ADDITIONAL NO. 3
March 22, 2018

Window Replacements & HVAC Upgrade (Eastern Middle School) Bid
Opening Date: 3/15/18
Opening Time: 11:00 a.m.
RFB # 2195-18

This Addendum No. 3 is being issued to make changes in the bid specifications. See following:
SECTION 23 09 00 - HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 1 Specification Sections, apply to this section.

1.2 SUMMARY
   A. This Section includes control equipment for HVAC systems and components, including control
      components for terminal heating and cooling units not supplied with factory-wired controls.

1.3 DEFINITIONS
   A. AHU: Air Handling Unit.
   B. ATC: Automatic Temperature Control.
   C. BMS: Building Management System.
   D. CFM: Cubic Feet per Minute.
   E. DDC: Direct-digital controls.
   F. HVAC: Heating, Ventilating and Air Conditioning.
   G. LAN: Local area network.
   H. LCD: Liquid Crystal Display
   I. MER: Mechanical Equipment Room.
   J. PID: Proportional Integral Derivative.
   K. POT: Portable Operators Terminal.
   L. VFD: Variable Frequency Drive.

1.4 SYSTEM DESCRIPTION
   A. Control system shall consist of sensors, indicators, actuators, final control elements, interface
      equipment, other apparatus, accessories and software connected to distributed controllers
      operating in multiuser, multitasking environment on a network and programmed to control
      mechanical systems. An operator workstation permits interface with the network via dynamic
      color graphics with each mechanical system, building floor plan and control device depicted by
      point-and-click graphics.

   B. The new control system shall be compatible with the existing Automated Logic (ALC) WebCtrl
      BMS. Provide a seamless tie-in to the existing ALC BMS. Tie-in shall be made via an
      extension of the existing BMS local area network.
C. Furnish a totally BACnet-based system, based on a distributed control system in accordance with this specification. The operator’s workstation, all controllers and all input/output devices shall communicate using the protocols and network standards as defined by the latest version of ANSI/ASHRAE Standard 135 - BACnet. In other words, all workstations and controllers shall be BACnet devices. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to existing systems or to systems installed under other sections. Use of proprietary protocol on any part of the network is prohibited.

1.5 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

B. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
   1. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
   2. Object Command: Reaction time of less than 2 seconds between operator command of a binary object and device reaction.
   3. Object Scan: Transmit change of state and change of analog values to control units or workstation within 6 seconds.
   4. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within 5 seconds of each other.

1.6 WORK INCLUDED

A. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all supervisory controllers, network controllers, logic controllers and all input/output devices. Items of work included are as follows:
   1. Provide a submittal that meets the requirements below for approval.
   2. Coordinate installation schedule with the mechanical contractor and general contractor.
   3. Provide installation of all panels and devices unless otherwise stated.
   4. Provide power for panels and control devices from a source designated by the electrical contractor. All 120 volt power circuits to the DDC panel(s) shall be provided by this Contractor (unless specifically shown on the electrical drawings).
   5. Provide all low voltage control wiring for the DDC system. All wiring of sensors and control devices including any power wiring of devices and necessary conduit shall be provided under this section of the specifications.
   6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.
   7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.
8. Provide testing, demonstration and training as specified below.

9. Provide all necessary BACnet-compliant hardware and software to meet the system’s functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system.

10. The BMS contractor shall provide an alternate price (ALT-1) to replace the existing BMS server with new. The BMS server licensing options shall allow a minimum of five (5) local workstation connections/access concurrently. The web server licensing options shall allow concurrent access by a minimum of five (5) remove browser connections. These licenses shall be in addition to the five (5) licenses assigned for local connections.

B. The successful bidder shall provide a seamless tie-in to the existing ALC BMS. This shall include all modification as needed for the existing BMS and control points and sequence of operations defined in this specification.

1.7 SUBMITTALS

A. One (1) submittal package shall be provided for the project that includes information for controls for all systems being provided as part of the project. Partial submittals are not acceptable and shall not be reviewed by the Engineer. For example, it is not acceptable to submit a control valve schedule as part of one package and control diagrams as part of a later package. For large projects or where partial submittals may be required to maintain the project schedule, the contractor shall coordinate a schedule for delivery of each partial submittal and the items to be contained within each submittal. It shall not be up to the contractor’s discretion as to what shall be included in each partial submittal.

B. Product Data: Include manufacturer’s technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials and installation and startup instructions for each type of product indicated.

1. Each control device labeled with setting or adjustable range of control.

2. DDC System Hardware: Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels and operator interface equipment.

3. Control System Software: Include technical data for operating system software, operator interface, color graphics and other third-party applications.

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

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection. Submittal shall include the following as a minimum:

1. Schematic flow diagrams showing fans, coils, dampers, valves, instrumentation and control devices.

3. Architecture drawing including all communication wiring, network devices, etc. Indicate type of cabling and number of conductors.

4. Symbol and abbreviation list for control diagrams.

5. Points list including hardwired and software points.

6. Manufacturer’s technical cut sheets which include a table of contents and an associated sheet numbering system for all pages. Model number shall be circled or pointed with an arrow.

7. A complete bill of materials specific to each system detailing the equipment to be used, quantity, manufacturer, specific model number and tag number.

8. List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule and operator notations.

9. Details of control panel faces, including controls, instruments and labeling.

10. Schedule of dampers including size, leakage and flow characteristics.

11. Schedule of valves including leakage, flow characteristics, GPM, design pressure drop, actual pressure drop, design CV, calculated CV, valve body pressure rating, and close-off pressure rating at a minimum.

12. All shop drawings used by field personnel for the installation of equipment shall bear an Engineer’s approval stamp.

13. Architectural floor plans indicating proposed locations of all wall-mounted devices (i.e., DDC units, control panels, sensors, thermostats, etc.) and mechanical drawings indicating proposed locations of all temperature, flow and pressure transmitters.


D. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with the latest version of ASHRAE 135 related to BACnet.

E. Samples for Initial Selection: For each color required, of each type of thermostat and/or sensor cover with factory-applied color finishes.

F. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device.


3. Inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.

4. Calibration records and list of set points.
G. The BMS Contractor shall correct any errors or omissions noted by the Owner and Engineer during review.

H. Device substitutions shall be considered as long as they are submitted to the engineer one week in advance of the bid via a formal RFI. Contractor shall provide a technical comparison in spreadsheet format that includes, at a minimum, comparison of physical size, accuracy, drift, cost, turndown, options provided, device warranty, as applicable.

1.8 SEQUENCING AND SCHEDULING

A. Sequence and coordinate the work of this Section with the scheduling requirements and the Engineer. Review the approved schedule with the Engineer, sub-contractors, manufacturers, vendors, suppliers and all other contractors. Schedule and sequence all Work with the adjoining Work, and Work of others such that the all Work can be accomplished concurrently during the same time period.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who is an authorized representative of the automatic control system manufacturer for both installation and maintenance of units required for this Project.

B. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction and marked for intended use.

C. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

D. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

E. All portions of the system must be designed, furnished, installed, commissioned and serviced by manufacturer-approved, factory-trained employees.

