

# **SPECIFICATION NHLS 001**

**BMS Specification for NHLS block 14 HVAC refurbishment and upgrade**

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## **PART 1 - General**

### **1.1 Related Documents**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Specification Sections, apply to this Section.

### **1.2 Related Sections**

- A. This Section includes the Building Management System (BMS) control equipment for HVAC systems and components, including open protocol control components for terminal heating and cooling units. Depending on the scope of the project, the complete specification may have numerous sections that interface to this section, including several from Division 25.

- B. Additional related sections and sub-sections can apply.

1. 25 01 00 Operation and Maintenance of Integrated Automation
2. 25 08 00 Commissioning of Integrated Automation
3. 25 11 00 Integrated Automation Network Devices
4. 25 13 00 Integrated Automation Control and Monitoring Network
5. Add additional sections as required.

### **1.3 Standard Terms**

#### A. Standard

1. ASHRAE: American Society Heating, Refrigeration, Air Conditioning Engineers
2. AHU: Air Handling Unit
3. BACnet: Building Automation Controls Network
4. BMS: Building Management System
5. DDC: Direct Digital Control
6. EIA: Electronic Industries Alliance
7. GUI: Graphical User Interface
8. HVAC: Heating, Ventilation, and Air Conditioning
9. IEEE: Institute Electrical Electronic Engineers
10. MER: Mechanical Equipment Room
11. PID: Proportional, Integral, Derivative
12. VAV: Variable Air Volume Box

#### B. Communications and protocols

1. ARP: Address Resolution Protocol
2. CORBA: Common Object Request Broker Architecture
3. CSMA/CD: Carrier Sense Multiple Access/Collision Detect

4. DDE: Dynamic Data Exchange
5. FTT: Free Topology Transceivers
6. HTTP: Hyper Text Transfer Protocol
7. IIOP: Internet Inter-ORB Protocol
8. LAN: Local Area Network
9. LON: Echelon Communication – Local Operating Network
10. MS/TP: Master Slave Token Passing
11. ODBC: Open Database Connectivity
12. ORB: Object Request Broker
13. SNVT: Standard Network Variables Types
14. SQL: Structured Query Language
15. UDP: User Datagram Protocol
16. XML: extensible Markup Language

**C. Controllers**

1. ASD: Application Specific Device
2. AAC: Advanced Application Controller
3. ASC: Application Specific Controller.
4. CAC: Custom Application Controller.
5. NSC: Network Server Controller
6. PPC: Programmable Process Controller
7. SDCU: Standalone Digital Control Units
8. SLC: Supervisory Logic Controller
9. UEC: Unitary Equipment Controller
10. VAVDDC: Variable Air Volume Direct Digital Controller

**D. Tools and Software**

1. CCDT: Configuration, Commissioning and Diagnostic Tool
2. BPES: BACnet Portable Engineering Station
3. LPES: LON Portable Engineering Station
4. POT: Portable Operator's Terminal

## **1.4 Scope of Work**

A. The Contractor shall furnish and install a complete building automation system including all necessary hardware and all operating and applications software necessary to perform the control sequences of operation as called for in this specification. All components of the system – workstations, servers, application controllers, unitary controllers, etc. shall communicate using the BACnet protocol, as defined by ASHRAE Standard 135-2007, or EIA standard 709.1, the LonTalk™ protocol, or Modbus protocol. No gateways shall be used for communication to controllers furnished under this section. At a minimum, provide controls for the following:

1. Air handling units
2. Return air fans
3. Exhaust and supply fans
4. Chilled water system including pumps, chillers, and cooling towers

5. Boilers including hot water pumps
  6. Computer room air handling units
  7. Refrigerant leak detection system
  8. Smoke evacuation sequence of AHUs and return fans including smoke control dampers and fire command override panel.
  9. Finned tube radiation control
  10. Variable volume and constant volume box control including interlocks with finned tube radiation.
  11. Cabinet unit heater controls
  12. Monitoring points for packaged equipment such as emergency generators,
  13. Power wiring to DDC devices, smoke control dampers and BMS panels except as otherwise specified.
- B. Except as otherwise noted, the control system shall consist of all necessary Ethernet Network Controllers, Standalone Digital Control Units, workstations, software, sensors, transducers, relays, valves, dampers, damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. Except as otherwise specified, provide operators for equipment such as dampers if the equipment manufacturer does not provide these. Coordinate requirements with the various Contractors.
- C. The BMS contractor shall review and study all HVAC drawings and the entire specification to familiarize themselves with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.
- D. All interlocking wiring, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BMS system is fully installed and operational, the BMS Contractor and representatives of the Owner will review and check out the system – see System Acceptance and Testing section of this document. At that time, the BMS contractor shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.
- E. Provide services and manpower necessary for commissioning of the system in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative.
- F. All work performed under this section of the specifications will comply with all governing codes, laws and governing bodies. If the drawings and/or specifications are in conflict with governing codes, the Contractor, with guidance from the engineer, shall submit a proposal with appropriate modifications to the project to meet code restrictions. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.

## **1.5 System Description**

- A. In accordance to the scope of work, the system shall also provide a graphical, web-based, operator interface that allows for instant access to any system through a standard browser. The contractor must provide PC-based programming workstations,

operator workstations and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing/control functions.

For this project, the system shall consist of the following components:

1. Administration and Programming Workstation(s): The BMS Contractor shall furnish (qty) Administration and Programming Workstation Computers as described in Part 2 of the specification. These workstations must be running the standard workstation software developed and tested by the manufacturer of the network server controllers and the standalone controllers. No third party front-end workstation software will be acceptable. Workstations must conform to the B-OWS BACnet device profile.
  2. Web-Based Operator Workstations: The BMS Contractor shall furnish licenses for (qty) concurrent web browser based users to the BMS system. Web-based users shall have access to all system points and graphics, shall be able to receive and acknowledge alarms, and shall be able to control setpoints and other parameters. All engineering work, such as trends, reports, graphics, etc. that are accomplished from the WorkStation shall be available for viewing through the web browser interface without additional changes. The web-based interface must conform to the B-OWS BACnet device profile. There will be no need for any additional computer based hardware to support the web-based user interface.
  3. Ethernet-based Network Router and/or Network Server Controller(s): The BMS Contractor shall furnish (qty) Ethernet-based Network Server Controllers as described in Part 2 of the specification. These controllers will connect directly to the Operator Workstation over Ethernet at a minimum of 100mbps, and provide communication to the Standalone Digital Control Units and/or other Input/Output Modules. Network Server Controllers shall conform to BACnet device profile B-BC. Network controllers that utilize RS232 serial communications or ARCNET to communicate with the workstations will not be accepted. Network Controllers shall be tested and certified by the BACnet Testing Laboratory (BTL) as Network Server Controllers (B-BC).
  4. Standalone Digital Control Units (SDCUs): Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment. Each BACnet protocol SDCU shall conform to the BACnet device profile B-AAC. BACnet SDCUs shall be tested and certified by the BACnet Testing Laboratory (BTL) as Advanced Application Controllers (B-AAC).
- B. The Local Area Network (LAN) shall be either a 10 or 100 Mbps Ethernet network supporting BACnet, Modbus, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Server Controllers (NSCs), user workstations and a local host computer system.
- C. The Enterprise Ethernet (IEEE 802.3) LAN shall utilize Carrier Sense

Multiple/Access/Collision Detect (CSMA/CD), Address Resolution Protocol (ARP) and User Datagram Protocol (UDP) operating at 10 or 100 Mbps.

- D. The system shall enable an open architecture that utilizes EIA standard 709.1, the LonTalk™ protocol and/or ANSI / ASHRAE™ Standard 135-2007, BACnet functionality to assure interoperability between all system components. Native support for the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2007, BACnet protocol are required to assure that the project is fully supported by the HVAC open protocols to reduce future building maintenance, upgrade, and expansion costs.
- E. The system shall enable an architecture that utilizes a MS/TP selectable 9.6-76.8 Kbaud protocol, as the common communication protocol between all controllers and integral ANSI / ASHRAE™ Standard 135-2008, BACnet functionality to assure interoperability between all system components. The AAC shall be capable of communicating as a MS/TP device or as a BACnet IP device communicating at 10/100 Mbps on a TCP/IP trunk. The AAC shall have a MS/TP bus that is capable of supporting up to 127 UEC's or VAVDDC's without the addition of repeaters. The ANSI / ASHRAE™ Standard 135-2008, BACnet protocol is required to assure that the project is fully supported by the leading HVAC open protocol to reduce future building maintenance, upgrade, and expansion costs.
- F. LonTalk™ packets may be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth where necessary or desired.
  - 1. Any such encapsulation of the LonTalk™ protocol into IP datagrams shall conform to existing LonMark™ guide functionality lines for such encapsulation and shall be based on industry standard protocols.
  - 2. The products used in constructing the BMS shall be LonMark™ compliant.
  - 3. In those instances in which Lon-Mark™ devices are not available, the BMS contractor shall provide device resource files and external interface definitions for LonMark devices.
- G. The software tools required for network management of the LonTalk™ protocol and the ANSI / ASHRAE™ Standard 135-2008, BACnet protocol must be provided with the system. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans and are required to meet the functional intent, shall be provided without additional cost to the Owner. Minimum BACnet compliance is Level 4; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet IP or MS/TP. Physical connection of LonWorks devices shall be via Ethernet IP or FTT-10A.
- H. The system shall support Modbus TCP and RTU protocols natively, and not require the use of gateways.
- I. Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation of Mechanical Equipment Room (MER) valves and dampers and electronic actuation of terminal equipment valves and actuators as specified herein. The BMS is intended to seamlessly connect devices throughout the building regardless of subsystem type, i.e. variable frequency drives, low voltage lighting systems, electrical circuit breakers, power metering and card access should easily coexist on the same network channel.
  - 1. The supplied system must incorporate the ability to access all data using Java enabled browsers without requiring proprietary operator interface and configuration programs.



