SECTION 23 09 00
BUILDING MANAGEMENT SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Building Management System (BMS), utilizing direct digital controls.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Products Supplied But Not Installed Under This Section:
1. Control valves.
2. Flow switches.
3. Wells, sockets and other inline hardware for water sensors (temperature, pressure, flow).
4. Automatic control dampers, where not supplied with equipment.
5. Airflow measuring stations.
6. Terminal unit controllers and actuators, when installed by terminal unit manufacturer.
7. Variable frequency drives. (This does not include VFDs integral to machinery such as chillers or boilers).

B. Products Installed But Not Supplied Under This Section:
1. None.

C. Products Not Furnished or Installed But Integrated with the Work of This Section:
1. Chiller control systems.
2. Boiler control systems.
3. Pump control packages.
4. In-line meters (gas, water, power).
5. Refrigerant monitors.
6. Smoke detectors (through alarm relay contacts).

D. Work Required Under Other Divisions Related to This Section:
1. Power wiring to line side of motor starters, disconnects or variable frequency drives.
2. Provision and wiring of smoke detectors and other devices relating to fire alarm system.
3. Campus LAN (Ethernet) connection adjacent to JACE network management controller.

1.3 RELATED SECTIONS

A. Section 23 05 00 - Basic Mechanical Materials and Methods: Performance and reference standards for products and materials required for the Project.

1.4 SYSTEM DESCRIPTION

A. Scope: Furnish all labor, materials and equipment necessary for a complete and operating Building Management System (BMS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over an open protocol bus (Examples: LonTalk, BACnet, MODBUS).
1. The intent of this specification is to provide a system that is consistent with BMS

systems throughout the owner's facilities running the Niagara 4 Framework.

2. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, BACnet and MODBUS. Lon Talk network being replaced with BACnet on this site(s).
3. System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Microsoft EDGE, Mozilla Firefox, or Google Chrome browsers from any computer on the owner's LAN.
4. All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset upon completion of this project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.
5. Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara 4 Framework shall satisfy the requirements of this section.
6. All graphics and navigation shall include display of all the existing systems and points similar to existing AX graphics, but, all new graphics shall use HTML5 Web pages using Niagara N4 tree navigation structure. All N4 WEB graphics shall be designed to be “mobile ready” to allow end users to use mobile device to access and control the connected graphics and systems.
   This would be the spot to indicate that the new N4 WEB Supervisor is to be installed on a local network VM hosted by the college IT. Unless the system is hosted in Cloud or as a SaaS architecture.
7. Owner shall receive all Administrator level login and passwords for engineering toolset at first training session. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS.
8. OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have the following NiCS: "accept.station.in=*"; "accept.station.out=*"; "accept.wb.in=*"; "accept.wb.out=*". All open NIC statements shall follow Niagara Open NIC specifications.
9. All JACE hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted “safe boot” technology. Two copies of the hardware licenses and certificates, via MicroSD memory card, will be supplied to the owner prior to closeout.
10. To ensure quality, ensure that all Niagara hardware is JACE 8000. JACE hardware products not meeting this requirement will not be allowed.

B. All products of the BMS shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided on request, with the submittal package. Systems or products not currently offering the following approvals are not acceptable.

1. Federal Communications Commission (FCC), Rules and Regulations, Volume II - July 1986 Part 15 Class A Radio Frequency Devices.
2. FCC, Part 15, Subpart B, Class B
3. FCC, Part 15, Subpart C
4. FCC, Part 15, Subpart J, Class A Computing Devices.
5. UL 504 - Industrial Control Equipment.
6. UL 506 - Specialty Transformers.
7. UL 910 - Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air-Handling Spaces.
8. UL 916 - Energy Management Systems All.
9. UL 1449 - Transient Voltage Suppression.
10. Standard Test for Flame Propagation Height of Electrical and Optical - Fiber Cables Installed Vertically in Shafts.

11. EIA/ANSI 232-E - Interface Between Data Technical Equipment and Data Circuit Terminal Equipment Employing Serial Binary Data Interchange.
12. EIA 455 - Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices.
13. IEEE C62.41- Surge Voltages in Low-Voltage AC Power Circuits.
14. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
15. NEMA 250 - Enclosures for Electrical Equipment.
16. NEMA ICS 1 - Industrial Controls and Systems.
17. NEMA ST 1 - Specialty Transformers.
18. NCSBC Compliance, Energy: Performance of control system shall meet or surpass the requirements of ASHRAE/IESNA 90.1-1999.
19. CE 61326
20. C-Tick
21. cUL

