SECTION 23 09 00

BUILDING AUTOMATION 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. 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 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 must communicate on a peer-to-peer bus over a LonTalk, BACnet, or IP Based open protocol bus. All controllers on the LonTalk bus must be LonMark certified.
   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 must fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet and MODBUS.
   3. System architecture must provide secure Web access using any of the current versions of Microsoft Internet Explorer, Mozilla Firefox, or Google Chrome browsers from any computer on the owner's LAN.

4. All control devices, including configurable and fully programmable controllers, furnished with this Section must 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 must not be acceptable.
5. Any control vendor that must provide additional BMS server software must be unacceptable. Only systems that utilize the Niagara 4 Framework must satisfy the requirements of this section.
6. The BMS server must host all graphic files for the control system. All graphics and navigation schemes for this project must match those that are on the existing campus NiagaraAX or Niagara 4 Framework server.
7. A new laptop computer including engineering/programming software to modify Operating System Server BMS programs and graphics must be included. An IPAD may be requested for monitoring of building operations and graphic access and will be job specific per a request by UNCW if required(Owner's discrepancy)
8. Owner must receive all Administrator level login and passwords for engineering toolset at first training session. The Owner must 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. UNCW will be responsible for setting up desired user accounts with necessary access limits per each
9. user's requirements and allowances.
10. OPEN NIC STATEMENTS - All Niagara 4 software licenses must have the following NiCS: "accept.station.in=*"; "accept.station.out=*"and "accept.wb.in=*"and "accept.wb.out=*". All open NIC statements must follow Niagara Open NIC specifications.
11. All JACE hardware licenses and certificates must be stored on local MicroSD memory card employing encrypted "safe boot" technology.
12. All JACE's provided as part of this project must be the appropriate JACE-8000 model licensed with all necessary drivers.
13. Approved Manufacturers: Honeywell, TAC I/A Series, Distech, Trane.
14. Approved Installation Contractors: Engineered Control Solutions, Schneider Electric CMS Controls

1.4 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.

1.5 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 A-E.

D. Electronic copies of shop drawings of the entire control system must be submitted and must 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 must be included for approval.

E. Shop drawings must 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 must be shown on the shop drawings.

F. Upon completion of the work, provide three (3) complete sets of ' as-built' drawings and other project-specific documentation in 3-ring hard-backed binders and one electronic copy.

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

H. All control panels associated with a field device such as air handlers and water systems must have a laminated page copy of the writing schematic and detail attached to the control cabinet.

I. A software copy of the controls as-built must be supplied and downloaded to the local system network controller (SNC) in 2 different formats. One PDF format and another in the format (Visio) used to produce and engineer the original document as to allow UNCW to modify the as-builts in future changes, construction, and modifications to the controls system.

1.6 QUALITY ASSURANCE

A. The Control System Contractor must have a full service DDC office within 50 miles of the job site. This office must be staffed with applications engineers, software engineers and field technicians. The Control System Contractor must be staffed with a minimum of ten (10) Niagara 4 certified software engineers and/or technicians. The Control System Contractor must maintain parts inventory and must have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment.

B. Single Source Responsibility of Supplier: The Control System Contractor must be responsible for the complete installation and proper operation of the control system. The Control System Contractor must 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 must be the manufacturer of the primary DDC system components or must have been the authorized representative for the primary DDC components manufacturer for at least 10 years. All control panels must be assembled by the Control System Contractor in a UL-Certified 508A panel shop. Control panels must be assembled such that all necessary I/O points are pre-wired to terminal blocks. Wire ducts must be installed within the panel as needed to accommodate field wiring.

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

1.7 SOFTWARE OWNERSHIP

A. The Owner must have full ownership 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.

1.8 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.

1.9 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It must 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, duct and conduit runs, electrical outlets and fixtures, air diffusers and structural and architectural features.

1.10 SEQUENCING

A. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

PART 2 - PRODUCTS

2.1 GENERAL

A. The Building Management System (BMS) must 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 must provide secure strong password access to all features, functions and data contained in the overall BMS.

2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing the LonWorks technology communication protocol in one open, interoperable system.

B. The supplied computer software must 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, must be via Ethernet or IP.

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

D. The supplied system must 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 must reside on the Operating System Server located in the Facilities Office on the LAN. Systems requiring proprietary database and user interface programs must not be acceptable.

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 must not be acceptable.
   1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation must 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 must not exceed 60 seconds for remote or dial-up connected user interfaces.