2. Data shall reside on a supplier-installed server for all database access.
  3. 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.
- J. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the approved manufacturer's local field office. The approved manufacturer's local field office shall have a minimum of 3 years of installation experience with the manufacturer and shall provide documentation in the bid and submittal package verifying longevity of the installing company's relationship with the manufacturer when requested. Supervision, hardware and software engineering, calibration and checkout of the system shall be by the employees of the approved manufacturer's local field office and shall not be subcontracted. The control contractor shall have an in place support facility within 100 miles of the site with factory certified technicians and engineers, spare parts inventory and all necessary test and diagnostic equipment for the installed system, and the control contractor shall have 24 hours/day, 7 days/week emergency service available.
- K. Provide the Commissioning, configuration and diagnostic tool (CCDT), color display personnel computer, software, and interfaces to provide uploading/downloading of High Point Count Controllers (AAC), Unitary Equipment Controllers (UEC) and VAV controllers (VAVDDC) monitoring all BACnet objects, monitoring overrides of all controller physical input/output points, and editing of controller resident time schedules.
- L. Provide a Portable Operator's Terminal (POT) color display personnel computer, software, and interfaces to provide uploading/downloading of Custom Application Controller and Application Specific Controllers databases, monitoring of all LonMark™ Standard Network Variables Types (SNVTs) including display of all bound SNVTs, monitoring and overrides of all controller physical input/output points, and editing of controller resident time schedules. POT connectivity shall be via digital wall sensor connected to controller.

## **1.6 Work by Others**

- A. The BMS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.
- B. The BMS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor.
- C. The BMS Contractor shall provide field supervision to the designated contractor for the installation of the following:
1. Automatic control dampers
  2. Fire/smoke dampers
  3. Blank-off plates for dampers that are smaller than duct size.
  4. Sheet metal baffles plates to eliminate stratification.
  5. The Electrical Contractor shall provide:
    - a. All power wiring to motors, heat trace, junction boxes for power to BMS

panels.

- b. Furnish smoke detectors and wire to the building fire alarm system. HVAC Contractor to mount devices. BMS Contractor to hardwire to fan shut down.
- c. Auxiliary contact (pulse initiator) on the electric meter for central monitoring of kWH and KW. Electrical Contractor shall provide the pulse rate for remote readout to the BAS. BMS contractor to coordinate this with the electrical contractor.

D. The BMS Contractor shall provide:

- 1. All power wiring to all smoke damper actuators for smoke control sequence.

## **1.7 Code Compliance**

- A. Provide BMS components and ancillary equipment, which are UL-916 listed and labeled.
- B. All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.
- C. All wiring shall conform to the National Electrical Code.
- D. All smoke dampers shall be rated in accordance with UL 555S.
- E. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.
- F. Comply with FCC, Part 68 rules for telephone modems and data sets.

## **1.8 Submittals**

- A. All shop drawings shall be prepared in AutoCAD software. In addition to the drawings, the Contractor shall furnish a CD containing the identical information. Drawings shall be B size or larger.
- B. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typical will be allowed where appropriate.
- C. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.
- D. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software. Information shall be bound or in a three ring binder with an index and tabs. Diagrams shall be on 11" by 17" foldouts. If color has been used to differentiate information, the printed copies shall be in color.
- E. Submit copies of submittal data and shop drawings to the Engineer for review prior to ordering or fabrication of the equipment. The Contractor, prior to submitting, shall check all documents for accuracy.
- F. The Engineer will make corrections, if required, and return to the Contractor. The Contractor will then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully approved.
- G. The following is a list of post construction submittals that shall be updated to reflect any changes during construction and re-submitted as "As-Built".
  - 1. System architecture drawing.
  - 2. Layout drawing for each control panel
  - 3. Wiring diagram for individual components
  - 4. System flow diagram for each controlled system
  - 5. Instrumentation list for each controlled system
  - 6. Sequence of control
  - 7. Binding map
  - 8. Operation and Maintenance Manuals
- H. Information common to the entire system shall be provided. This shall include but not be limited to the following.
  - 1. Product manuals for the key software tasks.
  - 2. Operating the system.
  - 3. Administering the system.
  - 4. Engineering the operator workstation.
  - 5. Application programming.
  - 6. Engineering the network.
  - 7. Setting up the web server.
  - 8. Report creation.
  - 9. Graphics creation.
  - 10. All other engineering tasks.

11. System Architecture Diagram.
12. List of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers and web clients.
13. Define the task.
14. Recommend a frequency for the task.
15. Reference the product manual that includes instructions on executing the task.
16. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
17. Licenses, guarantees, and warranty documents for equipment and systems.
18. Submit one copy for each building, plus two extra copies.
- I. Information common to the systems in a single building shall be provided.
  1. System architecture diagram for components within the building annotated with specific location information.
  2. As-built drawing for each control panel.
  3. As-built wiring design diagram for all components.
  4. Installation design details for each I/O device.
  5. As-built system flow diagram for each system.
  6. Sequence of control for each system.
  7. Binding map for the building.
  8. Product data sheet for each component.
  9. Installation data sheet for each component.
  10. Submit two copies for each building and two extra copies.
- J. Software shall be provided:
  1. Submit a copy of all software installed on the servers and workstations.
  2. Submit all licensing information for all software installed on the servers and workstations.
  3. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
  4. Submit all licensing information for all of the software used to execute the project.
  5. All software revisions shall be as installed at the time of the system acceptance.
  6. Firmware Files
  7. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
  8. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
  9. Submit a copy of all application files that were created during the execution of the project.
  10. Submit a copy of all graphic page files created during the execution of the project.

## **1.9 Coordination**

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

- B. Coordinate equipment from other divisions including "Intrusion Detection," "Lighting Controls," "Motor Control Centers," "Panel boards," and "Fire Alarm" to achieve compatibility with equipment that interfaces with those systems.
- C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
- D. Coordinate location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete".
- E. Coordinate with the Owner's IT department on locations for UNC's, Ethernet communication cabling and TCP/IP addresses.

### **1.10 Ownership**

- A. The Owner shall retain licenses to software for this project.
- B. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition off this contractor. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.
- C. The licensing agreement shall not preclude the use of the software by individuals under contract to the owner for commissioning, servicing or altering the system in the future. Use of the software by individuals under contract to the owner shall be restricted to use on the owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.
- D. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:
  - 1. Server and workstation software
  - 2. Application programming tools
  - 3. Configuration tools
  - 4. Network diagnostic tools
  - 5. Addressing tools
  - 6. Application files
  - 7. Configuration files
  - 8. Graphic files
  - 9. Report files
  - 10. Graphic symbol libraries
  - 11. All

documentati

on

### **1.11 Quality Assurance - System Startup and Commissioning**

- A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BMS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A

written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.

- B. The BMS contractor shall commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner and Architect's representatives.
- C. The BMS Contractor shall provide a technician for 4 days manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BMS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.
- D. Startup Testing shall be performed for each task on the startup test checklist, which shall be initialed by the technician and dated upon test was completion along with any recorded data such as voltages, offsets or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.
- E. Required elements of the startup testing include:
  - 1. Measurement of voltage sources, primary and secondary
  - 2. Verification of proper controller power wiring.
  - 3. Verification of component inventory when compared to the submittals.
  - 4. Verification of labeling on components and wiring.
  - 5. Verification of connection integrity and quality (loose strands and tight connections).
  - 6. Verification of bus topology, grounding of shields and installation of termination devices.
  - 7. Verification of point checkout.
  - 8. Each I/O device is landed per the submittals and functions per the sequence of control.
  - 9. Analog sensors are properly scaled and a value is reported
  - 10. Binary sensors have the correct normal position and the state is correctly reported.
  - 11. Analog outputs have the correct normal position and move full stroke when so commanded.
  - 12. Binary outputs have the correct normal state and respond appropriately to energize/de- energize commands.
  - 13. Documentation of analog sensor calibration (measured value, reported value and calculated offset).
  - 14. Documentation of Loop tuning (sample rate, gain and integral time constant).
- F. A performance verification test shall also be completed for the operator interaction with the system. Test elements shall be written to require the verification of all operator interaction tasks including, but not limited to the following.
  - 1. Graphics navigation.
  - 2. Trend data collection and presentation.
  - 3. Alarm handling, acknowledgement and routing.
  - 4. Time schedule editing.
  - 5. Application parameter adjustment.