F. Single source responsibility of supplier shall be the complete installation and proper operation of the BMS and control system and shall include debugging and proper calibration of each component in the entire system.

G. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

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

I. BMS shall comply with UL 916 PAZX and 864 UDTZ and be so listed at the time of bid.

J. System devices shall have UL 864 (UUKL smoke control) and shall be so certified at time of bid, if the system is being used for smoke control or life safety.

K. All system components shall be fault-tolerant. System shall include:
1. Satisfactory operation without damage at 110% and 90% of rated voltage and at plus 3 Hertz variation in line frequency.

2. Static, transient and short-circuit protection on all inputs and outputs.

3. Protection for communication lines against incorrect wiring, static transients and induced magnetic interference.

4. Network-connected devices to be AC coupled or equivalent so that any single device failure will not disrupt or halt network communication.

5. All real time clocks and data file RAM to be battery-backed for a minimum 100 hours and include local and remote system low battery indication.

L. The BMS contractor shall be regularly engaged in the installation and maintenance of BMS systems and shall meet the following qualifications.

1. A minimum of 10 years of demonstrated technical expertise and experience in the installation and maintenance of BMS systems similar in size and complexity to this project.

2. A minimum of 10 years experience installing the control system of the manufacturer that is to be proposed.

3. Shall be a certified-to-install, direct representative of a control system manufacturer that has a minimum of 10 years experience producing control systems similar to that which is to be proposed.

4. A maintained service organization consisting of at least 8 competent servicemen, within 50 miles of the project site, for a period of not less than 10 years.

5. The Bidder shall not be considered qualified to bid this project unless they can provide a list of 10 projects, similar in size and scope to this project, completed within the last 4 years.

6. The system manufacturer/installer shall provide an experienced project manager for this work from beginning of control installation until final completion. The project manager is responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion. If the BMS manufacturer wishes to change the project manager, the construction manager and/or owner’s representative must be notified immediately and both the new project manager and the previous project manager shall spend three (3) consecutive business days together on-site performing a project management switchover. Exceptions may be allowed for small projects as determined by the construction manager and/or owner’s representative.

M. Comply with all current governing codes, ordinances and regulations including UL, NFPA, the local Building Code, NEC, etc.

N. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be
defined as the ability for any existing control system component including but not limited to primary control panels, secondary control panels, personal operator workstations and portable operator’s terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters.

1.10 DELIVERY, STORAGE AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

B. Provide factory shipping cartons for each piece of equipment and control device. Maintain cartons while shipping, storing and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather. The stored products shall be protected from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

C. System Software: Update to latest version of software at project completion.

1.11 COORDINATION

A. Coordinate location of temperature sensors, humidity sensors and other exposed control sensors with plans and room details before installation.

B. Coordinate installation of taps, valves, airflow stations, etc. with the mechanical contractor.

C. Coordinate BMS equipment with all relevant divisions including, but not limited to, Fire Alarm to achieve compatibility with equipment that interfaces with that system.

D. Coordinate BMS equipment to achieve compatibility with motor starters and annunciation devices.

1.12 EXTRA MATERIALS

A. Maintenance Materials: One (1) thermostat adjusting key.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers/Authorized dealers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:

1. Automated Logic Corporation.

2. Niagara Tridium

3. Approved Niagara Equal

2.2 CONTROL PANELS

A. Fully enclosed, steel-rack-type cabinet with locking doors or locking removable backs. Match finish of panels and provide laminated as-built wiring diagrams, flow diagrams, etc. related to the system being controlled inside the associated cabinet. Each control panel shall be clearly
and permanently labeled with the controller designation and indication of the mechanical equipment served.

B. Where applicable, existing primary control panel enclosures shall be reused where possible. Replacement of any control panel enclosure and sub-panel shall be included in the base contract.

C. Unitize cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels.

1. Fabricate panels of furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. All panels shall have common keying.

2. Primary control panel: Provide minimum NEMA 1 rating for indoor application and NEMA 4 rating for outdoor application or the appropriate NEMA rating for application. Electrical piping and wiring shall be penetrated through the bottom of the panel with 4 inches nipples and 4 inches wiring trough.

3. Secondary control panel: Provide minimum NEMA 1 rating for indoor application.

4. Size control panel enclosures for twenty percent spare mounting capacity for future expansion.

5. Only one controller shall be allowed in a control panel with expansion modules if extra points are needed. The BMS vendor shall utilize the largest controller available in the product line to accommodate the points required. If maxed out, only then should a second controller be installed within the panel.

D. Control panel shop drawings shall be submitted for each system (air handling unit, chilled water system, hot water system, etc.) for approval prior to fabrication.

E. Coordinate installation of the control panels with the engineer/architect. Coordinate power for the panels with the electrical contractor.

F. Control Panel Internal Components:

1. Provide identification sleeves at each termination at the terminal strip.

2. All control panels shall be provided with DIN Rail mounted screw terminal blocks. Field wiring shall be connected to the screw terminal blocks. It is not acceptable to terminate any field wiring directly to the DDC controller or any panel devices such as relay and transducers. The screw terminal blocks located/attached to the DDC controller alone does not comply with this requirement. Terminal blocks shall be rated for 300 volts, medium duty. Provide Phoenix Feed-through terminal block UT 2,5 or pre-approved equal.

3. All control devices such as relays, transformers, transducers, power supplies, associated I/O devices, etc shall be installed inside the panel, not at the starter or electrical junction box.

4. All panel wirings shall in be installed in Panduit and wiring duct. This shall include but not be limited to wiring from the DDC controller to the terminal block, between DDC
controller and relay (and other panel mounted control devices), power wiring for the controller, communication, etc.

5. Mounting any control devices on the back of the control panel enclosure door is not acceptable.

6. The use of wire nuts in the control panel enclosures is also prohibited.

G. Power wiring and communication wiring shall be provided in separate conduits with separate hot, neutral, and ground wire runs and separate breakers.

H. Coordinate installation of the control panels with the engineer/architect. Coordinate power for the panels with the electrical contractor.

2.3 BMS SYSTEM ARCHITECTURE

A. The BMS system shall use a Client/Server architecture based on a modular PC network, utilizing industry standard operating systems, networks and protocols.

B. The system shall allow the distribution of system functions such as monitoring and control and graphical user interface etc. across the network to achieve maximum flexibility and performance.

C. Data communications protocol shall be BACnet and shall comply with the latest version of ASHRAE 135.

D. The BMS shall communicate over the primary network via TCP/IP over Ethernet.

E. The primary network will consist of Ethernet communication backbone and CAT6 horizontal homeruns from the floor level network switch to the individual primary controllers.

2.4 BMS NETWORK

A. The design of the BMS shall network the BMS server or servers, personal computer operator workstations (if applicable), primary control panels and secondary control panels. The network architecture shall consist of multiple network levels. Provide a peer-to-peer Primary Network to connect the server, operator workstation(s) and all primary control panels in the building for global system operation. Provide secondary networks to connect from each primary control panel to the secondary control panels of associated terminal equipment.