2.3 BAS SERVER HARDWARE (Provided by Owner)

A. Minimum Computer Configuration (Hardware Independent).
1. Central Server. Owner must provide a dedicated BAS server with configuration that includes the following components as a minimum:
2. Processor: Intel Xeon CPU E5-2640 x64 (or better), compatible with dual- and quad-core processors.
3. Memory: 8 GB or more.
4. Hard Drive: 80 GB minimum, more recommended depending on archiving requirements.
5. Display: Video card and monitor capable of displaying 1024 x 768 pixel resolution or greater.
6. Network Support: Ethernet adapter (10/100 Mb with RJ-45 connector).
7. Connectivity: Full-time high-speed ISP connection recommended for remote site access (i.e. T1, ADSL, cable modem).

B. Standard Client: The thin-client Web Browser BAS GUI must be Microsoft Internet Explorer (10.0 or later) running on Microsoft 7+. No special software must be required to be installed on the PCs used to access the BAS via a web browser.

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 must be fully programmable to meet the unique requirements of the facility it must control.

C. The controllers must 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 must employ a device count capacity license model that supports expansion capabilities.

F. The SNC must be enabled to support and must 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 must 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.

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

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

K. The SNC must 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 must be selectable for annunciation type and acknowledgement requirements including but not limited to:
      a. Alarm.
      b. Return to normal.
      c. To default.
   2. Alarms must 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 must 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.
   4. Alarms classes must be created in the local station to match N4 Supervisor class naming in the following manner with same naming for priority routing and annunciation. (listed in order of priority from highest to lowest)
      a. Critical Alarms (Priority 1)
      b. High Priority (Priority 2)

c. Space Temp Alarms (Priority 3)
d. Generator Alarms (Priority 3) (if required)
e. Plumbers Alarms (Priority 3) (if required)
f. Mid Priority (Priority 4)
g. Low Priority (Priority 5)
h. Ping Alarms (Priority 6)
i. *Back to normal state (Priority 7)*

5. All alarm classes in the local station must be directed to the N4 station recipient for routing. The Supervisors "Supervisor Console" should be added to a Px view accessible via a hyperlink with a filter applied to show only the selected buildings alarms on the appropriate buildings' graphics alarm page.
   a. Time Stamp
   b. Source
   c. Source State
   d. Alarm State
   e. Priority
   f. Alarm Class
   g. Ack or Clear Action link

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

M. The SNC must 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 must 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 must 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, AVAV, CVAV, VFD) must have an associated template file for reuse on future project additions.

P. The SNC point naming must follow a standard as set for a standardized naming convention. This naming standard must be applied to the SNC as well as the BAS Server Supervisor for all points related to setpoints, monitoring points, trending, alarming, and graphics

Q. The SNC must be provided with a 1 Year Software Maintenance license. Labor to implement not included.

2.5 BUILDING AUTOMATION SYSTEM CONTROLLERS

A. HVAC control must be accomplished using LonMark based devices. The controller platform must 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".

1. Programmable Equipment Controllers - a controller designed for more complex sequences of operations such as built up AHU's, central plant operations, electrical monitoring, and control and management for chillers, boilers and generators. The PECs are to allow for the flexibility of custom control programming to meet the needed sequences of operation. PEC's must be selected based upon I/O requirements. Additional I/O may be added via expansion modules.
    a. All PECs must be application programmable and must at all times maintain their certification. All control sequences within or programmed into the PEC must be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
    b. The PEC must provide LED indication of communication and controller performance to the technician, without cover removal.
    c. PEC's must have mixture of I/O including dry contact digital inputs, universal inputs (configurable as 0-10V, 0-10,000 ohm or, 20K NTC), analog outputs (4-20mA), and digital outputs (24 VAC TRIAC or relay).
2. Advanced Variable Air Volume Controller (AVAV) - a controller designed specifically for room-level VAV control - pressure-independent air flow control, pressure dependent damper control, supply and exhaust pressurization/de-pressurization control; temperature, humidity, complex CO2, occupancy, 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.
    a. The AVAV must be application programmable and must at all times maintain their certification. All control sequences within or programmed into the PEC must be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
    b. The controller must have an internal velocity pressure sensor.
    c. The AVAV must provide LED indication of communication and controller performance to the technician, without cover removal.
    d. AVAV's must have mixture of I/O including dry contact digital inputs, universal inputs (configurable as 0-10V, 0-10,000 ohm or, 20K NTC), analog outputs (4-20mA), and digital outputs (24 VAC TRIAC).
    e. The controller must provide an integrated actuator option.
3. Configurable VAV Controller (CVAV) - the configurable VAV controller platform must be designed specifically for room-level VAV control – pressure-independent air flow control, pressure dependent damper control, supply and exhaust pressurization/de-pressurization control; temperature, humidity, complex CO2, occupancy, 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.
    a. The CVAV must be application specific configuration and must at all times maintain their certification. All control sequences within or programmed into the CVAV must be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
    b. The controller must have an internal velocity pressure sensor.
    c. The CVAV must provide LED indication of communication and controller performance to the technician, without cover removal.