6. Manual control.
7. Report execution.
8. Automatic backups.
9. Web Client access.

G. A Startup Testing Report and a Performance Verification

Testing Report shall be provided upon test completion.

## **1.12 Warranty and Maintenance**

- A. All components, system software, and parts furnished and installed by the BMS contractor shall be guaranteed against defects in materials and workmanship for 1 year of substantial completion. Labor to repair, reprogram, or replace these components shall be furnished by the BMS contractor at no charge during normal working hours during the warranty period. Materials furnished but not installed by the BMS contractor shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the owner's request for warranty service within 24 standard working hours.

## **1.13 Training**

- A. The BMS Contractor shall provide both on-site and classroom training to the Owner's representative and maintenance personnel per the following description:
- B. On-site training shall consist of a minimum of (40) hours of hands-on instruction geared at the operation and maintenance of the systems. The curriculum shall include
1. System Overview
  2. System Software and Operation
  3. System access
  4. Software features overview
  5. Changing setpoints and other attributes
  6. Scheduling
  7. Editing programmed variables
  8. Displaying color graphics
  9. Running reports
  10. Workstation maintenance
  11. Viewing application programming
  12. Operational sequences including start-up, shutdown, adjusting and balancing.
  13. Equipment maintenance.
  14. Factory, classroom training will include a minimum of (2) training reservation for a 3-day course with material covering workstation operation tuition and travel expense. The option for 2-3 weeks of system engineering and controller programming shall be possible if necessary and desired.

## **PART 2 - Products**

### **2.1 System Architecture**

#### **A. General**

1. The Building Automation System (BAS) shall consist of Network Server/Controllers (NSCs), a family of Standalone Digital Control Units (SDCUs), Administration and Programming Workstations (APWs), and Web-based Operator Workstations (WOWs). The BMS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable.
2. An Enterprise Level BMS shall consist of an Enterprise Server, which enables multiple NSCs (including all graphics, alarms, schedules, trends, programming, and configuration) to be accessible from a single Workstation simultaneously for operations and engineering tasks.
3. For Enterprise reporting capability and robust reporting capability outside of the trend chart and listing ability of the Workstation, a Reports Server shall be installed on a Microsoft Windows based computer. The Reports Server can be installed on the same computer as the Enterprise Server.
4. The system shall be designed with a top-level 10/100bT Ethernet network, using the BACnet/IP, LonWorks IP, and/or Modbus TCP protocol. A sub-network of SDCUs using the BACnet MS/TP, LonTalk FTT-10A, and/or Modbus RTU protocol shall connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.

#### **B. TCP/IP Level**

1. The TCP/IP layer connects all of the buildings on a single Wide Area Network (WAN) isolated behind the campus firewall. Fixed IP addresses for connections to the campus WAN shall be used for each device that connects to the WAN.

#### **C. Fieldbus Level with Standalone Digital Control Units (SDCUs)**

1. The fieldbus layer shall support all of the following types of SDCUs:
  - a. BACnet SDCU requirements: The system shall consist of one or more BACnet MS/TP field buses managed by the Network Server Controller. Minimum speed shall be 76.8kbps. The field bus layer consists of an RS485, token passing bus that supports up to 50 Standalone Digital Control Units (SDCUs) for operation of HVAC and lighting equipment. These devices shall conform to BACnet standard 135-2007
  - b. LonWorks SDCU requirements: The system shall consist of one or more LonWorks FTT-10A field buses managed by the Network Server Controller. Minimum speed shall be 76.8kbps. The field bus layer shall consist of up to 50 SDCUs using peer-to-peer, event-driven communication for operation of HVAC and lighting equipment.
  - c. Modbus SDCU requirements: The system shall consist of one or more Modbus RTU (RS-485 or RS-232) field buses managed by the Network



Server Controller. The field bus layer shall consist of up to 240 SDCUs for operation of HVAC, power metering, and lighting equipment.

**D. BMS LAN Segmentation**

1. The BMS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN). Workstations can manage a single LAN (or building), and/or the entire system with all portions of that LAN maintaining its own, current database.

**E. Standard Network Support**

1. All NSCs, Workstation(s) and Servers shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NSC's, Workstation(s), and Server(s) shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the owner's Information Systems Department as all devices utilize standard TCP/IP components.

**F. System Expansion**

1. The BMS system shall be scalable and expandable at all levels of the system using the same software interface, and the same TCP/IP level and fieldbus level controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.
2. Web-based operation shall be supported directly by the NSCs and require no additional software, other than a Java supported network browser.
3. The system shall be capable of using graphical and/or line application programming language for the Network Server Controllers.

**G. Support For Open Systems Protocols**

1. All Network Server Controllers must natively support the BACnet IP, BACnet MS/TP, LonWorks IP, LonWorks FTT-10, Modbus TCP, Modbus RTU (RS-485 and RS-232), and Modbus ASCII protocols.

## 2.2 Operator Workstation Requirements

### A. General

1. The operator workstation portion of the BMS shall consist of one or more full-powered configuration and programming workstations, and one or more web-based operator workstations. For this project provide 5 user licenses.
2. The programming and configuration workstation software shall allow any user with adequate permission to create and/or modify any or all parts of the NSC and/or Enterprise Server database.
3. All configuration workstations shall be personal computers operating under the Microsoft Windows 7 operating system. The application software shall be capable of communication to all Network Server Controllers and shall feature high-resolution color graphics, alarming, trend charting. It shall be user configurable for all data collection and data presentation functions.
4. A minimum of 1 Workstation shall be allowed on the Ethernet network. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations since the changes are accomplished to the databases within the NSC. Systems with a central database will not be acceptable.

### B. Administration/Programming Workstation Requirements

1. The workstation shall consist of the following:
  - a. 3 GHz processor with 4GB of RAM
  - b. Microsoft Windows XP 32-bit SP3 or Microsoft Windows 7 operating system
  - c. Serial port, parallel port, USB port
  - d. 10/100MBPS Ethernet NIC
  - e. 80 GB hard disk
  - f. CD-RW drive
  - g. High resolution (minimum 1280 x 1024), 17" flat panel display
  - h. Optical mouse and full function keyboard
  - i. Audio sound card and speakers
  - j. License agreement for all applicable software.

### C. Web-Based Operator PC Requirements

1. Any user on the network can access the system, using the following software:
  - a. Windows 2000/XP and above
  - b. Internet Explorer 8.0 and above
  - c. Firefox and above
  - d. Java-enabled

### D. General Administration and Programming Workstation Software

1. System architecture shall be truly client server in that the Workstation shall operate as the client while the NSCs shall operate as the servers. The client is responsible for the data presentation and validation of inputs while the server is responsible for data gathering and delivery.
2. The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.
3. Programming of SDCUs shall be capable of being done either off-line or on-

line from any operator workstation. All information will be available in graphic or text displays stored at the NSC. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the DDC system. All operator functions shall be selectable through a mouse.

**E. User Interface:**

1. The BMS workstation software shall allow the creation of a custom, browser-style interface linked to the user when logging into any workstation. Additionally, it shall be possible to create customized workspaces that can be assigned to user groups. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows user security capabilities, will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BMS software, but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

**F. User Security**

1. The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. Additionally, the software shall enable the ability to add/remove users based upon Microsoft Windows Security Domains that enable the customer IT department to assist in user access.

**G. Configuration Interface**

1. The workstation software shall use a familiar Windows Explorer -style interface for an

operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a “network map” of all controllers and their associated points, programs, graphics, alarms, and reports in an easy-to-understand structure. All object names shall be alphanumeric and use Windows long filename conventions.

2. The configuration interface shall also include support for user defined object types. These object types shall be used as building blocks for the creation of the BMS database. They shall be created from the base object types within the system input, output, string variables, setpoints, etc., alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of user defined object types shall be able to be set up as a predefined aggregate of subsystems and systems. The configuration interface shall support copying/pasting and exporting/importing portions of the database for additional efficiency. The system shall also maintain a link to all “child” objects created. If a user wishes to make a change to a parent object, the software shall ask the user if he/she wants to update all of the child objects with the change.

#### H. Color Graphic Displays

1. The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.
2. Requirements of the color graphic subsystem include:
  - a. At a minimum, the user shall have the ability to import gif, png, bmp, jpeg, tif, and CAD generated picture files as background displays, and layering shall be possible.
  - b. It shall be possible for the user to use JavaScript to customize the behavior of each graphic.
  - c. The editor shall use Scalable Vector Graphics (SVG) technology.
  - d. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, and graphs which can be “dropped” on a graphic through the use of a software configuration “wizard”. These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.
  - e. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
  - f. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
  - g. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.