1.5 SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:
1. Actuator: Control device that opens or closes valve or damper in response to control signal.
2. AI: Analog Input.
3. AO: Analog Output.
4. Analog: Continuously variable state over stated range of values.
5. BMS: Building Management System.
6. DDC: Direct Digital Control.
7. Discrete: Binary or digital state.
8. DI: Discrete Input.
9. DO: Discrete Output.
10. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
11. FO: Fail open (position of control device or actuator). Device moves to open position on loss of control signal or energy source.
12. GUI: Graphical User Interface.
13. HVAC: Heating, Ventilating and Air Conditioning.
14. IDC: Interoperable Digital Controller.
15. ILC: Interoperable Lon Controller.
16. LAN: Local Area Network.
17. Modulating: Movement of a control device through an entire range of values, proportional to an infinitely variable input value.
18. Motorized: Control device with actuator.
19. NAC: Network Area Controller.
20. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
21. NO: Normally open position of switch after control signal is removed; or the open position of a controlled valve or damper after the control signal is removed; or the usual position of a manually operated valve.
22. OSS: Operating System Server, host for system graphics, alarms, trends, etc.
23. Operator: Same as actuator.
24. PC: Personal Computer.
25. Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.
26. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
27. PI: Proportional-Integral control, control mode with continuous proportional output

plus additional change in output based on both amount and duration of change in controller variable (reset control).

28. PICS: BACnet Product Interoperability Compliance Statement.
29. PID: Proportional-Integral-Derivative control, control mode with continuous correction of final controller output element versus input signal based on proportional error, its time history (reset) and rate at which it's changing (derivative).
30. Point: Analog or discrete instrument with addressable database value.
31. WAN: Wide Area Network.

1.6 SUBMITTALS

A. Submit under provisions of Section 01 30 00.

B. Product Data: Manufacturer's data sheets on each product to be used, including:
   1. Preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.
   3. Installation methods.

C. Submit documentation of contractor qualifications, including those indicated in "Quality Assurance" if requested by the owner.

D. 3 copies of shop drawings (hard copy and digital format) of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers' catalog data sheets and installation instructions. Submit in printed electronic format. Samples of written Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval.

E. Shop drawings shall also contain complete wiring and schematic diagrams, sequences of operation, control system bus layout and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

F. Upon completion of the work, provide 3 complete sets of ' as-built' drawings (hard copy and digital format) and other project-specific documentation in 3-ring hard-backed binders and on Flash media. Each provided to the owner prior to project closeout.

G. Any deviations from these specifications or the work indicated on the drawings shall be clearly identified in the Submittals.

1.7 QUALITY ASSURANCE

A. The Control System Contractor shall have a full service DDC office within 50 miles of the job site. This office shall be staffed with applications engineers, software engineers and field technicians. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment. This office shall NOT be the only office within 50 miles of the job site, from which parts, software, and authorized service can be provided by the system manufacturer. This office will employ at least four NiagaraN4 programmers.

B. Single Source Responsibility of Supplier: The Control System Contractor shall be responsible for the complete installation and proper operation of the control system. The Control System Contractor shall exclusively be in the regular and customary business of design, installation and service of computerized building management systems similar in size and complexity to the system specified. The Control System Contractor shall be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years. At least two other approved/authorized Control System Contractors providing the same DDC system

components, software and support shall have an office located within 50 miles of the job site. All control panels shall be assembled by the Control System Contractor in a UL-Certified 508A panel shop.

C. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of HVAC control systems. Products shall be manufacturer's latest standard design and have been tested and proven in actual use.

1.8 PRE-INSTALLATION MEETINGS

A. Convene minimum two weeks prior to starting work of this section.

1.9 DELIVERY, STORAGE AND HANDLING

A. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.10 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to insure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, fire suppression, existing IT infrastructure, duct and conduit runs, electrical outlets and fixtures, air diffusers and structural and architectural features. Roofing, plumbing, and mechanical contractors noted in project RFP.

1.11 SEQUENCING

A. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress. All work will be coordinated with Muskegon Community College to provide the least amount of disruption in daily operations.

PART 2 PRODUCTS

2.1 PRODUCT MANUFACTURERS AND CONTRACTORS

A. Acceptable Niagara N4 Manufacturers: Honeywell WEBS Building Control Systems, Vykon, Distech. Others not permitted.

B. Acceptable Field Controllers: Field controllers must be available from local supply house to multiple contractors: Honeywell WEBS Spyder, Niagra, and Distech. Others not permitted.

C. Acceptable Contractors: Shall meet all requirements outlined in all project documents and are subject to the selection process.

2.2 GENERAL

A. The Building Management System (BMS) shall be comprised of a network of interoperable, stand-alone digital controllers, a network area controller, graphics and programming and other control devices for a complete system as specified herein.