d. CVAV's must have mixture of I/O including dry contact digital inputs, universal inputs (configurable as 0-10V, 0-10,000 ohm or, 20K NTC), analog outputs (4-20mA), and digital outputs (24 VAC TRIAC).
e. The controller must provide an integrated actuator option.

4. Configurable Constant Volume AHU Controller (CVAHU) - the configurable constant volume AHU controller must be designed specifically for single zone unitary AHU control –temperature, humidity, complex CO2, occupancy, and emergency control. Equipment includes: unitary air handling units, fan coil units, blower coil units, unit ventilators, and heat pumps.
   a. The CVAHU controller must be application specific configuration and must at all times maintain their certification. All control sequences within or programmed into the CVAHU controller must be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
   b. The CVAHU controller must provide LED indication of communication and controller performance to the technician, without cover removal.
   c. CVAHU controllers must have mixture of I/O including dry contact digital inputs, universal inputs (configurable as 0-10V, 0-10,000 ohm or, 20K NTC), analog outputs (4-20mA), and digital outputs (24 VAC TRIAC).

2.6 OTHER CONTROL SYSTEM HARDWARE

A. Utility metering devices, (water, electric, and gas) must be non-pulse devices with non-volatile memory communicated directly to a gateway such as SCADA metrics Ethermeter, Onicon D-100, or kW switchgear meters which will be communicated to the building and supervisor Niagara system.

B. HVAC local non-programmable and non-configurable integration devices, (boilers, VFD's, and utility meters) must use LonMark, BACnet, Modbus, or IP based devices to communicate.

C. Motorized control dampers that will not be integral to the equipment must be furnished by the Control System Contractor. Control damper frames must be constructed of galvanized steel, formed into changes and welded or riveted. Dampers must be galvanized, with nylon bearings. Blade edge seals must be vinyl. Blade edge and tip seals must be included for all dampers. Blades must be 16-gauge minimum and 6 inches wide maximum and frame must be of welded channel iron. Damper leakage must not exceed 10 CFM per square foot, at 1.5 inches water gauge static pressure.

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

E. Control Valves: Control valves must 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 must operate satisfactorily against system pressures and differentials. Two-position valves must be ' line' size. Proportional control valves must 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) must be "screwed" configuration and 2-1/2 inches (63.5 mm) and larger valves must be "flanged" configuration. All control valves, including terminal unit valves, less than 2 inches (51 mm) must be globe valves. Electrically-actuated control valves must include spring return type actuators sized for tight shut-off against system pressures (as specified above) and, when specified, must be furnished with integral switches for indication of valve position (open-closed). Pneumatic actuators for valves, when utilized, must be sized for tight shut-off against system pressures (as specified above).

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

G. All control valves 2-1/2 inches (63.5 mm) or larger must have position indication. All hot water control valves must be Normally-Open arrangement; all chilled water control valves must be Normally-Closed arrangement.

H. Wall Mount Room Temperature sensors: Each room temperature sensor must provide temperature indication to the digital controller, provide the capability for a software-limited occupant set point adjustment (warmer-cooler slider bar or switch) and limited operation override capability. Room Temperature Sensors must be 20,000-ohm thermistor type with a temperature range of -40 to 140 degrees F (-38 to 60 degrees C). The sensor must be complete with a decorative cover and suitable for mounting over a standard electrical utility box. These devices must have an accuracy of 0.5 degrees F (.024 degrees C) over the entire range.

I. Duct-mounted and Outside Air Temperature Sensors: 20,000-ohm thermistor temperature sensors with an accuracy of ±; 0.2 degrees C. Outside air sensors must include an integral sun shield. Duct-mounted sensors must have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of -40 to 160 degrees F(-38 to 71 degrees C) The sensor must 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 must have accuracy of 0.5 degrees F (.024 degrees C) over the entire range.