B. Access to system data shall not be restricted by the hardware configuration of the BMS. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

C. The BMS design shall allow the co-existence of current and future primary control panels and personal computer operator workstations on the same primary network.

D. The BMS contractor shall provide new supervisory controllers/routers as required to connect to all new controllers being installed as part of this project, while still keeping with all requirements such as spare capacity requirements, etc.

E. The network shall not be utilized to send data required by a control algorithm from one controller to another. The data shall be a direct input to the controller containing the control
algorithm. If multiple controllers require the same piece of data for a control algorithm, the data shall be an input to each controller.

F. Primary Peer-to-Peer Network

1. All operator workstations and primary controllers shall directly reside on a network such that communications (i.e., ability to access, edit, modify, add, delete, back up, report, trend, restore all system point database and all programs) may be executed directly between servers, primary control panels, and operator workstations on a peer-to-peer basis.

2. All operator devices either network resident or connected via intranet and internet, shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the primary network or the secondary network. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.

3. The primary network shall provide the following minimum performance:

   a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Control Panel is displayed at any PC workstation, standalone alarm printer and/or Control Panel within 5 seconds.

   b. Support of any combination of primary control panels and operator workstations directly connected to the primary network. A minimum of 64 devices and a maximum of 100 devices shall be supported on a single primary network.

   c. Message and alarm buffering to prevent information from being lost.

   d. Error detection, correction and re-transmission to guarantee data integrity.

   e. Synchronization of real-time clocks between server, primary control panels, and operator workstations, including automatic daylight savings time corrections.

   f. Provide network wiring as required to ensure total system operation and communication without interruption, even if the network wiring is open in one (1) location.

   g. The primary network shall allow the primary control panels to access any data from, or send control commands and alarm reports directly to, any other primary control panel or combination of controllers on the network without dependence upon a central or intermediate processing device. The primary control panel shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The peer-to-peer network shall also allow any primary control panel to access, edit, modify, add, delete, back up, restore all system point database and all programs.

   h. The primary network shall allow the primary control panels to assign password access and control priorities to each system individually. The logon password (at
any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the system that the operator is authorized for. All other systems shall not be displayed at the PC workstation or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.

i. Each personal computer operator workstation shall support hardwired and dial up type primary networks.

G. Secondary Network

1. This network shall connect and support stand-alone secondary control panels and shall communicate bi-directionally with the primary network through primary control panels for transmission of global data. A sufficient number of primary control panels shall be provided for connection of secondary networks based on quantity of secondary controls panels and distance limitations.

2. Secondary control panels shall be arranged on the secondary network in a functional relationship manner with the primary control panels. For example, a VAV secondary control panel on a secondary network of a primary control panel that is controlling the VAV’s corresponding AHU.

3. A maximum of 60 secondary control panels may be configured on an individual secondary network to insure adequate global data and alarm response times and future space capacity.

4. The Secondary Network shall be connected to and communicate with the primary control panel independently.

2.5 PRIMARY CONTROL PANEL HARDWARE

A. Provide one (1) primary control panel for integration to the rooftop unit factory package controls, if needed.

B. ASHRAE 135 Compliance: Primary control panels shall use the latest version of BACnet/ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

C. Spare Capacity

1. All primary control panels shall be installed with 10% spare points (of each type) and 10% spare memory capacity for future connections. The type of spare point capacity shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two (2) spares of each implemented I/O type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2. Provide all processors, power supplies and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:
a. Expansion modules.
b. Sensor/actuator.
c. Field wiring/tubing.

D. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each primary control panel. Primary control panels shall not be dependent upon any higher level computer or another controller for operation.

E. Each primary control panel shall, at a minimum, be provided with:

1. Appropriate NEMA 12 rated metal enclosure.
2. An integral real-time clock.
4. Primary Network communication module, if needed for primary network communications.
5. Secondary Network communication module, if needed for secondary network communications.
6. Memory to accommodate all primary control panel software requirements, including but not limited to, its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications. Controller shall have a minimum of 32 MB RAM, 1 MB of flash, and 16K EPROM or EEPROM. Controller shall be provided with battery backup capable of supporting all RAM, clock functions, DDC database and operating programs within the controller for a minimum of 72 hours in the event of power failure or power interruption (if information is not stored in non-volatile memory).
7. Data collection/ Data Trend module sized for 10,000 data samples.
8. Power supplies as required for all associated modules, sensors, actuators, etc.
9. Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.
10. A portable operator terminal connection port to allow the temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
11. Monitoring of the status of all HOA switches. The status of the HOA switch shall be available as a BMS data point.
12. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
13. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent to the primary enclosure.

14. Local status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.

F. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. These override switches shall be operable whether the panel processor is operational or not. Provide HOA switch for each digital output, including spares. Provide hand/auto switch and gradual positioning potentiometer for each analog output, including spares.

G. Each primary control panel shall continuously perform self-diagnostics on all hardware modules and network communications. The primary control panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication with any system.

H. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM.

I. Each primary control panel shall support firmware upgrades without the need to replace hardware.

J. Primary control panels shall provide at least two (2) EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

K. Immunity to power and noise.
   1. Controller shall be able to operate at 90% – 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
   2. Operation shall be protected against electrical noise of 5 – 120 Hz and from keyed radios up to 5W at 1m (3’).
   3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
      a. RF-Conducted Immunity (RFCl) per ENV 50141 (IEC 1000-4-6) at 3V.
      b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8kV air discharge, 4kV contact.
      c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1kV power.
      d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).
4. Isolation shall be provided at all Primary Controller’s AC input terminals to suppress induced voltage transients consistent with:
   b. UL 864 Supply Line Transients.
   c. Voltage Sags, Surge and Dropout per EN 61000-4-11 (EN 1000-4-11).

2.6 PRIMARY CONTROL PANEL SOFTWARE

A. Furnish the following applications software to form complete operating system for building and energy management as described in this specification.

B. Provide all necessary software for a complete operating system as required. All software shall reside in each primary control panel. Primary control panels shall not be dependent upon any higher level computer or another controller for operation.

C. All points, panels and programs shall be identified by a 30 character name and a 16 character point descriptor. The same names shall be displayed at both the primary control panel(s) (via portable terminal, printer or modem) and the PC operator workstation(s).

D. All digital points shall have a user-defined, 2-state status indication with 8 characters minimum (e.g., Summer, Enabled, Disabled, Abnormal).

E. System Security
   1. User access shall be secured using individual security passwords and user names.
   2. Passwords shall restrict the user to the objects, applications and system functions as assigned by the system manager.
   3. Primary Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
   4. User Log On / Log Off attempts shall be recorded.
   5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.

F. Each primary control panel shall, at a minimum, be provided with software for:
   1. 2-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control algorithms, all with automatic control loop tuning.
   2. Limiting the number of times each piece of equipment may be cycled within any 1-hour period.
3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. Upon the resumption of power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

4. Priority load shedding (10 zones).

5. Energy management routines including time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start-stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating/cooling interlock, supply temperature reset, priority load shedding and power failure restart.