B. The installed system shall provide secure password access to all features, functions and data contained in the overall BMS to Muskegon Community College.

C. **NiCS REQUIREMENTS:** All Niagara software licenses for this project shall have a 100%

open, Tridium Niagara Compatibility Statement (NICS).

1. Brand ID = Open
2. Station Compatibility In = All "*"
3. Tool Compatibility In = Open or Open "All"
4. Tool Compatibility Out = "All"

All Passwords shall be given to the Owner and shall be verified by the Muskegon Community College Office of Physical Plant. **THE OWNER AND CONTRACTOR MUST CREATE PASSWORD(s) TOGETHER. NO RESETTING OR MANUFACTURER RESETTING OF PASSWORD IS AVAILABLE.**

Note: It is the requirement of this specification that the Tridium hardware and software system installed by the Contractor shall be 100% accessible by any other Contractor the Owner wishes to employ for the lifespan of the Tridium system (no less than 20 years). The NICS shall be set-up so that there is no limitation to the access, copying, and modification of programming, sequencing, coding, graphics, passwords, etc.

2.3 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing Open Protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. Physical connection of any BACnet control equipment, such as chillers, shall be BACnet IP or MSTP.

C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

D. The supplied system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on the Operating System Server located in the MCC network on the LAN. Systems requiring proprietary database and user interface programs shall not be acceptable. Unless the system is hosted in Cloud or as a SaaS architecture.

E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.
   1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
   2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.4 SYSTEM NETWORK CONTROLLER (SNC)

A. These controllers are designed to manage communications between the programmable equipment controllers (PEC), application specific controllers (ASC) and advanced unitary controllers (AUC) which are connected to its communications trunks, manage communications between itself and other system network controllers (SNC) and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

B. The controllers shall be fully programmable to meet the unique requirements of the facility it shall control.

C. The controllers shall be capable of peer-to-peer communications with other SNC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem or connected via the Internet.

D. The communication protocols utilized for peer-to-peer communications between SNC's will be Niagara 4 Fox, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between SNC's is not allowed.

E. The SNC shall employ a device count capacity license model that supports expansion capabilities.

F. The SNC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:
   1. BACnet
   2. Lon
   3. MODBUS
   4. SNMP
   5. KNX

G. The SNC shall be capable of executing application control programs to provide:
   1. Calendar functions.
   2. Scheduling.
   3. Trending.
   4. Alarm monitoring and routing.
   5. Time synchronization.
   6. Integration of LonWorks, BACnet, and MODBUS controller data.
   7. Network management functions for all SNC, PEC and ASC based devices.
   8. Operational analytics reporting that provides owner with detailed real-time function, failure, operation and data gathering.

H. The SNC shall provide the following hardware features as a minimum:
   1. Two 10/100 Mbps Ethernet ports.
   2. Two Isolated RS-485 ports with biasing switches.
   3. 1 GB RAM
   4. 4 GB Flash Total Storage / 2 GB User Storage
   5. ~~Wi-Fi (Client or WAP)~~
   6. USB Flash Drive
   7. High Speed Field Bus Expansion
   8. -20-60°C Ambient Operating Temperature
   9. Integrated 24 VAC/DC Global Power Supply
   10. MicroSD Memory Card Employing Encrypted Safe Boot Technology

I. The SNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

J. The SNC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.

K. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, or wide-area network.
   1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
      a. Alarm.
      b. Return to normal.

c. To default.

2. Alarms shall be annunciated in any of the following manners as defined by the user:
   a. Screen message text.
   b. Email of complete alarm message to multiple recipients.
   ~~c. Pagers via paging services that initiate a page on receipt of email message.~~
   d. Graphics with flashing alarm object(s).
3. The following shall be recorded by the SNC for each alarm (at a minimum):
   a. Time and date.
   b. Equipment (air handler #, access way, etc.).
   c. Acknowledge time, date, and user who issued acknowledgement.

L. Programming software and all controller "Setup Wizards" shall be embedded into the SNC.

M. The SNC shall support the following security functions.
1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2. Role-Based Access Control (RBAC) for managing user roles and permissions.
3. Require users to use strong credentials.
4. Data in Motion and Sensitive Data at Rest be encrypted.
5. LDAP and Kerberos integration of access management.

N. The SNC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:
1. Metadata: Descriptive tags to define the structure of properties.
2. Tagging: Process to apply metadata to components
3. Tag Dictionary

O. The SNC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PEC, AUC, AVAV, VFD…) shall have an associated template file for reuse on future project additions.

P. The SNC shall be provided with a 5 Year Software Maintenance license directly to Muskegon Community College. Labor to implement not included.