J. Humidity sensors must 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 must be 0 to 100% RH and 32 to 140 degrees F (0 to 60 degrees C). Sensors must be selected for wall, duct or outdoor type installation as appropriate. Honeywell is basis of design.

K. Carbon Dioxide Sensors (CO2): Sensors must utilize Non-dispersive infrared technology (N.D.I.R.), repeatable to plus or minus 20 PPM. Sensor range must be 0 - 2000 PPM. Accuracy must be plus or minus five percent (5%) or 75 PPM, whichever is greater. Response must be less than one minute. Input voltage must be 20 to 30 VAC or DC. Output must be 0 - 10 VDC. Sensor must be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure.

L. 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. Current switch

to include an integral LED for indication of trip condition and a current level below trip set point.

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

N. Differential Air Pressure Switches: Provide SPDT type, UL-approved, and selected for the appropriate operating range where applied. Switches must have adjustable set points and barbed pressure tips.

O. 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 must be UL listed.

P. 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 must be factory wired. Control panel must be assembled by the BMS in a UL-Certified 508A panel shop. A complete set of ' as-built' control drawings (relating to the controls within that panel) must be furnished within each control panel.

Q. Pipe and Duct Temperature sensing elements: 20,000-ohm thermistor temperature sensors with and accuracy of ±1% accuracy. Their range must be -5 to 250 degrees F (-20 to 121 degrees C). Limited range sensors must be acceptable provided they are capable of sensing the range expected for the point at the specified accuracy. Thermal wells with heat conductive gel must be included.

R. 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.

S. Variable Frequency Drives: The variable frequency drive (VFD) must 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, must have UL & CSA approval. VFD's must include communications capability with DDC BMS via built-in interface card (MODBUS or BACnet). Honeywell SmartVFD is basis of design.

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

U. Emergency Stop Switches: Provide toggle-type switch with normally-closed contact. Switch must be labeled "AIR HANDLER EMERGENCY SHUTOFF, NORMAL - OFF.".

V. Transducers: Differential pressure transducers must be electronic with a 4-20 mA output signal compatible to the Direct Digital Controller. Wetted parts must be stainless steel. Unit must be designed to operate in the pressure ranges involved.

W. Control Power Transformers: Provide step-down transformers for all DDC controllers and

devices as required. Transformers must be sized for the load, but must be sized for 50 watts, minimum. Transformers must be UL listed Class 2 type, for 120 VAC/24 VAC operation.

X. Line voltage protection: All DDC system control panels that are powered by 120 VAC circuits must be provided with surge protection. This protection is in addition to any internal protection provided by the manufacturer. The protection must meet UL, ULC 1449, IEEE C62.41B. A grounding conductor, (minimum 12 AWG), must be brought to each control panel.

Y. Lon Bus Surge Protectors: A Lon Bus Surge Protector, DITEK model # DTK-2MHLP24BWB or equivalent must be installed on the lon bus when it leaves and enters a building.

Z. Ethernet Port Surge Protector: An Ethernet Surge protector must be installed similar to the Honeywell 14507678-004 or comparable.

AA. Airflow Monitoring Stations: Ebtron Brand airflow monitoring stations must be Lon. Controls Contractor must verify installed duct sizes and airflows before ordering.

BB. Gas Meters: Onicon brand F-5400 Series Thermal Mass Flow Meter, D-100 display with LonWorks TP/FT-10F Output. Controls Contractor must verify installed pipe size, meter placement sizes and flows before ordering.

CC. Domestic Water Meters:
1. Building meters: Neptune with Neptune E-Coder register w/ the potted cable.
   a. 1.5 inches and below must be positive displacement type with matching strainer.
   b. 2 inches and above must be compound type meter with matching strainer.
2. Irrigation meters: Neptune
   a. Minimum 2" turbine meter with matching strainer
3. Meter Register: Neptune E-Coder register w/ the potted cable. (The R900i register is NOT compatible, since it does not feature a connection wire.)
4. Meter Gateway: Scadametrics Ethermeter http://www.scadametrics.com/ The gateway device must directly interrogate the meter register and must calculate and relay the following parameters to the BMS: Totalized Volume, Instantaneous Flowrate

DD. BTU Meters: Onicon System-10 BTU meter, LonWorks communication, F-3500 Electromagnetic Flow Meter.

EE. Electric Meter: Digital Electric Meter with Modbus communication (Honeywell / E-Mon Class 3200 Smart Meter With MODBUS RTU communication, basis of design). Unit must display and communicate totalized kWH, voltage, amps, kW.