- h. It shall be possible to create and save graphical components and JavaScript code in reusable and transferrable, customized libraries.
  - 3. Additionally, the Graphics Editor portion of the Engineering Software shall provide the following capabilities:
    - a. Create and save pages.
    - b. Group and ungroup symbols.
    - c. Modify an existing symbol.
    - d. Modify an existing graphic page.
    - e. Rotate and mirror a symbol.
    - f. Place a symbol on a page.
    - g. Place analog dynamic data in decimal format on a page.
    - h. Place binary dynamic data using state descriptors on a page.
    - i. Create motion through the use of animated .gif files or JavaScript.
    - j. Place test mode indication on a page.
    - k. Place manual mode indication on a page.
    - l. Place links using a fixed symbol or flyover on a page.
    - m. Links to other graphics.
    - n. Links to web sites.
    - o. Links to notes.
    - p. Links to time schedules.
    - q. Links to any .exe file on the operator work station.
    - r. Links to .doc files.
    - s. Assign a background color.
    - t. Assign a foreground color.
    - u. Place alarm indicators on a page.
    - v. Change symbol/text/value color as a function of an analog variable.
    - w. Change a symbol/text/value color as a function of a binary state.
    - x. Change symbol/text/value as a function of a binary state.
    - y. All symbols used in the creation of graphic pages shall be saved to a library file for use by the owner.
- I. Automatic monitoring
  - 1. The software shall allow for the automatic collection of data and reporting from any controller or NSC. The frequency of data collection shall be user-configurable.
- J. Alarm Management
  - 1. The software shall be capable of accepting alarms directly from NSCs or controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.
  - 2. Alarm management features shall include:
    - a. A minimum of 1000 alarm notification levels. Each notification level will establish a unique set of parameters for controlling alarm display, distribution, acknowledgment, keyboard annunciation, and record keeping.

- b. Automatic logging in the database of the alarm message, point name, point value, source device, timestamp of alarm, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement)
- c. Playing an audible sound on alarm initiation or return to normal.
- d. Sending an email or alphanumeric pager to anyone listed in a workstation's email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user- configurable timeframe. The ability to utilize email and alphanumeric paging of alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required and no email client software must be running in order for email to be distributed.
- e. Individual alarms shall be able to be re-routed to a user at user-specified times and dates. For example, a critical high temp alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.
- f. It shall be possible to re-route an alarm if a user-defined response time has been exceeded. For example, if a critical alarm has an acknowledgment time of 5 minutes and that acknowledgement does not occur, the alarm can be re-routed to a secondary receiver.
- g. An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.
- h. The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.
- i. The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.
- j. The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of causes for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.
- k. The active alarm viewer can be configured such that an operator must confirm that all of the steps in a check list have been accomplished prior to acknowledging the alarm.
- l. An operator shall have the capability to assign an alarm to another user of the system. Such assignments shall be tracked to insure alarm response.

#### K. Report Generation

1. The Reports Server shall be able to process large amounts of data and produce meaningful reports to facilitate analysis and optimization of each installation.
2. Reports shall be possible to generate and view from the operator Workstation, and/or Web station, and/or directly from a reports-only web

interface.

3. A library of predefined automatically generated reports that prompt users for input prior to generation shall be available. The properties and configurations made to these reports shall be possible to save as Dashboard reports, so that the configurations are saved for future used.
4. It shall be possible to create reports standard tools, such as Microsoft Report Builder 2.0 or Visual Studio, shall be used for customized reports.
5. Additional reports or sets of reports shall be downloadable, transferrable, and importable
6. All reports shall be able to be set up to automatically run or be generated on demand.
7. Each report shall be capable of being automatically emailed to a recipient in Microsoft Word, Excel, and/or Adobe .pdf format.
8. Reports can be of any length and contain any point attributes from any controller on the network.
9. Image management functionality shall be possible to enable the system administrators to easily upload new logos or images to the system.
10. It shall be possible to run other executable programs whenever a report is initiated.
11. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.
12. Minimum supplied reports shall include:
  - a. Points in each controller
  - b. Points in alarm
  - c. Disabled points
  - d. Overridden points
  - e. Operator activity report
  - f. Alarm history log
  - g. Program listing by controller with status
  - h. Network status of each controller
  - i. Activities Per Server Report
  - j. Activities Per User Report
  - k. Alarm Amount by Category Report
  - l. Alarm Amount by Type Report
  - m. Alarms Per Sever Report
  - n. Current Alarm Report
  - o. Most Active Alarm Report
  - p. System Errors Per Server Report
  - q. Top Activities Report
  - r. Top Alarms Report
  - s. Top System Errors Report
  - t. Trend Log Comparison Report
  - u. User Logins Report
  - v. Users and Groups Reports
13. Minimum Energy Reports shall include:
  - a. Energy Monitoring Calendar Consumption Report: Shall provide

an interactive report that shows the energy usage on one or multiple selected days.

- b. Energy Monitoring Consumption Breakdown Report: Shall provide a report on energy consumption broken down using sub-metering.
- c. Energy Monitoring Consumption Report: Shall show the energy consumption against a specified target value.

14. Reports Server Software Requirements

- a. Microsoft Windows Server 2008 32-bit or Windows 7 32-bit
- b. Microsoft SQL Server 2008 with Advanced Services
- c. Microsoft Net 3.5 SP1

L. Scheduling

- 1. From the workstation or webstation, it shall be possible to configure and download schedules for any of the controllers on the network.
- 2. Time of day schedules shall be in a calendar style and viewable in both a graphical and tabular view.
- 3. Schedules shall be programmable for a minimum of one year in advance.
- 4. To change the schedule for a particular day, a user shall simply select the day and make the desired modifications.
- 5. Additionally, from the operator webstations, each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.
- 6. Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.
- 7. It shall be possible to assign a lead schedule such that shadow/local schedules are updated based upon changes in the Lead.
- 8. It shall be possible to assign a list(s) of exception event days, dates, date ranges to a schedule.

M. Programmer's Environment

- 1. Programming in the NSC shall be either in graphical block format or line-programming format or both.
- 2. The programmer's environment will include access to a superset of the same programming language supported in the SDCUs.
- 3. NSC devices will support both script programming language as well as the graphical function block programming language. For both languages, the programmer will be able to configure application software off-line (if desired) for custom program development, and write global control programs.
- 4. It shall be possible to save custom programs as libraries for reuse throughout the system. A wizard tool shall be available for loading programs from a library file in the program editor.
- 5. It shall be possible to view graphical programming live and real-time from the Workstation.

N. Saving/Reloading

- 1. The workstation software shall have an application to save and restore NSC and field controller memory files.



2. For the NSC, this application shall not be limited to saving and reloading an entire controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

**O. Audit Trail**

1. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.
2. It shall be possible to view a history of alarms, user actions, and commands for any system object individually or at least the last 5000 records of all events for the entire system from Workstation.
3. It shall be possible to save custom filtered views of event information that are viewable and configurable in Workstation.

**P. Fault Tolerant Enterprise Server Operation (Top level NSC)**

1. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

**Q. Web-based Operator Software**

1. General:
  - a. Day-to-day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any part of the system from anywhere on the network.
2. Graphic Displays
  - a. The browser-based interface must share the same graphical displays as the Administration and Programming Workstations, presenting dynamic data on site layouts, floor plans, and equipment graphics. The browser's graphics shall support commands to change setpoints, enable/disable equipment and start/stop equipment.
  - b. Through the browser interface, operators must be able to navigate through the entire system, and change the value or status of any point in any controller. Changes are effective immediately to the controller, with a record of the change stored in the system database.
3. Alarm Management
  - a. Systems requiring additional client software to be installed on a PC for viewing the webstation from that PC will not be considered.
  - b. Through the browser interface, a live alarm viewer identical to the alarm viewer on the Administration and Programming workstation shall be presented, if the user's password allows it. Users must be able to receive alarms, silence alarms, and acknowledge alarms through a browser. If desired, specific operator text must be able to be added to the alarm record before acknowledgement, attachments shall be viewable, and alarm checklists shall be available.

**R. Groups and Schedules**

1. Through the browser interface, operators must be able to view pre-defined

groups of points, with their values updated automatically.

2. Through the browser interface, operators must be able to change schedules – change start and stop times, add new times to a schedule, and modify calendars.

**S. User Accounts and Audit Trail**

1. The same user accounts shall be used for the browser interface and for the operator workstations. Operators must not be forced to memorize multiple passwords.
2. All commands and user activity through the browser interface shall be recorded in the system's activity log, which can be later searched and retrieved by user, date, or both.

## **2.3 Network Server Controllers (NSCs)**

- A. Network Router Controllers shall combine both network routing functions, control functions, and server functions into a single unit.
- B. The BACnet NSC shall be classified as a "native" BACnet device, supporting the BACnet Network Server Controller (B-BC) profile. Controllers that support a lesser profile such as B-SA are not acceptable. NSCs shall be tested and certified by the BACnet Testing Laboratory (BTL) as BACnet Network Server Controllers (B-BC).
- C. The Network Server Controller shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NRS.
- D. They shall also be responsible for monitoring and controlling their own HVAC equipment such as an AHU or boiler.
- E. They shall also contain graphics, trends, trend charts, alarm views, and other similar presentation objects that can be served to workstations or web-based interfaces. A sufficient number of NSCs shall be supplied to fully meet the requirements of this specification and the attached point list.
- F. It 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 by means of an Internet site including automatic synchronization
  6. Native integration of LonWorks controller data and Modbus controller data or BACnet controller data and Modbus controller data
  7. Network Management functions for all LonWorks based devices
- G. Hardware Specifications
  1. Memory:
    - a. The operating system of the controller, application programs, and all other portions of the configuration database, shall be stored in non-volatile, FLASH memory.