2.5 PROGRAMMABLE EQUIPMENT CONTROLLER (PEC)

A. HVAC control shall be accomplished using BACnet based devices The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. All PECs shall be application programmable and shall at all times maintain their certification. All control sequences within or programmed into the PEC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.

C. The PEC shall provide LED indication of communication and controller performance to the technician, without cover removal.

D. The PEC shall not require any external configuration tool or programming tool. All configuration and programming tasks shall be accomplished and accessible from within the Niagara 4 environment.

E. Each PEC shall have expansion ability to support additional I/O requirements through the use of remote input/output modules.

F. PEC Controllers shall support at minimum the following control techniques:
   1. General-purpose control loops that can incorporate Demand Limit Control strategies, Set point reset, adaptive intelligent recovery, and time of day bypass.
   2. General-purpose, non-linear control loops.
   3. Start/stop Loops.
   4. If/Then/Else logic loops.
   5. Math Function loops (MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY).

2.6 ADVANCED UNITARY CONTROLLER (AUC)

A. The advanced unitary controller (AUC) platform shall be designed specifically to control HVAC - ventilation, filtration, heating, cooling, humidification, and distribution. Equipment includes: constant volume air handlers, VAV air handlers, packaged RTU, heat pumps, unit vents, fan coils, natural convection units and radiant panels. The controller shall use BACnet based devices. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. Minimum Requirements:
   1. The controller shall be fully programmable with full functionality on any Niagara 4 brand platform.
      a. Support downloads to the controller from any brand of Niagara 4 platform.
      b. Support uploads from the controller to any brand of Niagara 4 platform.
      c. Support simulation/debug mode of the controller.
      d. Maintain native GUI.
      e. Native function-block programming software and all controller “Setup Wizards” shall be embedded within the Niagara 4 environment.
   2. The controller shall be capable of either integrating with other devices or stand-alone operation.
   3. ~~The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications. Controller memory minimum requirements include:~~
      ~~a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.~~
      ~~b. FLASH Memory settings retained for ten years.~~
      ~~c. RAM: 2 Kilobytes.~~
   4. The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
      a. Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
      b. Accuracy: ±1 minute per month at 77 degrees F (25 degrees C).
   5. The controller shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.
   6. The controller shall have an internal DC power supply to power external sensors.
   7. The controller shall have a visual indication (LED) of the status of the device:
   8. The minimum controller Environmental ratings.
      a. Operating Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C).
      b. Storage Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C).
      c. Relative Humidity: 5% to 95% non-condensing.
   9. The controller shall have the additional approval requirements, listings, and approvals:

a. UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.
b. CSA (LR95329-3) Listed.
c. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
d. Meets Canadian standard C108.8 (radiated emissions).
e. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity).
f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission).

10. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
11. The controller shall have a mix of digital inputs (DI), digital outputs (DO), analog outputs (AO), and universal inputs (UI).
    a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
    b. Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA).
12. The controller shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.
13. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined in Section 4.
    a. Discharge air control and low limit.
    b. Pressure-dependent dual duct without flow mixing.
    c. Variable air volume with return flow tracking.
    d. Economizer with differential enthalpy.
    e. Minimum airflow coordinated with CO2.
    f. Unit ventilator cycle (1, 2, 3) 2-pipe.
    g. Unit ventilator cycle (1, 2, 3) 2-pipe with face/bypass.
    h. Unit ventilator cycle (1, 2, 3) 4-pipe.
    i. Unit ventilator cycle (1, 2, 3) 4-pipe with EOC valve.

2.7 VARIABLE AIR VOLUME CONTROLLER (VAV)

A. The VAV controller platform shall be designed specifically for room-level VAV control - pressure-independent air flow control, pressure dependent damper control, temperature, occupancy, use scheduling, and emergency control. Equipment includes: VAV terminal unit, VAV terminal unit with reheat, Series fan powered terminal unit, Parallel fan powered terminal unit, Supply and Exhaust air volume terminals and Constant volume dual-duct terminal unit. Control shall be accomplished using BACnet based devices. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. Minimum Requirements:
1. The controller shall be fully programmable with full functionality on any Niagara 4 brand platform.
    a. Support downloads to the controller from any brand of Niagara 4 platform.
    b. Support uploads from the controller to any brand of Niagara 4 platform.
    c. Support simulation/debug mode of the controller.
    d. Maintain native GUI.
    e. Native function-block programming embedded software and all controller “Setup Wizards” shall be embedded within the Niagara 4 environment.
2. The controller shall be capable of either integrating with other devices or stand-alone room-level control operation.
3. The controller shall have an internal velocity pressure sensor.

a. Sensor Type: Microbridge air flow sensor with dual integral restrictors.
b. Operating Range: 0 to 1.5 inch H2O (0 to 374 Pa).
c. Accuracy: ±2% of full scale at 32 degrees to 122 degrees F (0 degrees to 50 degrees C); ±1% of full scale at null pressure.