FF. Liquid Flow Meters: Onicon F-3500 Electromagnetic Flow Meter, D-100 Display with LonWorks Communication (other Onicon displays allowed with designer approval).

2.7 BAS SERVER & WEB BROWSER GUI - SYSTEM OVERVIEW

A. The BAS Contractor must provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server must communicate using Ethernet and TCP. Server must 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) must 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, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Window operating systems.

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

D. The web browser GUI must provide a completely interactive user interface and must 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. Configuration of operators.
   12. Execution of global commands.
   13. Add, delete, and modify graphics and displayed data.

E. Software Components: All software must be the most current version. All software components of the BAS system software must be provided and installed as part of this project. BAS software components must 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 must 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 must be thin client or browser based and must 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 must be required on the operator's GUI workstation/client. Connection must be over an intranet or the Internet.
   2. Secure Socket Layers: Communication between the Web Browser GUI and BAS server must offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol must be Hyper-Text Transfer Protocol (HTTP).

2.8 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation: The Thin Client web browser GUI must provide a comprehensive user interface. Using a collection of web pages, it must be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It must be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI must (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 must be presented with a login page that will require a login name and strong password. Navigation in the system must be dependent on the operator's role-based application control privileges.

C. Navigation: Navigation through the GUI must 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 must be displayed simultaneously, enabling the operator to select a specific system or equipment and view the corresponding graphic. The navigation tree must as a minimum provide the following views: Geographic, Network, Groups and Configuration.
   1. Geographic View must display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
   2. Groups View must display Scheduled Groups and custom reports.
   3. Configuration View must display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

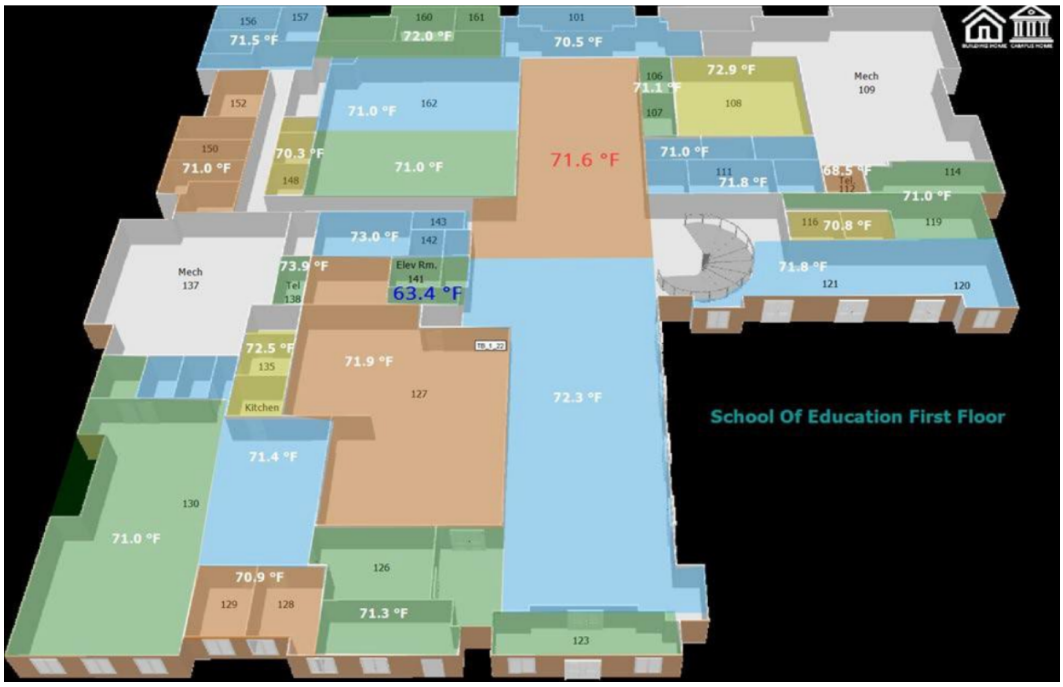
D. Action Pane: The Action Pane must provide several functional views for each subsystem specified. A functional view must be accessed by clicking on the corresponding button:
   1. Graphics: Using graphical format suitable for display in a web browser, graphics must include aerial building/campus views, color building floor-plans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page must automatically refresh.
   2. Dashboards: User customizable data using drag and drop HTML5 elements. Must include Web Charts, Gauges, and other custom developed widgets for web browser. User must have ability to save custom dashboards.
   3. Search: User must have multiple options for searching data based upon Tags. Associated equipment, real time data, Properties, and Trends must be available in result.
   4. Properties: Must 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 must require the operator to depress an 'accept/cancel' button.
   5. Schedules: Must be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).
   6. Alarms: Must be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
   7. Charting: Must be used to display associated trend and historical data, modify colors, date range, axis and scaling. User must have ability to create HTML charts through web browser without utilizing chart builder. User must be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.
   8. Logic - Live Graphic Programs: Must 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 must be available via a drop-down window.