6. Custom, job-specific processes defined by the user, to automatically perform calculations and special control routines and sequences of operations.

   a. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

   b. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process or any user-defined constant in any controller in the system.

   c. Any process shall be able to issue commands to points in any and all other controllers in the system.

   d. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

   e. The custom control programming feature shall be documented via English language descriptors.

   f. Each controller shall support text comment lines in the operating program to allow for quick troubleshooting, documentation and historical summaries of program development.

   g. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.

7. Generate and receive automatic and manual operator messages and advisories.

8. Comment lines for all programs.

9. Distributed independent alarm analysis and filtering. Reporting of selected alarms during system shutdown and start-up shall be automatically inhibited. A minimum of 6 priority levels shall be provided for each point.

10. Automatically accumulate and store run-time hours for all digital points.
11. Automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and pulse input type points.

G. Trend data shall be stored at the primary control panels and automatically uploaded to the PC workstation. Uploads shall occur based on user-defined intervals, manual commands, or automatically when the trend buffer is 80% full. All trend data shall be available for use in any 3rd party personal computer applications located in the BMS.

H. Primary control panels shall be able to assign password access and control priorities to each system individually. The logon password (at any PC workstation(s) or POT) shall enable the operator to monitor, adjust and/or control only the systems, programs, primary control panel and/or secondary control panels that the operator is authorized for. All other systems, programs, primary and secondary control panels shall not be displayed at the PC workstation, POT or modem. Passwords and priority levels for each system, program, primary control panel and secondary control panel shall be fully programmable and adjustable.

I. Primary control panels shall be able to access any data from, or send control commands and alarm reports directly to, any other primary control panel or combination of controllers on the network without dependence upon a central or intermediate processing device. Primary control panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

J. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of 6 priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. Alarm reports and messages shall be routed to user-defined list of operator workstations or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages and display graphics.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
a. Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

5. Operator-selected alarms shall be capable of initiating a call to a remote operator device.

K. Scheduling:

1. Provide a comprehensive menu driven program to automatically start and stop designated object or group of objects in the system according to a stored time.

2. It shall be possible to define a group of objects as a custom event (i.e., meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.

3. For points assigned to one (1) common load group, it shall be possible to assign variable time delays between each successive start and stop within that group.

4. The operator shall be able to define the following information:
   a. Time, day.
   b. Commands such as on, off, auto and so forth.
   c. Time delays between successive commands.
   d. There shall be provisions for manual overriding of each schedule by an appropriate operator.

5. It shall be possible to schedule calendar-based events up to 1 year in advance based on the following:
   a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
   b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.
   c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

L. Peak Demand Limiting (PDL):

1. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
2. PDL shall continuously track the amount of electricity being consumed, by monitoring one (1) or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW) or both.

3. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.

4. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.

5. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

M. Temperature-compensated duty cycling.
   1. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
   2. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

N. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

O. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

P. Enthalpy switchover (economizer). The Primary Controller Software shall control the position of the air handler relief, return and outside air dampers. If the outside air enthalpy is below the return air enthalpy, the software will modulate the dampers to provide 100% outside air. The user will be able to quickly changeover to an economizer system based on enthalpy and will be able to override the economizer cycle and return to minimum outside air operation at any time.

Q. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point and PID gains shall be user-selectable.

R. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment.

S. Staggered Start:
   1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order, in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.
   2. Upon the resumption of power, each Primary Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

T. Totalization:
1. Run-Time Totalization. Primary Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.

2. Consumption totalization. Primary Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

3. Event totalization. Primary Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

U. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points.

1. DDC Controllers shall store point history data for selected analog and digital inputs and outputs:
   a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two (2) methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
   b. Trend data shall be stored at the DDC Controllers and automatically uploaded to the workstation. Uploads shall occur based upon user-defined interval, manual command or automatically when the trend buffers are 80% full. All trend data shall be available for use in any third party personal computer applications located on the MLN.
   c. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for a minimum of 36 operator-selected PID control loops. Provide capability to view or print trend and tuning reports.
      1) The controller shall perform a step response test with a minimum 1-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.
      2) Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation, or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

V. DDC Controllers shall automatically accumulate and store run-time hours for all digital input and output points.

W. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for all analog and digital pulse input type points.
X. DDC Controllers shall count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly and monthly basis for all points. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.

2.7 SECONDARY CONTROL PANEL HARDWARE

A. ASHRAE 135 Compliance: Secondary control panels shall use the latest version of BACnet/ASHRAE 135 protocol over MS/TP.

B. Each secondary control panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each secondary control panel shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each Primary Controller shall be able to communicate with secondary controllers over the Secondary Network to control terminal equipment only.

D. Each secondary controller shall include all point inputs and outputs necessary to perform the specified control sequences. The secondary controller shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs may be utilized either for 2-state, modulating, floating or proportional control, allowing for additional system flexibility.

E. Provide a secondary control panel for each of the following types of equipment (if applicable):

1. Exhaust Fans.
2. Fan-Powered Variable Air Volume (VAV) Boxes.
3. Radiant Panel
4. Unit Heaters (UH) / Cabinet Unit Heaters (CUH).
5. Variable Air Volume (VAV) Boxes.
6. Other terminal equipment.

F. Each secondary control panel shall, at a minimum, be provided with:

1. Appropriate NEMA rated enclosure.
3. Secondary network communications ability.
4. Power supplies as required for all associated modules, sensors, actuators, etc.
5. Input/output points as required.
6. Software as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.
7. A portable operator terminal connection port.
8. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.

G. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.

H. Control Algorithms. The controller shall receive its real-time data from the Primary Controller time clock to insure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator’s terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

I. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

J. Calibration. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

1. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

K. Each secondary control panel shall continuously perform self-diagnostics on all hardware and secondary network communications. The secondary control panel shall provide both local and remote annunciation of any detected component failures or repeated failure to establish communication to the system.

L. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs shall be of the Universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of Universal outputs, provide a minimum of 50% spare outputs of each type via additional point termination boards or controllers. Analog outputs shall be industry standard signals such as 24 VAC floating control, allowing for interface to a variety of modulating actuators. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable.

M. Provide each secondary control panel with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility.
Controllers that require factory changes of all applications are not acceptable. Controller shall have a minimum of 16K EPROM or EEPROM.

N. The secondary control panels shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of 18 – 28 VAC (-25% – 17%), allowing for power source fluctuations and voltage drops. Install plenum data line and sensor cable in accordance with local code and NEC. The BMS contractor shall provide a dedicated power source and separate isolation transformer for each controller to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32º – 122ºF (0º – 50ºC) and 10% – 95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly. Power supply must be rated at a minimum of 125% of power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 VAC power to the terminal units by utilizing:

1. The existing line voltage power trunk and installing separate isolation transformers for each controller.
2. Dedicated line voltage power source and isolation transformers at a central location and installing 24 VAC power trunk to supply multiple controllers in the area.

O. Environment. The controllers shall function normally under ambient conditions of 32º – 122ºF (0º – 50ºC) and 10% – 95% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

P. Immunity to noise. Operation shall be protected against electrical noise of 5 – 120Hz and from keyed radios up to 5W at 1m (3’).