4. The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
   a. Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
   b. Accuracy: ±1 minute per month at 77 degrees F (25 degrees C).
5. The controller shall have Significant Event Notification, Periodic Update capability and Failure Detect when network inputs fail to be detected within their configurable time frame.
6. The controller shall have an internal DC power supply to power external sensors.
7. The controller shall have a visual indication (LED) of the status of the devise:
8. The minimum controller Environmental ratings:
   a. Operating Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C).
   b. Storage Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C).
   c. Relative Humidity: 5% to 95% non-condensing.
9. The controller shall have the additional approval requirements, listings, and approvals:
   a. UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.
   b. CSA (LR95329-3) Listed.
   c. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
   d. Meets Canadian standard C108.8 (radiated emissions).
   e. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity).
   f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission).
10. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
11. The controller shall provide an integrated actuator option.
    a. Actuator type: Series Floating.
    b. Rotation stroke: 95 degrees ±3 degrees for CW or CCW opening dampers.
    c. Torque rating: 44 lb-inch (5 Nm).
    d. Run time for 90 degrees rotation: 90 seconds at 60 Hz.
12. The controller shall have digital inputs (DI), digital outputs (DO), three analog outputs (AO), and universal inputs (UI).
    a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
13. The controller shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.
14. The controller shall have a loop execution response time of 1 second.
15. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined in Section 4.
    a. VAV terminal unit.
    b. VAV terminal unit fan speed control.
    c. Series fan.
    d. Parallel fan.
    e. Regulated air volume (room pressurization/de-pressurization).
    f. CV dual-duct.
    g. TOD occupancy sensor stand-by set points.

2.8 OTHER CONTROL SYSTEM HARDWARE

A. Control damper actuators shall be furnished by the Control System Contractor. Two-position or proportional electric actuators shall be direct-mount type sized to provide a minimum of 5 in-lb. torque per square foot of damper area. Damper actuators shall be spring return type. Operators shall be heavy-duty electronic type for positioning automatic dampers in response to a control signal. Motor shall be of sufficient size to operate damper positively and smoothly to obtain correct sequence as indicated. All applications requiring proportional operation shall utilize truly proportional electric actuators. Belimo is basis of design.

B. Control Valves: Control valves shall be 2-way or 3-way pattern as shown and constructed for tight shutoff at the pump shut-off head or steam relief valve pressure. Control valves shall operate satisfactorily against system pressures and differentials. Two-position valves shall be ' line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (unless otherwise noted or scheduled on the drawings). Valves with sizes up to and including 2 inches (51 mm) shall be "threaded" configuration and 2-1/2 inches (63.5 mm) and larger valves shall be "flanged" configuration. All control valves, including terminal unit valves, less than 2 inches (51 mm) shall be globe valves. Electrically-actuated control valves shall include spring return type actuators sized for tight shut-off against system pressures (as specified above) and, when specified, shall be furnished with integral switches for indication of valve position (open-closed). Belimo is basis of design.

C. Control Valve Actuators: Actuators for VAV terminal unit heating coils shall be "drive-open; drive-closed" type. All actuators shall have inherent current limiting motor protection. Valve actuators shall be 24-volt, electronic type, modulating or two-position as required for the correct operating sequence. Actuators on valves needing ' fail-safe' operation shall have spring return to Normal position. Modulating valves shall be positive positioning in response to the signal. All valve actuators shall be UL listed. Belimo is basis of design.

D. All control valves 2-1/2 inches (63.5 mm) or larger shall have position indication. All hot water control valves shall be Normally-Open arrangement; all chilled water control valves shall be Normally-Closed arrangement. Belimo is basis of design.

E. Wall Mount Room Temperature sensors: Replacement of all existing space thermostats, in non-BACnet current environments with wall mounted thermostat, occupancy sensor for occupied response (classrooms only), override button and warmer / cooler adjustment temperature, or equivalent finalized by College. Programmable options for each option in control software. Corridors will be stainless steel blank plate temperature sensors, labeled with equipment served. Distech is basis of design.

F. Duct-mounted and Outside Air Temperature Sensors: 10,000-ohm thermistor (type 2 or 3) temperature sensors with an accuracy of ±; 0.2 degrees C. Outside air sensors shall include an integral sun shield. Duct-mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size The sensor shall include a utility box and a gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 feet (2438 mm) long sensor element. These devices shall have accuracy of 0.5 degrees F (.024 degrees C) over the entire range.