Servers/Controllers shall contain enough memory for the current application, plus required history logging, plus a minimum of 20% additional free memory.

2. Each NRC shall provide the following on-board hardware for communication:
  - a. One 10/100bT Ethernet for communication to Workstations, other NRCs and onto the Internet
  - b. Two RS-485 ports for communication to BACnet MSTP bus or serial Modbus (software configurable)
  - c. One TP/FT port for communication to LonWorks devices.
  - d. One Device USB port
  - e. Two host USB Ports

H. Modular Expandability:

1. The system shall employ a modular I/O design to allow expansion. Input and output capacity is to be provided through plug-in modules of various types. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

I. Hardware Override Switches:

1. All digital outputs shall, optionally, include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.

J. Local Status Indicator Lamps:

1. The NSC shall provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each input or output, provide LED indication of the value of the point (On/Off). The LED indication shall support software configuration to set whether the illumination of the LED corresponds to On or Off or whether the color when illuminated is Red or Green.

K. Real Time Clock (RTC):

1. Each NSC shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. Each NSC will allow for its own UTC offset, depending upon the time zone. When the time zone is set, the NSC will also store the appropriate times for daylight savings time.

L. Power Supply:

1. The 24 VDC power supply for the NSCs shall provide 30 watts of available power for the NSC and associated IO modules. The system shall support the use of more than one power supply if heavily power consuming modules are required.

M. Automatic Restart After Power Failure:

1. Upon restoration of power after an outage, the NSC shall automatically and without human intervention update all monitored functions, resume operation based on current, synchronize time and status, and implement

special start-up strategies as required.

**N. Battery backup:**

1. The NSC shall include an on-board battery to back up the controller's RAM memory. The battery shall provide accumulated backup of all RAM and clock functions for at least 30 days. In the case of a power failure, the NSC shall first try to restart from the RAM memory. If that memory is corrupted or unusable, then the NSC shall restart itself from its application program stored in its FLASH memory.

**O. Software Specifications**

1. The operating system of the controller, application programs, and all other portions of the configuration database such as graphics, trends, alarms, views, etc., shall be stored in non-volatile, FLASH memory. There will be no restrictions placed on the type of application programs in the system. Each NSC shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.
2. Each NSC shall have an available capacity of 4 GB of memory. This shall represent 2 GB for application and historical data and 2 GB dedicated for backup storage.

**P. User Programming Language:**

1. The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be either a script-based structured text or graphical function block based and fully programmable by the user. The language shall be structured to allow for the configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, and histories. Users shall be able to place comments anywhere in the body of either script or function block programs.
2. Network Server Controllers that use a "canned" program method will not be accepted.

**Q. Control Software:**

1. The NSC shall have the ability to perform the following pre-tested control algorithms:
  - a. Proportional, Integral plus Derivative Control (PID)
  - b. Two Position Control
  - c. Digital Filter
  - d. Ratio Calculator
  - e. Equipment Cycling Protection

**R. Mathematical Functions:**

1. Each controller shall be capable of performing basic mathematical functions (+, -, \*, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the same

equations with the mathematical operators and nested up to five parentheses deep.

S. NSCs shall have the ability to perform any or all of the following energy management routines:

1. Time of Day Scheduling
2. Calendar Based Scheduling
3. Holiday Scheduling
4. Temporary Schedule Overrides
5. Optimal Start
6. Optimal Stop
7. Night Setback Control
8. Enthalpy Switchover (Economizer)
9. Peak Demand Limiting
10. Temperature Compensated Duty Cycling
11. CFM Tracking
12. Heating/Cooling Interlock
13. Hot/Cold Deck Reset
14. Hot Water Reset
15. Chilled Water Reset
16. Condenser Water Reset
17. Chiller Sequencing

T. History Logging:

1. Each NSC controller shall be capable of LOCALLY logging any input, output, calculated value or other system variable either over user defined time intervals ranging from 1 second to 1440 minutes or based upon a user configurable change of value. A minimum of 1000 values shall be stored in each of these types of logs. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logged data shall be downloadable to a higher level NSC long term archiving based upon user-defined time intervals, or manual command.
2. Management of a power meter replacement to ensure meter log data is accurate shall be possible in the NSC.
3. Every hardware input and output point shall be trended automatically without the requirement for manual creation, and each of these logs shall log values based upon a change of value and store at least 500 trend samples before replacing the oldest sample with new data.
4. The presentation of logged data shall be built into the server capabilities of the NSC Presentation can be in time stamped list formats or in a chart format with fully configurable pen colors, weights, scales and time spans.

U. Alarm Management:

1. For each system point, alarms can be created based on high/low limits or in comparison to other point values. All alarms will be tested each scan of the NSC and can result in the display of one or more alarm messages or reports.
2. There is no limit to the number of alarms that can be created for any point/
3. Alarms can be configured to be generated based upon a single system condition or multiple system conditions.
4. Alarms will be generated based on an evaluation of the alarm conditions

and can be presented to the user in a fully configurable order, by priority, by time, by category, etc. These configurable alarm views will be presented to a user upon logging into the system regardless of whether the log in takes place at a WorkStation or a Webstation.

5. The alarm management system shall support the ability to create and select cause and action notes to be selected and associated with an alarm event. Checklists shall also be possible in order to present to an operator a suggested mode of troubleshooting. When acknowledging an alarm, it shall be possible to assign it to a user of the system such that the user is notified of the assignment and is made responsible for the alarm resolution.
6. Alarms must be capable of being routed to any BACnet workstation that conforms to the B-OWS device profile and uses the BACnet/IP protocol.

#### V. Embedded Web Server

1. Each NSC must have the ability to serve out web pages containing the same information that is available from the WorkStation. The development of the screens to accomplish shall not require any additional engineering labor over that required to show them at the WorkStation itself.

### 2.4 Enterprise Server Hardware Requirements

- A. Processor: 2 GHz or higher
- B. Memory: 4 GB
- C. Hard-Disk Drive: 20 GB
- D. Embedded Intel PRO/100+ Server Adapter for TCP/IP Communication
- E. DVD-ROM Drive: 24X, IDE CD-ROM with software decoding.
- F. Operating System: Microsoft Windows XP 32-bit SP3, Windows 7 32-bit, Server 2008 32 bit.

### 2.5 LON Fieldbus and LON SDCUs

#### A. IP Network

1. All devices that connect to the WAN shall be capable of operating at 10 megabits per second and 100 megabits per second

#### B. Field Bus

1. The field busses shall be FTT-10A operating at 78 kilobits per second.
2. The wiring of components shall use a bus or daisy chain concept with no tees, stubs or free topology.
3. The wiring type and length limitations shall conform to Echelon's Junction Box and Wiring Guideline for Twisted Pair LonWorks Networks.
4. Each field bus shall have a termination device at both ends of each segment.

C. IP to Field Bus Router

1. These devices shall perform layer 3 routing of ANSI/EIA 709.1B packets onto the IP network.
2. These devices shall be configurable locally without the use of the IP network (local cross over cable connection is acceptable) and configurable via the IP network.
3. These devices shall be configurable as routers such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.

D. Network Server Controller

1. These devices shall perform layer 3 routing of ANSI/EIA 709.1B packets onto the IP network.
2. These devices shall be configurable locally without the use of the IP network (local cross over cable connection is acceptable) and configurable via the IP network.
3. These devices shall be configurable as routers such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.
4. These devices shall provide the following support for the field bus devices that are connected below the Network Server Controller.
  - a. Time schedules
  - b. Trend logging
  - c. Alarm message generation and handling
5. These devices may provide supervisory logic support for the field bus devices that are connected below the Network Server Controller.
6. These devices may have physical inputs and outputs and provide process control for systems using these inputs and outputs.
7. If a Network Server Controller has physical inputs and outputs, it shall also comply with all of the requirements for programmable process controllers.

E. Physical Layer Repeaters (PLR)

1. PLRs are required to connect two segments to create a channel.
2. The design of the PLRs shall conform to LONMark standards.
3. LON to LON routers configured as repeaters may be used as a PLR.
4. Physical layer repeaters shall be installed in an enclosure. The enclosure may be in an interstitial space.

F. Standalone Digital Control Units (SDCUs)

1. General Requirements
  - a. Devices shall incorporate a service pin which, when pressed, will cause the device to broadcast its 48 bit node ID and its program ID over the network. The service pin shall be distinguishable and accessible.
  - b. Devices shall have a light indicating that they are powered.
  - c. Devices shall incorporate a TP/FT-10A transceiver in accordance with ANSI/EIA 709.3 and connections for TP/FT control network wiring.

- d. Devices shall be locally powered. Link powered devices are not acceptable.
- e. Application programs shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings.