E. Color Graphics: The Web Browser GUI must 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 must be used to enhance usability. Graphics tools used to create Web Browser graphics must be non-proprietary and conform to the following basic criteria:

1. Display Size: The GUI workstation software must graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.
2. General Graphic: General area maps must show locations of controlled buildings in relation to local landmarks.
3. Color Floor Plans: Floor plan graphics must 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 must be updated dynamically as a zone's actual comfort condition changes.
4. Mechanical Components: Mechanical system graphics must 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 must be displayed with the appropriate engineering units. Animation must be used for rotation or moving mechanical components to enhance usability. .
5. Minimum System Color Graphics: Color graphics must 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.
6. Display Size : The GUI workstation software must graphically display in a minimum of 1024 by 728 pixels 24 bit True Color.
7. General Graphic: General area maps must show locations of controlled buildings in relation to local landmarks.
8. Color Floor Plans: Floor plan graphics must be multi-colored to differentiate between the different zones and areas. Colors selected are based on a neutral palette as to not show a large variance in bright colors but more of a neutral, slightly different tones. Provide a visual display of temperature relative to their respective set points via the use of a color changing font and size that displays the zone temperature. The displayed temperature must change to a red blinking, size 20 font for high space temperature and blue blinking, size 20 font for low space temperature. The colors and font size must be updated as a zone's actual comfort condition changes from a normal range to a high or low out of range measurement.



F. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with proper access credentials) must 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 must be shown in a summary schedule table and graph.

1. Schedules: Schedules must comply with the LonWorks and BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and must allow events to be scheduled based on:
   a. Types of schedule must 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 must allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories must 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 must 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 must be able to define an ' individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the ' tenant group' must automatically be downloaded to control modules affecting spaces occupied by the ' tenant group'.

4. Intelligent Scheduling: The control system must 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 must 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 must 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 must 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 must apply.

G. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, must be displayed in the Action Pane by selecting an ' Alarms' view. Alarms, and reporting actions must have the following capabilities:
1. Alarms View: Each Alarm must 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 must indicate the system location, address and other pertinent information. An operator must 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 must be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon must be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
3. Alarm Templates: Alarm template must define different types of alarms and their associated properties. As a minimum, properties must 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 must 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 must be used to setup Alarm Areas in the Graphic Pane.
5. Alarm Time/Date Stamp: All events must 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 must be able to define the type of Alarm generated per object. A ' network' view of the Navigation Tree must expose all objects and their respective Alarm Configuration. Configuration must 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 must 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 must 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 must be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators must be able to easily define these Reporting Actions using the Navigation Tree

and Graphic Pane through the web browser GUI. Reporting Actions must be as follows:

a. Print: Alarm information must be printed to the BAS server's PC or a networked printer.
b. Email: Email must be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action must also be used to support alphanumeric paging services, where email servers support pagers.
c. File Write: The ASCII File write reporting action must 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 must 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 must be enabled to trend. Trends must both be displayed and user configurable through the Web Browser GUI. Trends must comprise analog, digital or calculated points simultaneously. A trend log's properties must be editable using the Navigation Tree and Graphic Pane.

1. Viewing Trends: The operator must have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system must allow y- and x-axis maximum ranges to be specified and must be able to simultaneously graphically display multiple trends per graph.
2. Local Trends: Trend data must 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 must be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
3. Resolution. Sample intervals must 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 must be able to dynamically update at operator-defined intervals.
5. Zoom/Pan. It must 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 must be possible to pick any sample on a trend and have the numerical value displayed.
7. Copy/Paste. The operator must 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 must require a Login Name and Strong Password. Access to different areas of the BAS system must be defined in terms of Role-Based Access Control privileges as specified:

1. Roles: Roles must reflect the actual roles of different types of operators. Each role must comprise a set of ' easily understood English language' privileges. Roles must be defined in terms of View, Edit and Function Privileges.

a. View Privileges must comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
b. Edit Privileges must comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
c. Function Privileges must 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 must be geographically assigned using a similar expandable/collapsible navigation tree. For example, it must be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

2.9 GRAPHICAL PROGRAMMING

A. The system software must 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 must not be accepted. All systems must 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 must be interactive and contain the programming necessary to execute the function of the device it represents.