G. Humidity sensors shall be thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH. Sensors shall be selected for wall, duct or outdoor type installation as appropriate.

H. Carbon Dioxide Sensors (CO_2): Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.), repeatable to plus or minus 20 PPM. Sensor range shall be 0 - 2000 PPM. Accuracy shall be plus or minus five percent (5%) or 75 PPM, whichever is greater. Response shall be less than one minute. Input voltage shall be 20 to 30 VAC or DC. Output

shall be 0 - 10 VDC. Sensor shall be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure.

I. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point.

J. Differential Analog (duct) Static Pressure Transmitters Provide a pressure transmitter with integral capacitance type sensing and solid-state circuitry. Accuracy shall be plus or minus 1% of full range; range shall be selected for the specific application. Provide zero and span adjustment capability. Device shall have integral static pickup tube.

K. Differential Air Pressure Switches: Provide SPDT type, UL-approved, and selected for the appropriate operating range where applied. Switches shall have adjustable set points and barbed pressure tips. Honeywell is basis of design.

L. Water Flow Switches: Provide a SPST type contact switch with bronze paddle blade, sized for the actual pipe size at the location. If installed outdoors, provide a NEMA-4 enclosure. Flow switch shall be UL listed.

M. Temperature Control Panels: Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. All electrical devices within a control panel shall be factory wired.

N. Pipe and Duct Temperature sensing elements: 10,000-ohm thermistor (type 2 or 3) temperature sensors with and accuracy of ±1% accuracy. Limited range sensors shall be acceptable provided they are capable of sensing the range expected for the point at the specified accuracy. Thermal wells with heat conductive gel shall be included.

O. Low Air Temperature Sensors: Provide SPST type switch, with 15 to 55 degrees F (-9 to 13 degrees C), range, vapor-charged temperature sensor. Honeywell model L482A, or approved equivalent.

P. Variable Frequency Drives: The variable frequency drive (VFD) shall be designed specifically for use in Heating, Ventilation, and Air Conditioning (HVAC) applications in which speed control of the motor can be applied. The VFD, including all factory installed options, shall have UL & CSA approval. VFD's replaced must include communications capability with DDC BMS via built-in interface card (BACnet). All VFD's installed or added shall have bypass – either e-bypass or mechanical. Integrated disconnect is required. Approved VFD's shall be ABB, Siemens BT Series and Eaton H Max.

Q. Relays: Start/stop relay model shall provide either momentary or maintained switching action as appropriate for the motor being started. All relays shall be plugged in, interchangeable, mounted on a sub base and wired to numbered terminals strips. Relays installed in panels shall all be DPDT with indicating lamp. Relays installed outside of controlled devices shall be enclosed in a NEMA enclosure suitable for the location. Relays shall be labeled with UR symbol. RIB-style relays are acceptable for remote enable/disable.

R. Transducers: Differential pressure transducers shall be electronic with a 4-20 mA or 0–10 vdc output signal compatible to the Direct Digital Controller. Wetted parts shall be stainless steel. Unit shall be designed to operate in the pressure ranges involved.

S. Control Power Transformers: Provide step-down transformers for all DDC controllers and devices as required. Transformers shall be sized for the load, but shall be sized for 40 watts, minimum. Transformers shall be UL listed Class 2 type, for 120 VAC/24 VAC operation. Honeywell is basis of design.

T. Line voltage protection: All DDC system control panels that are powered by 120 VAC circuits

shall be provided with overload protection. This protection is in addition to any internal protection provided by the manufacturer. A grounding conductor, (minimum 12 AWG), shall be brought to each control panel.

2.9 BAS SERVER & WEB BROWSER GUI - SYSTEM OVERVIEW

A. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet.

B. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft Internet Explorer, Microsoft EDGE, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Window operating systems.

C. The BAS server software shall support at least the following server platforms (Windows 7, 8.1, 10, Server 12). The BAS server software shall be developed and tested by the manufacturer of the system stand-alone controllers and network controllers/routers.

D. The web browser GUI shall provide a completely interactive user interface and shall provide a HTML5 experience that supports the following features as a minimum:
   1. Trending.
   2. Scheduling.
   3. Electrical demand limiting.
   4. Duty Cycling.
   5. Downloading Memory to field devices.
   6. Real time 'live' Graphic Programs.
   7. Tree Navigation.
   8. Parameter change of properties.
   9. Set point adjustments.
   10. Alarm / event information.
   11. Access to user programming log – date, time, user and programming completed.
   12. Configuration of operators.
   13. Visual animation of equipment operation – real time.
   14. Execution of global commands.
   15. Add, delete, and modify graphics and displayed data.