2. Programmable Process Controllers (PPC)

a. The key characteristics of a PPC are:

- 1) They have physical input and output circuits for the connection of analog input devices, binary input devices, pulse input devices, analog output devices and binary output devices. The number and type of input and output devices supported will vary by model.
- 2) They may or may not provide support for additional input and output devices beyond the number of circuits that are provided on the basic circuit board. Support for additional I/O may be by additional circuit boards that physically connect to the basic controller or by a standalone device that communicates with the basic controller via the FTT-10A field bus.
- 3) The application to be executed by a PPC is created by an application engineer using the vendor's application programming tool.
- 4) PPCs shall support embedded time schedules. When time schedules are not embedded in a PPC, an occupancy command shall be an input network variable when time based control is required by the sequence of control. Systems that use a Network Server Controller shall provide time schedule support in the Network Server Controller and the PPCs are not required to support for time schedules. Systems that use LON to IP routers require that PPCs support embedded time schedules.
- 5) PPCs shall, support trend data storage with periodic upload to the data server. When trend data storage is not supported, the variables to be trended shall be broadcast over the field bus to another device that does support embedded trend data storage. Systems that use a Network Server Controller shall provide trend logging support in the Network Server Controller and the PPCs are not required to support trend logging. Systems that use LON to IP routers require that PPCs support embedded trend logging.
- 6) PPCs shall, support the initiation of an alarm message to the system server. When alarm message initiation is not supported, binary alarm indication variables shall be broadcast over the field bus to another device that does support the initiation of alarm messages to the system server. Systems that use a Network Server Controller shall provide alarm message initiation support in the Network Server Controller and the PPCs are not required to support alarm message initiation. Systems that use LON to IP routers require that PPCs support alarm messaging initiation.

b. Analog Input Circuits

- 1) The electrical signals from analog sensors shall be processed by an analog to digital (A/D) converter chip. The output of the A/D chip shall then be processed mathematically to produce data within the controller that has the required engineering units.
- 2) The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.
- 3) For non-flow sensors, the control logic shall provide support for the use of a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the Operator Workstation (OWS).
- 4) For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low



- range value and a high range value are adjusted to match values determined by a calibration instrument).
- 5) For non-linear sensors such as thermistors and flow sensors the PPC shall provide software support for the linearization of the input signal.
  - c. Binary Input Circuits
    - 1) Dry contact sensors shall wire to the controller with two wires.
    - 2) An external power supply in the sensor circuit shall not be required.
  - d. Pulse Input Circuits
    - 1) Pulse input sensors shall wire to the controller with two wires.
    - 2) An external power supply in the sensor circuit shall not be required.
    - 3) The pulse input circuit shall be able to process up to 50 pulses per second.
  - e. True Analog Output Circuits
    - 1) The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range (Example: 0 to 100% creates 3 to 6 VDC where the full output range is 0 to 10 VDC).
    - 2) The resolution of the D/A chip shall not be greater than 0.04 Volts per increment or 0.08 milliamps per increment.
  - f. Pulse Width Modulation Outputs with PWM transducers
    - 1) The controller shall be able to generate incremental pulses as small as 0.1 seconds.
  - g. Binary Output Circuits
    - 1) Single pole single throw or single pole double throw relays with support for up to 230 VAC and a maximum current of 2 amps.
    - 2) Voltage sourcing or externally powered triacs with support for up to 30 VAC and 0.8 amps.
  - h. Program Execution
    - 1) Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
    - 2) The sample rate for a process control loop shall be adjustable and shall support a minimum sample rate of 1 second.
    - 3) The sample rate for process variables shall be adjustable and shall support a minimum sample rate of 1 second.
    - 4) The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
    - 5) The application shall have the ability to determine if a power cycle to the controller has occurred, and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.
  - i. Local Interface: The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
    - 1) Adjust application parameters.
    - 2) Edit time schedule parameters if time schedules are embedded in the controller.
    - 3) Execute manual control of input and output points.
    - 4) View dynamic data.
    - 5) View alarm messages if alarm messaging is embedded in the controller.
  - j. Each PPC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.

3. Supervisory Logic Controller (SLC)

a. The key characteristics of an SLC are:

- 1) The application to be executed by as SLC is created by an application engineer using the vendor's application programming tool.
- 2) SLCs shall support embedded time schedules. When time schedules are not embedded in a SLC, an occupancy command shall be an input network variable when time based control is required by the sequence of control.

Systems that use a Network Server Controller shall provide time schedule support in the Network Server Controller and the SLCs do not have to support for time schedules. Systems that use a LON to IP router will provide time schedule support in the SLCs.

- 3) SLCs shall support trend data storage with periodic upload to the data server. When trend data storage is not supported, the variables to be trended shall be broadcast over the field bus to another device that does support embedded trend data storage. Systems that use a Network Server Controller shall provide trend logging support in the Network Server Controller and the SLCs are not required to support trend logging. Systems that use LON to IP routers require that SLCs support embedded trend logging.
- 4) SLCs shall support the initiation of an alarm message to the system server. When alarm message initiation is not supported, binary alarm indication variables shall be broadcast over the field bus to another device that does support the initiation of alarm messages to the system server. Systems that use a Network Server Controller shall provide alarm message initiation support in the Network Server Controller and the SLCs are not required to support alarm message initiation. Systems that use LON to IP routers require that SLCs support alarm messaging initiation.

b. Program Execution

- 1) Control algorithms shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
- 2) The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
- 3) The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of control immediately following a power cycle.

c. Local Interface

- 1) The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
  - a) Adjust application parameters.
  - b) Edit time schedule parameters if time schedules are embedded in the controller.
  - c) Execute manual control of input and output network variables.
  - d) View dynamic data.
  - e) View alarm messages if alarm messaging is embedded in the controller.
- d. Each SLC shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.
- e. Programmable Process Controllers (PPCs) with un-used I/O may be used as Supervisory Logic Controllers provided they meet all other requirements.

- f. Supervisory logic controllers shall have support a minimum of 200 input network variables and 70 output network variables.
  - 1) The SNVT for each of the 200 input network variables shall be selectable.
  - 2) The SNVT for each of the 70 output network variables shall be selectable.
- g. For the input and output network variables there shall not be any limitations as to the SNVT selected. (Example: SNVT\_temp\_p can only be used on 10 input network variables.)
- 4. Application Specific Devices (ASD)
  - a. ASD shall have fixed function configurable applications.
  - b. If the application can be altered by the vendor's application programming tool, the device is a programmable controller and not an application specific device.
  - c. All input and output network variables shall be formatted with SNVTs.
  - d. All input configuration parameters shall be formatted with SNVTs or SCPTs. If UNVTs or UCPTs are used, the device resource files that allow these custom parameters to be read shall be provided to the owner.
  - e. The network interface shall conform to the LonMark profile for the application provided by the ASD.
  - f. Each ASD shall have a network interface port that allows for an external device to connect to the FTT-10A network by plugging into the port. This port shall be built into the controller.
- 5. Portable Operating Terminals (POT)
  - a. Laptop Computer
  - b. 3GHz Pentium 4 processor with 1GB of RAM
  - c. Serial port, parallel port and 4 USB ports
  - d. 2 PCMCIA Slots
  - e. 10/100 MBS Ethernet network interface
  - f. 40GB Hard Disk
  - g. CD-RW drive
  - h. Touchpad mouse functionality
  - i. Software Requirements: The software requirements for a POT are identical to those for an operator workstation.

## **2.6 BACnet Fieldbus and BACnet SDCUs**

### **A. Networking**

- 1. IP Network: All devices that connect to the WAN shall be capable of operating at 10 megabits per second or 100 megabits per second.
- 2. IP To Field Bus Routing Devices
  - a. A Network Server Controller shall be used to provide this functionality.
  - b. These devices shall be configurable locally with IP crossover cable and configurable via the IP network.
  - c. The routing configuration shall be such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.

### **B. Field Bus Wiring and Termination**

- 1. The wiring of components shall use a bus or daisy chain concept with no tees, stubs, or free topology.
- 2. Each field bus shall have a termination resistor at both ends of each segment.

- 3. The field bus shall support the use of wireless communications.
- C. Repeaters
  - 1. Repeaters are required to connect two segments.
  - 2. Repeaters shall be installed in an enclosure. The enclosure may be in an interstitial space.
- D. Field Bus Devices
  - 1. General Requirements
    - a. Devices shall have a light indicating that they are powered.
    - b. Devices shall be locally powered. Link powered devices (power is furnished from a central source over the field bus cable) are not acceptable.
    - c. Application programs shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings. (Battery backup, flash memory, etc.)
  - E. Network Server Controllers (NSCs)
    - a. If NSCs have embedded I/O, all of the requirements for I/O that are described under Advance Application Controllers shall apply.
    - b. Shall support the export of data to NSCs from other vendors that support the data sharing, read property service.
    - c. Shall support the export of data using Change of Value (COV) initiation to NSCs from other vendors that support the subscription to data using the COV concept.
    - d. Shall support the export of data to any BACnet OWS that supports the data sharing, read property service.
    - e. Shall support the export of data using Change of Value (COV) initiation to any BACnet OWS that supports the subscription to data using the COV concept.
    - f. Shall provide trend log support for all of the devices on the field bus. They shall provide sufficient memory to store up to 300 samples for each variable required to be trended by the sequence of control.
    - g. Shall support the exporting of trend log data to any BACnet OWS that supports the read range BACnet service for trending.
    - h. Shall provide time schedule support for all of the devices on the field bus.
    - i. Shall support the editing of time schedule entries from any BACnet OWS that supports the BACnet service for writing of time schedule parameters.
    - j. Shall provide alarm message initiation for all alarms conditions from any of the field bus devices.
    - k. Shall deliver alarm messages to any BACnet OWS that supports the BACnet service for receiving alarm messages and is configured to be a recipient of the notification.
    - l. Shall support alarm acknowledgement from any BACnet OWS that supports the BACnet service for executing alarm/event acknowledgement.
    - m. Shall support the control of the out of service property and assignment of value or state to analog and binary objects from any BACnet OWS that supports writing to the out of service property and the value property of analog and binary objects.
    - n. Shall support the receipt and response to Time Synchronization commands from any device that supports the BACnet service for initiating time synchronization commands.
      - o. Shall support the "Who is?" and "I am." BACnet service.
      - p. Shall support the ""Who has?" and "I have." BACnet service.