2.8 SECONDARY CONTROL PANEL SOFTWARE

A. Provide all necessary software for a complete operating system as required. All software shall reside in each secondary control panel. Secondary control panels shall not be dependent upon any higher level computer or another controller for operation.

B. Secondary control panel software configured for CAV or VAV control algorithms shall include provisions for manual and automatic calibration of attached differential pressure transducer in order to maintain stable control and insuring against drift over time. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

C. Each secondary controller shall perform its primary control function independent of primary controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the primary control panel time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) control for all applications. All PI parameters shall be field-adjustable by the user via a portable operator’s terminal.
D. Secondary control panels shall support pressure independent terminal boxes including VAV cooling only, VAV with hot water or electric reheat, Fan-powered VAV and Fan-powered VAV with hot water or electric reheat. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

2.9 BACNET DEVICE OBJECTS

A. The BAS manufacturer's representative shall submit a BACnet Device Object Naming Convention Plan (DONCP) to the owner and consulting engineer during the submittal process. The plan must be approved by the owner and consulting engineer prior to implementation. It is the responsibility of the BAS contractor to coordinate the DONCP with the owner and consulting engineer.

B. The DONCP shall be designed to eliminate any confusion between individual points in a facility/campus wide BMS system. It will also be designed to allow for future expansion and consistency. Each device on the BACnet network (including other manufacturer’s devices) must have a unique device instance. This is a major consideration when adding to an existing system or interconnecting networks. Thorough and accessible site documentation is critical.

C. A consistent object (point) naming convention shall be used to facilitate familiarity and operational ease across an eventual large campus or inventory of facilities. The following section is designed as recommendations only. It is the responsibility of the BMS contractor to coordinate the DONCP with the owner and consulting engineer.

D. BACnet requires that all devices have a Device object name that is unique throughout the entire network. To comply with this requirement, all BACnet devices shall be configured with a Device Object Name that is based on the naming conventions described in this section. This includes all physical devices as well as any logical BACnet devices that are represented by gateways. The BMS contractor shall coordinate with the Owner’s staff to ensure that the correct names are used. Device Object Name properties shall support strings of at least 50 characters in length.

E. Every system device has addresses by which any other BACnet device can identify it and route information to and from it. The BMS contractor shall document all addresses and utilize a logical addressing scheme that is coordinated with the Owner.

F. Adopt a hierarchical and uniform addressing scheme for device instances to help quickly identify the function and location of different devices when troubleshooting. Additionally, document every element of the addressing scheme and update the site documentation with any changes.

G. Standard BACnet object types supported shall includes as a minimum: Analog value, Binary value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types.

2.10 BMS SERVER

A. The BMS contractor shall provide an alternate price (ALT-1) to replace the existing BMS server with new.
B. The BMS Server shall consist of the following, at a minimum:

1. Dual processors, Eight Cores Intel® Xeon® E5-2667 v4 3.2GHZ with 35 MB Cache, 64 GB of RDIMM RAM, xUGA graphics card capable of 1920x1080 pixel resolution (or better) and 64 Bit colors, non-interlaced (70Hz or better vertical refresh rate), 12 function-key keyboard, 2-button Intellimouse pointing device with scrolling wheel, 2X Western Digital VelociRaptor WD6000HLHX SATA Hard Disk Drive (1 TB) in a RAID 1 configuration with SAS 5iR internal RAID Controller. Multiple USB 3.0 ports located in the front and back of Tower. Hot-plug hard drives, redundant power, ECC memory, battery-backed cache. ATAPI DVD+/-RW Drive and Dual NIC (network interface card) for Ethernet Networking compatible with TCP/IP network protocols. Server shall have capability to plug in at least two (2) monitors.

2. Color monitor shall be a minimum of 24”, Flat Panel type with height adjustable stand which allows the panel to swivel, tilt and pivot. Separate controls shall be provided for color, contrasts, brightness, size, geometry, position and degauss. The screen shall be non-reflective. The LCD module shall be active matrix, thin film transistor (TFT). The monitor shall support a resolution of 1920x1080 pixels at 60 Hz, at a minimum. Available power supply is 120 VAC at 60Hz.

2.11 WEB BASED OPERATOR INTERFACE

A. Operator Interface. Web server shall reside on high-speed network with primary controllers. Each standard browser connected to server shall be able to access all system information. In addition to the primary operator interface, the system shall include a secondary interface compatible with a locally available commercial wireless network and viewable on a commercially available wireless device such as a Wireless Access Protocol (WAP) enabled cellular telephone or personal digital assistant (PDA). This secondary interface may be text-based and shall provide a summary of the most important data. As a minimum, the following capabilities shall be provided through this interface:

1. An operator authentication system that requires an operator to log in before viewing or editing any data and which can be configured to limit the privileges of an individual operator.

2. The ability to view and acknowledge any alarm in the system. Alarms or links to alarms shall be provided on a contiguous list so the operator can quickly view all alarms.

3. A summary page or pages for each piece of equipment in the system. This page shall include the current values of all critical I/O points and shall allow the operator to lock binary points on or off and to lock analog points to any value within their range.

4. Navigation links that allow the operator to quickly navigate from the home screen to any piece of equipment in the system and then return to the home screen. These links shall be arranged in a hierarchical fashion, such as navigating from the home screen to a particular building, then to a specific floor in the building and then to a specific room or piece of equipment.

B. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using
ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in the latest version of ANSI/ASHRAE 135, BACnet Annex J.

C. Hardware. Each workstation or web server shall consist of the following:

1. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet requirements included herein. Hard disk shall have sufficient memory to store system software, 1 year of data for trended points and a system database at least twice the size of the existing database at system acceptance. Configure computers and network connections if multiple computers are required to meet specified memory and performance.

2. Modem. Auto-dial modem and associated cables shall transmit over voice-grade telephone lines at a nominal 56,000 baud and shall provide communication between workstation or web server and remote buildings and workstations.

D. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:

1. Log In and Log Out. System shall require user name and password to log in to operator interface.

2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.

3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls and sensor calibration.

4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.

5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm and to clear (delete) unneeded alarms.

6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.

7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results and to customize report configuration to show data of interest.

8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller and to download new control software to each controller.

9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system
access and of functions they can perform while logged in. Operators shall be able to add
operators, to delete operators and to edit operator function authorization. Operator shall
be able to authorize each operator function separately.

E. System Software.

1. Operating System. Web server shall have an industry-standard professional-grade
operating system. Acceptable systems include Microsoft Windows 8.

2. System Graphics. Operator interface shall be graphically based and shall include at least
one (1) graphic per piece of equipment, air handling unit or occupied zone, graphics for
each chilled water and hot water system and graphics that summarize conditions on each
floor. The BMS contractor shall review and standardize these graphics with the owner on
site team.

3. Provide links on each graphic to PDF files of the associated sequence of operation, flow
diagram, and wiring diagrams.

4. Functionality. Graphics shall allow operator to monitor system status, to view a summary
of the most important data for each controlled zone or piece of equipment, to use point-
and-click navigation between zones or equipment and to edit setpoints and other specified
parameters.