B. Graphic programming must be performed while on screen and using a mouse; each microblock must 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.

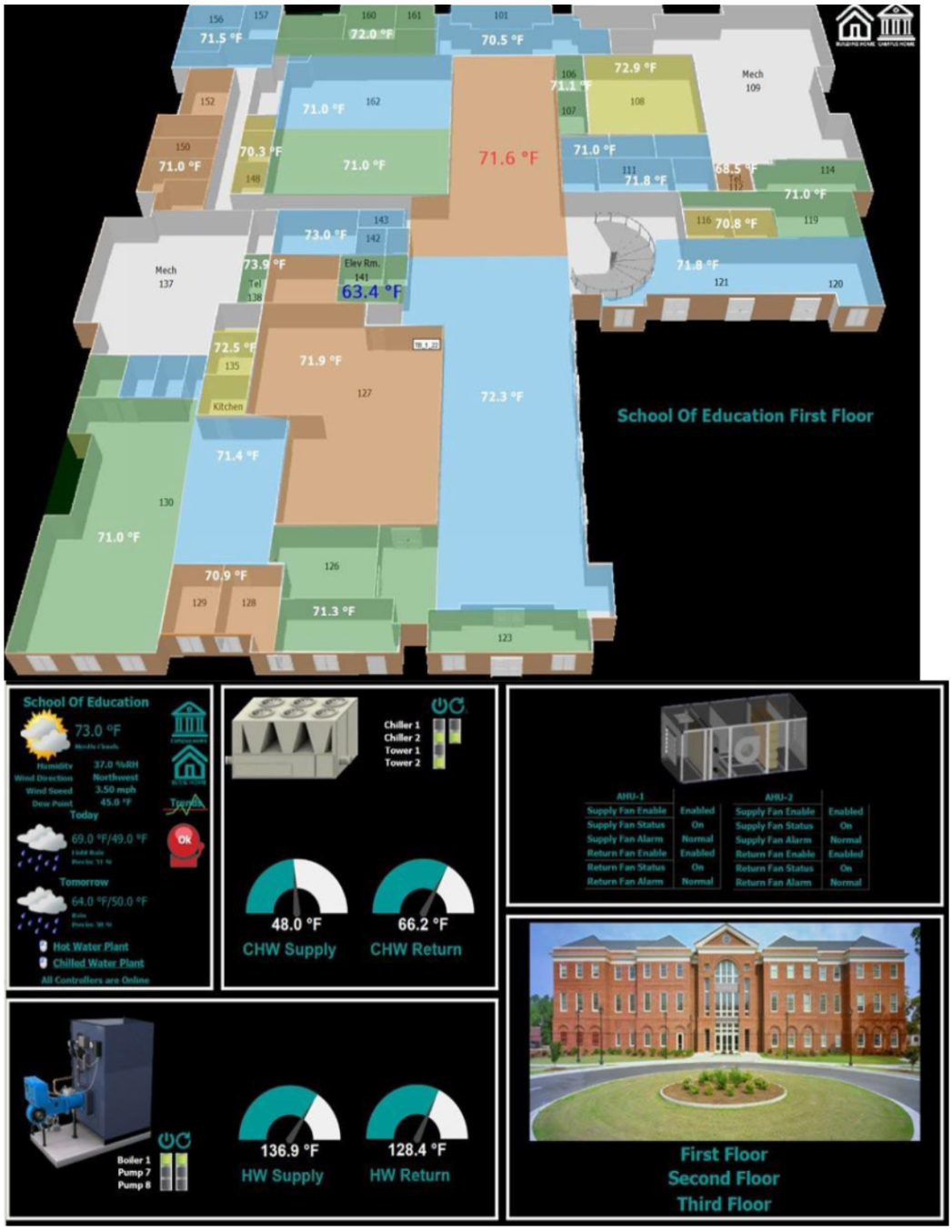
C. Graphic Sequence: The clarity of the graphic sequence must be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming must be self-documenting and provide 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): Must 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 must 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: Must be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks must be submitted with the control contractors bid.
4. Wires: Must be Graphical elements used to form logical connections between microblocks and between logical I/O.