E. Software Components: All software shall be the most current version. All software components of the BAS system software shall be provided and installed as part of this project. All user and programming access to software shall be provided to owner. BAS software components shall include:
   1. Server Software, Database and Web Browser Graphical User Interface.
   2. 5 Year Software Maintenance license. Labor to implement not included.
   3. Embedded System Configuration Utilities for future modifications to the system and controllers.
   4. Embedded Graphical Programming Tools.
   5. Embedded Direct Digital Control software.
   6. Embedded Application Software.

F. BAS Server Database: The BAS server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2. BAS systems written to Non -Standard and/or Proprietary databases are NOT acceptable.

G. Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:
   1. Web Browser's for PC's: Only the current released browser (Explorer/Firefox/Chrome) will be required as the GUI and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet.
   2. Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol Secure (HTTPS).

2.10 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for operator access, reports and reporting actions for events.

B. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and strong password. Navigation in the system shall be dependent on the operator's role-based application control privileges.

C. Navigation: Navigation through the GUI shall be accomplished by clicking on the appropriate level of a navigation tree (consisting of an expandable and collapsible tree control like Microsoft's Explorer program) and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.
   1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
   2. Groups View shall display Scheduled Groups and custom reports.
   3. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

D. Action Pane: The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:
   1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
   2. Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web browser. User shall have ability to save custom dashboards. See Section 2.13 below.
   3. Search: User shall have multiple options for searching data based upon Tags. Associated equipment, real time data, Properties, and Trends shall be available in result.
   4. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an

'accept/cancel' button.

5. Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).
6. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
7. Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.
8. Logic - Live Graphic Programs: Shall be used to display' live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
9. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

E. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated .gifs or .jpg, vector scalable, active set point graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:

1. Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.
2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
4. Graphic animations shall be provided to provide status of equipment, devices, control, failures, etc.
5. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.
6. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
   a. Each piece of equipment monitored or controlled including each terminal unit.
   b. Each building.
   c. Each floor and zone controlled.

F. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with proper access credentials) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day ' Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the ' Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

1. Schedules: Schedules shall comply with the BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and

shall allow events to be scheduled based on:

a. Types of schedule shall be Normal, Holiday or Override.
b. A specific date.
c. A range of dates.
d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
e. Wildcard (example, allow combinations like second Tuesday of every month).

2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
3. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an ' individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the ' tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the ' tenant group'.
4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
6. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

G. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an ' Alarms' view. Alarms, and reporting actions shall have the following capabilities:

1. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.
2. Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
3. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.
4. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to

email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.

5. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
6. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A ' network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.
7. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.
8. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.
9. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
    a. Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
    b. Email: Email shall be sent via any POP3, SMTP email and SMS text services (where applicable) - compatible e-mail server (most Internet Service Providers use POP3, SMTP email and SMS text services (where applicable)). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
    c. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
    d. Write Property: The write property reporting action updates a property value in a hardware module.
    e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
    f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

H. Trends: As system is engineered, all points shall be enabled to trend. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points

are selected for displays that have different trend intervals, the system will automatically scale the axis.

4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and ' pan through' historical data by simply scrolling the mouse.
6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
7. Copy/Paste. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

I. Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges as specified:

1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of ' easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
   a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
   b. Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
   c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.
2. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

2.11 GRAPHICAL PROGRAMMING

A. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. Any system that does not use a drag and drop method of graphical icon programming shall not be accepted. All systems shall use a GPL method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

B. Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

C. Graphic Sequence: The clarity of the graphic sequence shall be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming shall be self-documenting and provide the operator with an understandable and exact

representation of each sequence of operation.

D. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:
   1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
   2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
   3. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
   4. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
   5. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
   6. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
   7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields, and shall contain 'push buttons' for the purpose of selecting default parameter settings.
   8. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.
   9. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
   10. Live Graphical Programs: The Graphic Programming software shall support a ' live' mode, where all input/output data, calculated data and set points shall be displayed in a ' live' real-time mode.

2.12 ENERGY DASHBOARD

A. Furnish and install dashboard display graphics as a subset of the standard graphics package. Dashboard display graphics shall consist of a minimum of the following user selectable viewlets or widget libraries for easy visualization changes:
   1. Circular and Semi-Circular Gauge
   2. Column and Drilldown Charts
   3. Demand Duration
   4. Pie and Drilldown Charts
   5. Axis Charts
   6. History Color Grid and Line Charts
   7. Visual Electric Meters
   8. Point Line and Table Charts
   9. Utility Usage Rankings Charts
   10. Resource Consumption Charts
   11. Scatter Plot
   12. Spyder Charts

B. The Energy Dashboard display shall consist of the following “pages” or “screens”:
   1. Home Page: The “Home Page” for ___ Muskegon Community College _ (Associated cooling or heating device(s) determined with MCC Office of Physical Plant) _shall indicate the following information:
      a. Picture or render of _Associated cooling or heating device(s) determined

with MCC Office of Physical Plant ___ along with information about the building.

b. Tabs or Icons that take the user to the other sections of the interactive display.

c. Screen saver mode that will scroll through selected images of the building and its features.