5. Animation. Graphics shall be able to animate by displaying different image files for
changed object status.

6. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other
visual indicator.

7. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG,
PNG or GIF. Web-based system graphics shall be viewable on browsers compatible with
World Wide Web Consortium browser standards. Web graphic format shall require no
plug-in (such as HTML and JavaScript) or shall only require widely available no-cost
plug-ins (such as Active-X and Macromedia Flash).

F. System Tools. System shall provide the following functionality to authorized operators as an
integral part of the operator interface or as stand-alone software programs. If furnished as part
of the interface, the tool shall be available from each workstation or web browser interface. If
furnished as a stand-alone program, software shall be installable on standard IBM-compatible
PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. Each workstation or web server shall store on
its hard disk a copy of the current system database, including controller firmware and
software. Stored database shall be automatically updated with each system configuration
or controller firmware or software change.

2. Controller Memory Download. Operators shall be able to download memory from the
system database to each controller.

3. System Configuration. Operators shall be able to configure the system.
4. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.

5. Security. System shall require a user name and password to view, edit, add or delete data.

6. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding and deleting functions in each system application, editor and object.

7. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.


9. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).

10. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states and alarm reactions for each system object. Configure and enable alarm points as specified.

11. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location and nature.

12. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page and audibly announce.

13. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.

14. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified or required by the Owner.

15. Object and Property Status and Control. Operator shall be able to view and to edit if applicable, the status of each system object and property by menu, on graphics or through custom programs.

16. Reports and Logs. Operator shall be able to select, to modify, to create and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

17. Standard Reports. Furnish the following standard system reports:
18. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location or by combination of filter criteria.


20. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:
   a. Alarm History.
   b. Trend Data. Operator shall be able to select trends to be logged.
   c. Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

21. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations and that present results in tabular or graphical format. Reports shall be launched from the operator interface.

22. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text and animation files to a background graphic using a mouse.

23. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers and ductwork. Library graphic file format shall be compatible with graphics generation tools.

24. Custom Application Programming. Operator shall be able to create, edit, debug and download custom programs. System shall be fully operable while custom programs are edited, compiled and downloaded. Programming language shall have the following features:

25. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below and operators shall be able to create custom or compound function blocks.

26. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify and delete custom programming code and to copy blocks of code to a file library for reuse in other control programs.

27. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
28. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

29. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

30. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

31. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.
   a. Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours and days. Operator shall be able to start, stop and reset elapsed time variables using the program language.
   b. System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable and change setpoints of Controller Software as described in Controller Software section.

2.12 REMOTE NOTIFICATION PAGING SYSTEM

A. Workstations shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices and email accounts based on a point's alarm condition.

B. There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices that can receive messages from the system.

C. On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.

D. Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.

E. System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.

F. Message detail shall be configurable on a per user basis.
G. During a "flood" of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.

H. Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.

I. Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.

2.13 SENSORS

A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion or duct mounting as required.

B. Instruments and control devices shall be provided for all required points detailed herein. Instruments shall have accuracies as stated herein. Instrument characteristics such as hysteresis, relaxation time, span, and maximum and minimum limits, shall be accounted for in applications of instruments and controls. Not all devices specified may be required for this project.

C. Field wiring for each digital device shall be as per the manufacturer’s standard. The details of the wiring shall be included in the submittal.

D. Outside Air Stations: Assembly shall consist of capacitive type humidity sensing element with 1000 ohm platinum RTD and a solid-state, 2 wire, 4-20 mA transmitter mounted in an integrated ventilated radiation shield suitable for outdoor installation. Assembly shall be factory calibrated to an accuracy of ±2% RH over a range of 0%-90% RH and ±3% over a range of 90-100% RH and an accuracy of ±0.6°F over entire operating span. Assembly shall be Vaisala HMS112 Series or pre-approved equal.

E. Sensors for duct locations shall not be affected by vibrations encountered in normal duct systems.

F. Temperature Sensors

1. Temperature sensors used in duct or space sensing applications shall be thermistors. Temperature sensors shall have the following characteristics.
   a. Accuracy: ±0.5°F.
   b. Wire: Twisted, shielded-pair cable.

2. Insertion Elements in Ducts: Single point; use where not affected by temperature stratification or where ducts are smaller than 9 sq ft. (1 sq m). The length of the sensor shall be a minimum of one-third of the width of the duct with a maximum length of eighteen (18) inches. Provide duct mounted metal housing with conduit entrance.

3. Averaging Elements in Ducts: Use where prone to temperature stratification or where ducts are larger than 9 sq ft (1 sq m); length as required. The length of the sensor shall be twelve (12) feet minimum or one (1) linear foot per every one (1) sq ft of cut cross section, whichever is greater. Provide duct mounted metal housing with conduit entrance.

4. Space sensors:
a. Set-Point Adjustment: Concealed
b. Set-Point Indication: Concealed
d. Orientation: Vertical.
e. Provide a communication port for connection of a laptop or other portable interface device.
f. Match existing site standard.

G. Static Pressure Transmitter: Nondirectional sensor with suitable range for expected input and temperature compensated.
   1. Accuracy: 1% of full scale with repeatability of 0.1%.
   2. Output: 4 – 20 mA.
   3. Building Static-Pressure Range: 0-0.25” wg (0-62 Pa).
   4. Duct Static-Pressure Range: 0-5” wg (0-1243 Pa).
   5. Provide a Setra M264 or pre-approved equal.
   6. These sensors shall be used for control of fan VFDs, monitoring of filter DP, etc.

H. Equipment operation sensors as follows:
   1. Status Inputs for Electric Motors: Current sensor with current transformers, adjustable and up to 175% of rated motor current.

I. Air Differential Pressure Switches
   1. Diaphragm type air differential pressure switches with die-cast aluminum housing, adjustable setpoint and minimum 5A switch rating at 120 VAC, SPST switches and the switch pressure range shall be suited for the application. Switch shall be manual reset type. Manual reset switches shall be Dwyer 1800. High and low ports shall be 1/8 inch NPT connected to angle type tips designed to sense pressure.

J. Control Relays
   1. Mechanical relay: The control relay shall be rated for 24 Vac or 24vdc; maximum contact rating of 10 amp at 30 Vdc or 250 Vac. Outputs shall be true Form C type contacts; solid-state relays are not acceptable.

K. Control Transformer
   1. Control transformers shall be UL listed. Furnish class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity. Provide step-down transformer for each control panel. Step-down transformer shall be 277/24 Vac or 120/24 Vac. Coordinate with the electrical contractor for available circuit.
2.14 AUTOMATIC CONTROL VALVES

A. All automatic control valves shall meet the following requirements:

1. Fully proportioning.

2. Capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements.

3. Body pressure rating and connection type construction shall conform to piping and fittings in which the valve is to be installed and to the valve schedules.

4. Isolation valve shall be line size, full port ball valve with stainless steel ball and stem. Isolation valve 4” and large shall be butterfly valves.