5. Reference Labels: Labels must be similar to wires in that they are used to form logical connections between two points. Labels must 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 must be a value that may be tied to the input of a microblock.
7. Properties: Dialog boxes must appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes must contain various editable and non-editable fields, and must contain 'push buttons' for the purpose of selecting default parameter settings.
8. Icon: An icon must 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: Must 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 must support a ' live' mode, where all input/output data, calculated data and set points must be displayed in a ' live' real-time mode.

2.10 WEB BROWSER GRAPHICAL USER INTERFACE

A. Color Graphics: The Web Browser GUI must 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 must be used to enhance usability. Graphics tools used to create Web Browser graphics must be non-proprietary and conform to the following basic criteria:
   1. Display Size: The GUI workstation software must graphically display in a minimum of 1024 by 768 pixels 24-bit True Color.
   2. General Graphic: General area maps must show locations of controlled buildings in relation to local landmarks.
   3. Color Floor Plans: Floor plan graphics must be multi-colored to differentiate between the different zones and areas. Colors selected are based on a neutral palette as to not show a large variance in bright colors but more of a neutral, slightly different tones. Provide a visual display of temperature relative to their respective set points via the use of a color changing font and size that displays the zone temperature. The displayed temperature must change to a red blinking, size 20 font for high space temperature and blue blinking, size 20 font for low space temperature. The colors and font size must be updated as a zone's actual comfort condition changes from a normal range to a high or low out of range measurement.
   4. General Graphic: A general first page for the building must be of a standard summary format showing vital information and links to the building’s operation and status. This PX page is named “overview” and is the first page to go to when accessing the building from the N4 Campus homepage.



2.11 LONWORKS NETWORK MANAGEMENT

A. Systems requiring the use of third-party LonWorks network management tools must not be accepted.

B. Network management must include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

C. The Network configuration tool must also provide diagnostics to identify devices on the network, to reset devices and to view health and status counters within devices.

D. These tools must provide the ability to "learn" an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.

E. The network management database must be resident in the Site Network Controller (SNC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times and within the control system must not be accepted.

F. Color Graphics: The Web Browser GUI must 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 must be used to enhance usability. Graphics tools used to create Web Browser graphics must be non-proprietary and conform to the following basic criteria:
   1. Display Size: The GUI workstation software must graphically display in a minimum of 1024 by 768 pixels 24-bit True Color.
   2. General Graphic: A general first page for the building must be of a standard summary format showing vital information and links to the building's operation and status. This PX page is named "overview" and is the first page to go to when accessing the building from the N4 Campus homepage.

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 Architect 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 must 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 must 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 must be clearly identified as to function and system served with permanently engraved phenolic labels.

3.4 WIRING

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

B. All wiring must be in accordance with the Project Electrical Specifications (Division 16), the National Electrical Code and any applicable local codes. All control wiring must be installed in raceways.

C. Excess wire must not be looped or coiled in the controller cabinet.

D. Incorporate electrical noise suppression techniques in relay control circuits.

E. There must be no drilling on the controller cabinet after the controls are mounted inside.

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

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

H. Use approved optical isolation and lightning protection when penetrating building envelope.

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

3.5 ACCEPTANCE TESTING

A. Upon completion of the installation, the Control System Contractor must load all system software and start-up the system. The Control System Contractor must 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 must perform tests to verify proper performance of components, routines and points. Repeat tests until proper performance results. This testing must 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 must 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 must provide on-site operator instruction to the owner's operating personnel. Operator instruction must be done during normal working hours and must be performed by a competent representative familiar with the system hardware, software and accessories.

B. The Control System Contractor must provide 8 total hours of comprehensive training 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. The first class starting after final commissioning and the last class is to be in the last month of 1-year warranty period.

3.7 WARRANTY PERIOD SERVICES

A. Equipment, materials and workmanship incorporated into the work must be warranted for a period of one year 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 must 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 must 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 must 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 must come with a 1 Year Software Maintenance license. All SNC and BAS Servers are included in this coverage.

D. Maintenance of Control Hardware: The Control System Contractor must inspect, repair, replace, adjust, and calibrate, as required, the controllers, control devices and associated peripheral units during the warranty period. The Control System Contractor must 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 must clearly certify that all hardware is functioning correctly.

E. Service Period: Calls for service by the Owner must 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 must be provided to the owner.

3.8 WARRANTY ACCESS

A. The Owner must 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 must 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. Completed Performance Verification sheets.
   5. 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.

END OF SECTION 230900