2. Building Education Page: The “Building Education Page” shall indicate the following information:

a. Building Green Features

b. Facility Information

3. Monitoring Page: The “Monitoring Page” shall indicate a minimum of five (5) icons that shall display the following information:

a. Electricity Usage (KW & KWH)

b. Outside Air Temperature and Relative Humidity

This information shall have the historical information displayed through a graph and the live information displayed on a gauge. The historical information will be shown daily, weekly, monthly, and yearly. The historical points shall be shown in a combination of totalization, peak, and average demand.

PART 3 EXECUTION

3.1 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Owner of unsatisfactory preparation before proceeding.

3.2 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 GENERAL

A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.

B. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.

C. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.

D. All control devices mounted on the face of control panels shall be clearly identified.

3.4 WIRING

A. All electrical control wiring to the control panels shall be the responsibility of the Control System Contractor.

B. All wiring shall be in accordance with the Project Electrical Specifications (Division 16), the

National Electrical Code and any applicable local codes.

C. All wiring installations will be in a secured, supported, neat, orderly, and professional manner.

D. All wiring is required to be labeled in a readily recognizable format and location on the wire jacketing.

E. Careful stripping of wire while inside the cabinet is required to ensure that no wire strand fragments land on circuit boards.

F. Use manufacturer-specified wire for all network connections.

G. BACnet wiring color will be determined with Muskegon Community College.

H. Read installation instructions carefully. Any unavoidable deviations shall be approved by owner's rep prior to installation.

3.5 ACCEPTANCE TESTING

A. Upon completion of the installation, the Control System Contractor shall load all system software and start-up the system. The Control System Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.

B. The Control System Contractor shall perform tests to verify proper performance of components, routines and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.

C. System Acceptance: Satisfactory completion is when the Control System Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.6 OPERATOR TRAINING

A. During system commissioning and at such time acceptable performance of the Control System hardware and software has been established, the Control System Contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories.

B. The Control System Contractor shall provide 24 total hours of comprehensive training with Q & A, in multiple sessions, for system orientation, product maintenance and troubleshooting, programming and engineering. These classes are to be spread out during the 1st year warranty period.

3.7 WARRANTY PERIOD SERVICES

A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of 3 years from the time of system acceptance.

B. Within this period, upon notice by the Owner, any defects in the BMS due to faulty materials, methods of installation or workmanship shall be promptly repaired or replaced by the Control System Contractor at no expense to the Owner.

C. Maintenance of Computer Software Programs: The Control System Contractor shall maintain all software during the standard first year warranty period. In addition, all factory or sub-vendor upgrades to software during the first year warranty period shall be added to the systems, when they become available, at no additional cost. In addition to first year standard warranty, software provided by Control System Contractor shall come with a 5 Year Software Maintenance license. All SNC and BAS Servers are included in this coverage. Labor to implement upgrades in years two through five are not included in standard warranty.

D. Maintenance of Control Hardware: The Control System Contractor shall inspect, repair, replace, adjust, and calibrate, as required, the controllers, control devices and associated peripheral units during the warranty period. The Control System Contractor shall then furnish a report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective actions taken. The report shall clearly certify that all hardware is functioning correctly.

E. Service Period: Calls for service by the Owner shall be honored within 24 hours and are not to be considered as part of routine maintenance.

F. Service Documentation: A copy of the service report associated with each owner-initiated service call shall be provided to the owner.

3.8 WARRANTY ACCESS

A. The Owner shall grant to the Control System Contractor reasonable access to the BMS during the warranty period. Remote access to the BMS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

3.9 OPERATION & MAINTENANCE MANUALS

A. See Division 1 for requirements. O&M manuals shall include the following elements, as a minimum:
   1. As-built control drawings for all equipment.
   2. As-built Network Communications Diagram.
   3. General description and specifications for all components.
   4. Device lists with quantities for each functional areas described in the RFP.
   5. Completed Performance Verification sheets.
   6. Completed Controller Checkout/Calibration Sheets.

3.10 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

C. Bid bond secured by Vendor.

D. Liquidated damages accepted by Vendor.

END OF SECTION