5. Control valves 2” and smaller shall have screwed connections.

6. Control valves larger than 2-1/2” shall have flanged connections.

B. Water Control Valves: Hot water

1. Modulating control valves shall have the following characteristics:
   a. Valve shall be up to two sizes below pipe size.
   b. Valve shall have replaceable seat, plug, or disc.
   c. Equal percentage flow characteristic (characterized ball or globe type valves).
   d. Valve body shall be bronze, cast iron, forged brass or red brass.
   e. Ball valve shall have stainless steel stem, stainless steel ball, and PTFE seats.
   f. Globe valve shall have stainless steel stem and single stainless steel seat.

C. Provide one (1) control valve for each heating coil at a minimum.

D. Control valves shall be Belimo, Honeywell, Johnson Controls, Siemens or pre-approved equal.

E. Control valves 4” and larger shall be butterfly valves for isolation applications and globe valves for modulating applications.

F. All valve actuators shall meet the following requirements:

1. All valve actuation shall be electric. Pneumatic actuation is not acceptable.

2. Valve actuator shall be by same manufacturer as valve body unless pre-approved.

3. Valve actuators shall:
   a. Be quiet in operation.
   b. Provide smooth modulation at design flow and pressure conditions.
c. Be capable of operating in sequence with other valves and/or damper actuators when required by the sequence of operation.

d. Be sized to close against a differential pressure equal to the design pump head plus 15%. Where pressure and flow combinations exceed ratings for commercial valves and actuators, industrial class valves and actuators shall be provided.

e. Valve actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe positions are as follows:

1) Unit Ventilator Hot Water Heating Valves Fail Open

4. Electric Valve Actuation

a. Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.

b. Actuators shall be equipped with a permanent manual override hand wheel and visual and electronic stroke indicators.

c. Operating Voltage: 24 VAC.

d. Input Signal: 0-10 VDC, 4 – 20 mA.

e. Power Consumption: 18VA maximum (valves 2” and under), 28VA maximum (valves 2-1/2” – 4”)

f. Spring Return Time: 15 seconds maximum

g. Spring return position should be field adjustable with a switch.

h. Nominal Force: 225lb Minimum (valves 2” and under), 610lb. (valves 2-1/2”-4”)

i. Stroke: 3/4” (20mm) maximum (valves 2” and under), 1-1/2” (valves 2-1/2”-4”)

j. For use when the maximum media temperature is 300°F.

2.15 DAMPER ACTUATION

A. All damper actuation shall be electric. Pneumatic actuation is not acceptable.

B. Damper actuators used for emergency generator intake or exhaust applications shall be fast-acting type.

C. Size actuators for running torque calculated as follows:

1. Parallel-Blade Damper with Edge Seals: 7”-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.

2. Opposed-Blade Damper with Edge Seals: 5”-lb/sq. ft. (62 kg-cm/sq. m) of damper.

3. Parallel-Blade Damper without Edge Seals: 4”-lb/sq. ft (49.6 kg-cm/sq. m) of damper.

4. Opposed-Blade Damper without Edge Seals: 3”-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
5. Dampers with 2” to 3” wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.

6. Dampers with 3” to 4” wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

D. All damper actuators shall meet the following requirements:

1. Damper actuators shall have external adjustable stops to limit the stroke in either direction.

2. All damper actuators shall have sufficient power to overcome friction of damper linkage and air pressure acting on louvers and to operate the damper smoothly throughout the entire damper range.

3. Actuators shall be sized with a torque greater than 150% of the design damper torque.

4. Actuators shall have mounting arrangement for location outside of the air stream. The damper actuators shall be mounted on the damper extension so that it is not buried in the wall construction.

5. Damper actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:
   a. Exhaust Air Dampers Normally Closed
   b. Isolation Dampers Normally Closed
   c. Outside Air Dampers Normally Closed
   d. Return Air Dampers Normally Open

6. Incremental Electronic Actuator for Terminal Equipment Damper Actuation
   a. Incremental actuators shall be allowed for terminal equipment only.
   b. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.
   c. Actuators shall be equipped with a permanent manual adjustment.
   d. Minimum Torque: 35” lb.
   e. Operating Voltage: 24 VAC.
   f. Input Signal: 3 wire floating, 0 – 10 VDC, or 4 – 20 mA.
   g. Frequency: 50 – 60 Hz.
   h. Power Consumption: 1.5VA maximum.
   i. Spring Return Time: 20sec maximum.
j. Spring return position should be field adjustable with a switch.


l. Stroke: 7/32” (5.5mm) maximum.

m. For use when the maximum media temperature is 230°F.

7. Electric Damper Actuation

a. Provide proportional, electronic, direct-coupled spring return actuators for all automatic dampers used for modulating service. Each actuator shall be equipped with a brushless DC motor, self centering shaft coupling, metal housing, permanent manual override, visual stroke indicators and built in adjustable start and span controls with the following specifications:

1) Operating Voltage: 24 VAC./ 120 VAC (Hardwired to starter circuit)

2) Input Signal: 0-10 VDC, 4 – 20 mA (modulating), on/off (2 position).

3) Frequency: 50 – 60 Hz.

4) Power Consumption: 9 VA Maximum.

5) Spring Return Time: 15 seconds Maximum.

6) Spring return position should be field adjustable with a switch.

7) Minimum Torque: 133” lb.

8) Angular Rotation: 90°.

E. Damper actuators shall be Belimo or pre-approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. All control components including automatic control valves, dampers, instruments, sensors, etc shall be tagged for identification. Acceptable methods of tagging are: laminated plastic, stamped metal and engraved plastic.

D. Install equipment level and plumb.

E. Verify location of temperature sensors, humidity sensors and other exposed control sensors with plans and room details before installation. Locate all 60” above the floor or as otherwise required by ADA.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
F. Install guards on thermostats in the following locations:
   1. Entrances.
   2. Public areas.
   3. Where indicated.

G. Install hydronic instrument wells, valves and other accessories according to Division 23.

H. Install refrigerant instrument wells, valves and other accessories according to Division 23.

I. Install duct volume-control dampers according to Division 23.

J. Install electronic cables according to Division 26.

K. Averaging temperature sensors (i.e. freezestats, mixed air temperature sensor, etc.) shall be provided with fasteners or mounting clips to prevent shearing due to vibrations in the ductwork.

L. Water line mounted sensors shall be removable without shutting down the system in which they are installed.

M. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.

N. Averaging temperature sensors (i.e. freezestats, mixed air temperature sensor, etc.) shall be provided with fasteners or mounting clips to prevent shearing due to vibrations in the ductwork.

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings and related wiring accessories.

B. All exposed wiring and wiring in mechanical equipment rooms shall be installed in conduit.

C. Plenum rated cable shall be acceptable in hung ceilings, walls and raised floors.

D. All wiring located outside shall be installed in rigid conduit, seal tite or EMT with compression fittings.

E. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.

F. Install cable in raceway.

G. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

H. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

I. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
J. Wires and cables shall be as follows:

1. Single Conductor (120 VAC): Type THWN 12AWG stranded copper with 600V insulation.

K. Primary and Secondary Communications Network Cabling

1. Primary network shall be Ethernet based and shall utilize CAT5, CAT6 or fiber optic cable. All wiring runs longer than 300’ shall utilize fiber optic cable.