- q. Shall support Backup and Restore commands from any BACnet OWS that supports the initiation of Backup and Restore commands.
- r. Shall be BTL certified.

#### **F. Advance Application Controllers (B-AAC)**

##### **1. The key characteristics of a B-AAC are:**

- a. They have physical input and output circuits for the connection of analog input devices, binary input devices, pulse input devices, analog output devices, and binary output devices. The number and type of input and output devices supported will vary by model.
- b. They may or may not provide support for additional input and output devices beyond the number of circuits that are provided on the basic circuit board. Support for additional I/O shall be provided by additional circuit boards that physically connect to the basic controller.
- c. The application to be executed by a B-AAC is created by an application engineer using the vendor's application programming tool.
- d. If local time schedules are embedded, the B-AAC shall support the editing of time schedule entries from any BACnet OWS that supports the BACnet service for writing of time schedule parameters.
- e. If local trend logging is embedded, the B-AAC shall support the exporting of trend log data to any BACnet OWS that supports the read range BACnet service for trending.
- f. If local alarm message initiation is embedded, the B-AAC shall:
  - 1) Deliver alarm messages to any BACnet OWS that supports the BACnet service for receiving alarm messages and is configured to be a recipient off the alarm message.
  - 2) Support alarm acknowledgement from any BACnet OWS that supports the BACnet service for executing alarm/event acknowledgement,
- g. Shall support the reading of analog and binary data from any BACnet OWS or Building Controller that supports the BACnet service for the reading of data.
- h. Shall support the control of the out of service property and assignment of value or state to analog and binary objects from any BACnet OWS that supports writing to the out of service property and the value property of analog and binary objects.
- i. Shall support the receipt and response to Time Synchronization commands from a BACnet Building Controller.
- j. Shall support the "Who is" and "I am." BACnet services.
- k. Shall support the "Who has" and "I have." BACnet services.

##### **2. Analog Input Circuits**

- a. The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.
- b. For non-flow sensors, the control logic shall provide support for the use of a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the Operator Workstation (OWS).
- c. For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low range value and a high range value are adjusted to match values

- determined by a calibration instrument).
- d. For non-linear sensors such as thermistors and flow sensors the B-AAC shall provide software support for the linearization of the input signal.
- 3. Binary Input Circuits
  - a. Dry contact sensors shall wire to the controller with two wires.
  - b. An external power supply in the sensor circuit shall not be required.
- 4. Pulse Input Circuits
  - a. Pulse input sensors shall wire to the controller with two wires.
  - b. An external power supply in the sensor circuit shall not be required.
  - c. The pulse input circuit shall be able to process up to 20 pulses per second.
- 5. True Analog Output Circuits
  - a. The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range (Example: 0 to 100% creates 3 to 6 VDC where the full output range is 0 to 10 VDC).
  - b. The resolution of the D/A chip shall not be greater than 0.04 Volts per increment or 0.08 milliamps per increment.
- 6. Binary Output Circuits
  - a. Single pole, single throw or single pole, double throw relays with support for up to 230 VAC and a maximum current of 2 amps.
  - b. Voltage sourcing or externally powered triacs with support for up to 30 VAC and 0.5 amps at 24 VAC.
- 7. Program Execution
  - a. Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
  - b. The sample rate for a process control loop shall be adjustable and shall support a minimum sample rate of 1 second.
  - c. The sample rate for process variables shall be adjustable and shall support a minimum sample rate of 1 second.
  - d. The sample rate for algorithm updates shall be adjustable and shall support a minimum sample rate of 1 second.
  - e. The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of controller immediately following a power cycle.
- 8. Local Interface
  - a. The controller shall support the connection of a portable interface device such as a laptop computer or vendor unique hand-held device. The ability to execute any tasks other than viewing data shall be password protected. Via this local interface, an operator shall be able to:
    - 1) Adjust application parameters.
    - 2) Execute manual control of input and output points.
    - 3) View dynamic data.
- G. Application Specific Devices
  - 1. Application specific devices shall have fixed function configurable applications.
  - 2. If the application can be altered by the vendor's application programmable tool, the device is an advanced application controller and not an application specific device.

3. Application specific devices shall be BTL certified.

## **2.7 DDC Sensors and Point Hardware**

### **A. Temperature Sensors**

1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
2. Standard space sensors shall be available in an off white enclosure for mounting on a standard electrical box.
3. Where manual overrides are required, the sensor housing shall feature both an optional sliding mechanism for adjusting the space temperature setpoint, as well as a push button for selecting after hours operation.
4. Where a local display is specified, the sensor shall incorporate either an LED or LCD display for viewing the space temperature, setpoint and other operator selectable parameters. Using built in buttons, operators shall be able to adjust setpoints directly from the sensor.
5. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
6. Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
7. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.
8. A pneumatic signal shall not be allowed for sensing temperature.

### **B. Humidity Sensors**

1. Humidity devices shall be accurate to +/- 5% at full scale for space and +/- 3% for duct and outside air applications. Suppliers shall be able to demonstrate that accuracy is NIST traceable.
2. As an option, provide a hand held field calibration tool that both reads the output of the sensor and contains a reference sensor for ongoing calibration.

### **C. Pressure Sensors**

1. Air pressure measurements in the range of 0 to 10" water column will be accurate to +/- 1% using a solid-state sensing element. Acceptable manufacturers include Modus Instruments and Mamac.
2. Differential pressure measurements of liquids or gases shall be accurate to +/- 0.5% of range. The housing shall be Nema 4 rated.

### **D. Current and KW Sensors**

1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in solid and split core models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.

2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

**E. Flow Sensors**

1. Provide an insertion vortex flowmeter for measurement of liquid, gas or steam flows in pipe sizes above 3 inches.
2. Install the flow meter on an isolation valve to permit removal without process shutdown.
3. Sensors shall be manufactured by EMCO or approved equal.

**F. Control Valves**

1. Provide automatic control valves suitable for the specified controlled media (steam, water or glycol). Provide valves which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
2. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.
3. Trim material shall be stainless steel for steam and high differential pressure applications.
4. Electric actuation should be provided on all terminal unit reheat applications.

**G. Dampers**

1. Automatic dampers, furnished by the Building Automation Contractor shall be single or multiple blade as required. Dampers are to be installed by the HVAC Contractor under the supervision of the BMS Contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.
2. Damper frames are to be constructed of 13 gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction. Compressible spring stainless steel side seals and acetal or bronze bearings shall also be provided.
3. Damper blade width shall not exceed eight inches. Seals and 3/8 inch square steel zinc plated pins are required. Blade rotation is to be parallel or opposed as shown on the schedules.
4. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.
5. Control and smoke dampers shall be Ruskin, or approved equal.
6. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

**H. Damper Actuators**

1. Damper actuators shall be electronic, and shall be direct coupled over the shaft, without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety



applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.

**I. Smoke Detectors**

1. Air duct smoke detectors shall be by Air Products & Controls or approved equal. The detectors shall operate at air velocities from 300 feet per minute to 4000 feet per minute.
2. The smoke detector shall utilize a photoelectric detector head.
3. The housing shall permit mechanical installation without removal of the detector cover.
4. The detectors shall be listed by Underwrites Laboratories and meet the requirements of UL 268A.

**J. Airflow Measuring Stations**

1. Provide a thermal anemometer using instrument grade self heated thermistor sensors with thermistor temperature sensors.
2. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.
3. The output signal shall be linear with field selectable ranges including 0-5 VDC, 0-10VDC and 4-20 mA.

**PART 3 - Execution**

**3.1 Contractor Responsibilities**

**A. General**

1. Installation of the building automation system shall be performed by the Contractor or a subcontractor. However, all installation shall be under the personal supervision of the Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training, and warranty requirements for the project be delegated to a subcontractor.

**B. Demolition**

1. Remove controls which do not remain as part of the building automation system, all associated abandoned wiring and conduit, and all associated pneumatic tubing. The Owner will inform the Contractor of any equipment which is to be removed that will remain the property of the Owner. All other equipment which is removed will be disposed of by the Contractor.

**C. Access to Site**

1. Unless notified otherwise, entrance to building is restricted. No one will be permitted to enter the building unless their names have been cleared with the Owner or the Owner's Representative.

**D. Code Compliance**

1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring specifications in Division 17 and

Division 16, wiring requirements of Division 17 will prevail for work specified in Division 17.

E. Cleanup

1. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.

### 3.2 Wiring, Conduit, and Cable

- A. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 Volt
Communications	Per Mfr.	Per Mfr.

