output voltage of 12.5V.
 - b. The CO2 sensors shall be FCC compliant to CFR47 Part 15 subpart B Class A.
4. The CO2 Sensors shall be available with
 - a. CO2 response time (0-63%) of 1 minute
 - b. Less than 0.083% of full scale/F° temperature dependence of CO2 output
 - c. Long term CO2 stability $\pm 5\%$ of full scale for 5 years
 - d. CO2 measurement accuracy of $\pm(40\text{ppm} + 2.0\%$ of reading)
 - e. CO2 non-linearity of less than 1.0% of full scale
5. The CO2 Sensors may include the following items:
 - a. Relay output module
 - b. Liquid Crystal Display module
 - c. Analog temperature module with linear 0-10VDC output for 32-122F

PART 3 – PERFORMANCE / EXECUTION

3.1 BMS Specific Requirements

A. Graphic Displays

1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.
3. Temperature Control Contractor shall coordinate all graphics with final room signage.

B. Custom Reports:

1. Provide custom reports as required for this project:

C. Actuation / Control Type

1. Primary Equipment

- a. Controls shall be provided by equipment manufacturer as specified herein.
- b. All damper and valve actuation shall be electric.

2. Roof Top Unit Equipment

- a. All roof top units shall be controlled with a HVAC-DDC Controller
- b. All damper and valve actuation shall be electric.

3.2 Installation Practices

- A. All control and interlock wiring shall comply with the national and local electrical codes and Division 26 of these specifications. Where the requirements of this section differ with those in Division 26, the requirements of this section shall take precedence.
- B. Where Class 2 wires are in concealed and accessible locations - including ceiling return air plenums, approved cables not in raceway may be used provided that:
 1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
 2. All cables shall be UL listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.

- C. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).
- D. Where class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 3 m [10 ft] intervals. Such bundled cable shall be fastened to the structure, using specified fasteners, at 1.5 m [5 ft] intervals or more often to achieve a neat and workmanlike result.
- E. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- F. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, the Control System Contractor shall provide step down transformers.
- G. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.
- H. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.
- I. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation and NEC.
- J. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.
- K. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.
- L. Adhere to Division 26 requirements for installation of raceway.
- M. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- N. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.3 Training

- A. The BMS contractor shall provide the following training services:
 - 1. 40 Hours of on-site training broken down into 4-hour sessions by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project

as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.4 Acceptance

- A. The control systems will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.

3.5 Software License

- A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). The owner, or his appointed agent, shall determine which organizations to be named in the “**orgid**” of all Niagara Framework™ and BAS system software licenses and programming tools required for ongoing system maintenance and reprogramming.

END OF SECTION 230900

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