2. Cable shall be of type recommend by the DDC System Manufacturer and 20AWG at a minimum.

3. Cable shall be shielded.

L. Cables for 120 VAC wiring and low level signal wiring (i.e., 4 – 20 mA analog) shall always be run in separate raceways.

3.3 CONNECTIONS

A. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

B. Connect HOA selector switches to override automatic interlock controls when switch is in hand position.

C. Ground equipment.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units and retest.

2. Test and adjust controls and safeties.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.

1. Start, test and adjust control systems.

2. Demonstrate compliance with requirements, including calibration and testing and control sequences.

3. Adjust, calibrate and fine tune circuits and equipment to achieve sequence of operation specified.

D. Verification

1. Verify that instruments are installed before calibration, testing and loop or leak checks.
2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth and other applicable considerations.

4. Check instrument tubing for proper fittings, slope, material and support.

5. Check installation of air supply for each instrument.

6. Check flow instruments. Inspect tag number and line and bore size and verify that inlet side is identified and that meters are installed correctly.

7. Check pressure instruments, piping slope, installation of valve manifold and self-contained pressure regulators.

8. Check temperature instruments and material and length of sensing elements.

9. Check control valves. Verify that they are in correct direction.

10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.

11. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.

3.5 COMMISSIONING

A. Prior to full operation, the contractor in the presence of the owner’s representative and engineer shall perform a complete demonstration and testing of the system operating functions and alarms. This testing shall take place after having satisfactorily met the requirements of shop drawing acceptance. Upon successful completion of system operation, the contractor shall submit a statement in writing stating that the full operation of all systems, functions and alarms has been demonstrated and are operational as well as a listing of all systems, alarms and functions that have been commissioned. All items shall be submitted for review and acceptance to the owner, owner’s representative and engineer before final acceptance can take place.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain HVAC instrumentation and controls. Refer to Division 1 Section "Closeout Procedures" and “Demonstration and Training."
3.7 TRAINING

A. The BMS contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays.

B. Provide twenty-four (24) hrs of training for Owner’s operating and maintenance personnel. All training shall be on-site training. Videotape all sessions and edit each session to 1-hour DVDs. Turn over two (2) copies each unedited and edited DVD to the Owner. Training shall include:

1. Explanation of drawings, operators and maintenance manuals.
2. Walk-through of the job to locate all control components.
3. Operator workstation and peripherals.
4. DDC Controller operation/function.
5. Operator control functions including graphic generation, if design includes color graphics and field panel programming.
6. Explanation of adjustment, calibration and replacement procedures.

C. The BMS contractor shall also create a color PDF reference guide for the use of the Owner and the operating staff which provide graphical step-by-step instructions on how to perform basic tasks at the BMS that are part of the owner's operating staff's daily duties. This shall include, but not be limited to, navigating the BMS screens, setpoint adjustment, turning units on/off, turning systems on/off, overriding commands, acknowledging alarms, adjusting time schedules, etc. Coordinate with the Owner's operating staff as required.

D. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer’s standard pricing such as transportation, meals, etc.

E. The BMS Contractor shall provide phase training to ensure that when the new BMS workstation is installed, the facility staff are able to utilize the new workstation/software as equipment is switched over from the existing BMS to the new BMS. Below is a timeline of how to phase the training schedule:

1. After cut-over of first system to the new BMS:
   a. Familiarize the owner and their operating staff with the new BMS workstation, BMS software and how an overview of operator control functions including but not limited to:
      1) Navigating the new BMS software screens
      2) Setpoint adjustment
3) Alarm notifications and acknowledgment
4) Adjusting the occupancy schedule
5) Overriding commands and setpoints

b. Familiarize the Owner and the Owner's operating staff with the new DDC controllers and their functions
c. Provide a simple navigation and basic operator control function tutorial in color in PDF for easy reference for the owner and the operating staff. The tutorial shall include how to access data and complete all operator control functions required for the owner's operating staff to perform their duties.

2. After the major hydronic systems (chiller plant, hot water system) have been cut over:
   a. Provide a more detailed version of the training that occurred after the cut-over of the first system.
   b. Familiarize the Owner and the Owner's operating staff with the new DDC controllers and their functions
   c. Update the navigation and basic operator control function as necessary

3. At the conclusion of the project, the BMS contractor shall provide a formal training that includes all items listed in this section along with any items recommended by the manufacturer of the BMS software/hardware. Update the navigation and basic operator control function as necessary.

4. The BMS Contractor shall also include training to be provided before the first heating season and before the first cooling season to assist the Owner's operating staff with switch-over of equipment and systems. This training shall be scheduled with the owner.

3.8 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within 1 year of date of Substantial Completion, provide up to three (3) Project-site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.9 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. Record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.

1) BMS network riser diagram
2) Wiring diagrams
3) Electrical drawings
4) Flow diagrams and device locations
5) Hardware and software points list
6) Bill of materials
7) Sequence of operations.
8) I/O point lists
9) Cut sheets of all equipment installed

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.

h. Training course list.

B. 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.

3.10 WARRANTY

A. The BMS shall include a one (1) year parts and labor warranty to begin upon system acceptance that covers the entire system to correct any operational issues at no additional cost to the Owner. The warranty shall cover adjustment and calibration of components and assistance to building personnel in making program changes and in adjusting sensors and controls to suit actual conditions. System acceptance shall be determined by the Owner.

B. During the warranty period, the Contractor shall guarantee the following in a form satisfactory to the Owner:

1. All work installed will be free from any and all defects in workmanship and or materials.

2. All devices will operate as per the capacities and performance characteristics specified.
3. The systems shall operate without malfunction.

C. Maintain an adequate supply of materials within 100 miles of the Project site

END OF SECTION 23 09 00
GREENWICH PUBLIC SCHOOLS
EASTERN MIDDLE SCHOOL
WINDOW REPLACEMENTS & HVAC UPGRADES
51 HENDRIE AVENUE
RIVERSIDE, CONNECTICUT
E-202
1/16"=1'-0"
SL FM
ELECTRICAL SECOND FLOOR
PLAN - POWER
GREENWICH PUBLIC SCHOOLS
EASTERN MIDDLE SCHOOL
WINDOW REPAIRS & HVAC UPGRADES
51 HENDRIE AVENUE
RIVERSIDE, CONNECTICUT

WIRE & CONDUIT SIZING SCHEDULE

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**NOTE:**
- All wiring must be done in conformance with the National Electric Code (NEC) and all local electrical codes and ordinances.
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**DRAWING TITLE:** ELECTRICAL SINGLE LINE DIAGRAM

**DRAWING NO.:** E-300

**SCALE:** NTG

**DRAWN BY:**

**REVIEWED BY:**
GREENWICH PUBLIC SCHOOLS
EASTERN MIDDLE SCHOOL
WINDOW REPLACEMENTS & HVAC UPGRADES
51 HENDRIE AVENUE
RIVERSIDE, CONNECTICUT

E-400

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All project requirements, except for those that are specifically added or modified by this Addendum, shall remain in full effect.

Eugene H. Watts

END OF ADDENDUM NO. 3