- B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.
- C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the SANs Code.
- D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal-off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
- E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.
- F. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.
- G. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.
- H. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.
- I. Only glass fiber is acceptable, no plastic.
- J. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BMS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

### 3.3 Hardware Installation

- A. Installation Practices for Wiring
- B. All controllers are to be mounted vertically and per the manufacturer's installation documentation.
- C. The 120VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.
- D. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.
- E. Wires are to be attached to the building proper at regular intervals such that wiring does not droop. Wires are not to be affixed to or supported by pipes, conduit, etc.
- F. Conduit in finished areas will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exception; metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.
- G. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit will run parallel to or at right angles to the building structure.
- H. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.
- I. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.
- J. Wire will not be allowed to run across telephone equipment areas.

### **3.4 Installation Practices for Field Devices**

- A. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
- B. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
- C. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
- D. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
- E. For duct static pressure sensors, the high pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low pressure port shall be left open to the plenum area at the point that the high pressure port is tapped into the ductwork.
- F. For building static pressure sensors, the high pressure port shall be inserted into the space via a metal tube. Pipe the low pressure port to the outside of the building.

### **3.5 Enclosures**

- A. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
- B. FIPs shall contain power supplies for sensors, interface relays and contactors, and safety

circuits.

- C. The FIP enclosure shall be of steel construction with baked enamel finish; NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.
- D. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.
- E. All outside mounted enclosures shall meet the NEMA-4 rating.
- F. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

### **3.6 Identification**

- A. Identify all control wires with labeling tape or sleeves using words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
- B. All field enclosures, other than controllers, shall be identified with a Bakelite nameplate. The lettering shall be in white against a black or blue background.
- C. Junction box covers will be marked to indicate that they are a part of the BMS system.
- D. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with name plates.
- E. All I/O field devices inside FIP's shall be labeled.

### **3.7 Existing Controls.**

- A. Existing controls which are to be reused must each be tested and calibrated for proper operation. Existing controls which are to be reused and are found to be defective requiring replacement, will be noted to the Owner. The Owner will be responsible for all material and labor costs associated with their repair.

### **3.8 Control System Switch-over**

- A. Demolition of the existing control system will occur after the new temperature control system is in place including new sensors and new field interface devices.
- B. Switch-over from the existing control system to the new system will be fully coordinated with the Owner. A representative of the Owner will be on site during switch-over.
- C. The Contractor shall minimize control system downtime during switch-over. Sufficient installation mechanics will be on site so that the entire switch-over can be accomplished in a reasonable time frame.

### **3.9 Location**

- A. The location of sensors is per mechanical and architectural drawings.
- B. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.
- C. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.
- D. Field enclosures shall be located immediately adjacent to the controller panel(s) to

which it is being interfaced.

### **3.10 Software Installation**

#### **A. General.**

1. The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.

### **3.11 Database Configuration.**

- A. The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

### **3.12 Color Graphic Displays.**

- A. Unless otherwise directed by the owner, the Contractor will provide color graphic displays as depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner.

### **3.13 Reports.**

- A. The Contractor will configure a minimum of 4 reports for the owner. These reports shall, at a minimum, be able to provide:
  1. Trend comparison data
  2. Alarm status and prevalence information
  3. Energy Consumption data
  4. System user data

### **3.14 Documentation**

- A. As built software documentation will include the following:
  1. Descriptive point lists
  2. Application program listing
  3. Application programs with comments.
  4. Printouts of all reports.
  5. Alarm list.
  6. Printouts of all graphics
  7. Commissioning and System Startup

### **3.15 Point to Point Checkout.**

- A. Each I/O device (both field mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the owner or owner's representative.

### **3.16 Controller and Workstation Checkout.**

- A. A field checkout of all controllers and front end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.

### **3.17 System Acceptance Testing**

- A. All application software will be verified and compared against the sequences of operation.
  - 1. Chiller control
  - 2. Boiler Control
  - 3. Single Zone Air Handlers
  - 4. Multi Zone Air Handlers
  - 5. Packaged Roof Top Control
  - 6. Cooling Only VAV
  - 7. Fan Powered VAV
  - 8. Fan Coil Control
  - 9. Heat Pump Control
  - 10. Unit Ventilator Control
- B. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.
- C. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.
- D. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.
- E. Perform an operational test of each third-party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

### **3.18 BMS POINT SCHEDULES**

The BMS point schedule shall include but not limited to the following as applicable.

#### **01 CHILLER PLANT**

Water cooled Water Chiller (2 off)

Stop/start

Status

A/O/M selector switch position

Chiller alarm monitoring  
Low suction temperature alarm  
Chilled water return temperature  
Chilled water supply temperature  
Chilled water supply temperature  
setpoint  
Cooling capacity required  
Cooling capacity delivered  
Saturated Suction refrigerant  
temperature  
Discharge refrigerant temperature  
Common alarm  
High / Low return chilled water  
temperature alarm  
High / Low refrigerant discharge  
temperature alarm  
Chiller run hours  
kVA/kWh meter  
Voltage  
COP  
% RLA Load Limit  
Phase failure relay  
No of starts  
Compressor 1 fault  
Compressor 2 fault  
Sat Evap Temperature  
Sat Evap Pressure  
Sat Cond Temperature  
Sat Cond Pressure  
Ambient air temperature  
Automatic lead/lag control - primary  
pumps  
Automatic lead/lag control - chillers  
Chilled and Hot Water Temperatures  
PH sensor  
Make-up water meter  
Chiller flow switches  
Motorized shut-off valve status  
Motorized shut-off valve fault  
Motorized shut-off valve open/close

**Cooling tower (2 off)**

inlet water temperature (/outlet)  
outlet water temperature  
water level (sump high/low)  
Fan status (on/off, speed, trip)  
Water Flow status  
water quality parameters (pH, dissolved solids)  
water treatment

status (chemical pump status/trip), and air flow status.

Water Treatment System Status(On/Off status and trip alarms for chemical dosing pumps used in water treatment.

Fan & Airflow Monitoring Points

- Fan Status (On/Off):
- Fan Speed:
- Fan Trip Alarm:
- Air Flow Status: .

Operational & Electrical Monitoring Points

- System Status (On/Off)
- Auto/Manual Status
- Trip Signals:
- Valve Status

## **02 Chilled Water Pumps and Condenser water pumps( 8 Off)**

Pump run status

Start/Stop of pumps

Indication of manual switch position

Pump trip alarm indication

Pump speed for variable speed units

Pump discharge pressure at common header

Supply and return water pressure

## **03 CHW Pressurization Units ( 2 Off)**

The chilled water system pressure

In case of HI/LO Pressure in the chilled water system there will be an alarm.

Power supply status of panel

Running switch indicator

## **04 Extract Fans (10 off)**

Start/Stop of fans

The status of each fan from MCC panel

Trip alarm indication

VSD enable/disable

VSD speed control

VSD speed feedback

Variable speed drive fault

Variable speed drive run status

## **05 Fresh Air Handling Units (8 off)**

Variable speed drive fault

VSD enable/disable

Supply duct pressure



Fire alarm  
Ambient temp and humidity  
EA temperature  
CW Control valve modulate  
Supply air temperature  
Off coil temperature  
Filter status  
Thermal wheel trip status  
Wheel run status  
Thermal wheel start/stop  
HOA switch auto status (thermal wheel)  
Fan start/stop command  
Fan trip status (supply & return)  
Fan run status (supply & extract)  
Fan start/stop command  
HOA switch auto status (supply & extract)  
Variable speed drive run status  
Duct humidity (supply/intake)  
Air flow indicator

#### **06 Fan Coil Units (75 off)**

Monitoring of space temperature  
Run status of FCU fan  
Room temperature set point  
FCU shall have additional 3 speed switch  
Unit Start/Stop  
Unit Status  
A/O/M selector switch position  
Unit common alarm  
Fire Signal  
Return air temperature  
Supply air temperature  
Supply air temperature reset  
Space temperature - actual  
Temperature Set Point  
Cooling valve position - Commanded  
Cooling valve position - Actual  
CHW temp entering  
CHW temp leaving  
Heating valve position - Commanded  
Heating valve position - Actual  
HW temp entering  
HW temp leaving  
Air pressure switch  
Primary Filter bank pressure drop

#### **07 Air Handling Unit (14 Off)**

Run status of AHU fan  
Start/Stop of AHU fan

Cooling coil air on/air off temperatures monitoring

Reheat coil on/off(monitored)

Filter status

Reheat coil trip alarm

VSD enable/disable

VSD speed control

VSD speed feedback

Variable speed drive fault

Variable speed drive run status

Note: Each AHU shall have a local temperature set point adjuster

## **08 CO2 Control Panel**

Run status

System alarm

Trip alarm indication

## **09 Electricity and water monitoring meters**

Monitoring and recording (hourly, daily, weekly and annually)

Compare consumption for the recorded periods for trend analysis

Determine 'out-of-range' values and alert building operator

Record peak energy consumption for each end use

## **10 Water Make-up Plant CHW System (2 off)**

Water make-up flow meter

Water pressure

Water consumption

Booster pump status - (4 off)

Booster pump fault/trip - (4 off)

Water make up tank level

High/low level alarm