GENERAL

The intent of this specification is to define Building Controls System (BCS) that will successfully integrate multiple equipment controllers into a common platform that will allow for a consistent graphical display of control and functionality regardless of the control system vendor for this project.

The Tridium Niagara Web Supervisor Software will be deployed at the JACE. The Systems Integrator (SI) shall be responsible for obtaining IT standards from the owner's IT department as it relates to the connecting to the owner's network (if applicable). The SI shall coordinate with the Owner's IT department regarding security, authentication, network drop locations and any other areas that effect connecting to the Owner's network. The Building Controls System will be accessed via the Owner's Local Area Network (LAN), which will allow navigation to each piece of equipment that is integrated into the BCS.

The SI shall install a new Integration Gateway (Tridium Vykon JACE 8000) in order to integrate the equipment controllers as shown in the systems architecture. The SI shall not use more than 80% of the new JACE's resources. If more than 80% is required to complete the integration, a second JACE shall be supplied. After the equipment controllers are integrated, the SI shall commission the BCS and provide a drawing showing the system architecture integrated.

This section defines the major systems, subsystems and components that make up the Building Controls System:

1. INTEGRATION PLATFORM
   a. Integration Platform- Server Software

2. INTEGRATION GATEWAY
   a. Java Application Control Engine (TRIDIUM VYKON JACE 8000)

INTEGRATION PLATFORM

PART 1 – GENERAL

1.1   INTENT

A. The intent of this section is to define the Integration of the Building Systems and Control Systems in to the Integration Platform as provided by the Systems Integrator (SI). This platform will allow for a consistent graphical display of all systems shown in the overall topology.

B. Refer to drawing M- (insert drawing number here) for a diagrammatic representation of the System Architecture/Topology.

1.2 SUMMARY

A. This section describes the Systems Integrator's (SI) scope for the Building Controls Syhstem for the project.

B. Coordinates the responsibilities of the Mechanical and Electrical trade contractors pertaining to control products or systems, furnished by each trade, that will be integrated by this Division.

C. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the owner.

D. It is the owner's goal to implement an *"Open System"* that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. The owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

1.3 SYSTEMS INTEGRATOR (SI):

A. The Systems Integrator (SI) shall connect the building stakeholders with their building control systems and provide useful, meaningful and important information and control capabilities. The SI shall provide a unified database and graphical user interface tools by collaboration with the owners building control needs.

B. Roles & Responsibilities: Services required but not limited to:

1. Install integration server software platform capable of handling the entire portfolio in a location defined by the owner.
2. Co-ordinate with owner on proper use of IT within the Enterprise to include but not limited to Authentication, Security Certificates, SSL, and or any owner IT requirements. This is required only if connection is made to the owner's network.
3. Jointly develop integrated software plan with the owners building team and vendors to make sure all systems will communicate properly.

4. Reviews and meets with building team to ensure the building control system information will be accessible and useful.
5. Develop the software layer responsible for integration, aggregation and communications to the building control systems.
6. Standardize software tagging library, templates and menu hierarchy system, develop strategy for long term template maintenance.
7. Create and maintain graphical controls, monitors and dashboards as defined by the functional requirements of the system.
8. Configure alarm interface / controls, scheduling and user management capabilities.
9. Commission connected systems for usability and sustainability (all the software tools should be incorporated).
10. Document software maintenance strategy and upgrade procedures

C. Qualifications:

   Specific Requirements per Company

1. Experience in implementing Niagara framework similar to this project and of similar size and scope.
2. Must have a successful history in the design and installation of Niagara Framework
3. Must have 5 years consecutive licensing capabilities with the Niagara Framework.
4. Must have minimum of 2 employed individuals who meet System Requirements per individual
5. Firms shall have specialized in and be experienced with the installation of the Niagara Framework for not less than one year from date of final completion on at least three (3) projects of similar size and complexity. Submittals shall document this experience with references.

D. Specific Requirements: per individual

1. Must have 3 years experience with the firm represented
2. Proof of Niagara AX and Niagara 4 Certification.
3. List and describe a Niagara Enterprise (more than one building) integration project and the programmers involvement
4. List and describe a Niagara integration project involving multiple communication protocols or databases.
5. List and describe a Niagara integration project involving multiple platforms such as HVAC, Lighting Control, Security, Life Safety, Utilities and other building control and or monitoring systems.

1.4   APPROVED SYSTEMS INTEGRATORS

   A. INSERT INTEGRATORS NAME HERE
   B. INSERT INTEGRATORS NAME HERE
   C. INSERT INTEGRATORS NAME HERE
   D. INSERT INTEGRATORS NAME HERE
   E. INSERT INTEGRATORS NAME HERE

1.5   SYSTEM DESCRIPTION

The Building Controls System shall include, but not be limited to, the following components/sub systems in order to provide a fully functional platform required for integrating the systems shown on the system architecture/topology on drawing M-(insert drawing number here):

   a. Supervisory Front End Software

   A. The SI shall furnish all labor, materials and equipment necessary for a complete and operating BCS using the Niagara 4 Framework and Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over an open protocol bus (Examples: LonTalk, BACnet, MODBUS). The SI shall submit a Data Plan that includes database standards, graphics, dashboards, data tagging and program guidelines for the Engineer and Owner's review.

   B. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via vendor protocols including, at a minimum, LonTalk, BACnet and MODBUS.

   C. System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Mozilla Firefox, or Google Chrome browsers from any computer on the owner's LAN.

   D. All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset upon completion of this project. The use of configurable or programmable controllers that require additional software tools or tools that require a specific Niagara 4 license brand to operate for post-installation maintenance shall not be acceptable.

   E. Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara 4 Framework shall satisfy the requirements of this section.

F. The JACE 8000 shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the Niagara 4 Framework server.

G. A laptop computer including engineering/programming software to modify Operating System Server BCS programs and graphics shall be included.

H. Owner shall receive all Administrator level login and passwords for engineering toolset at first training session. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS.

I. OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have the following NiCS: "accept.station.in=*"; "accept.station.out=*"and "accept.wb.in=*"and "accept.wb.out=*". All open NIC statements shall follow Niagara Open NIC specifications.

J. All JACE 8000 hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted "safe boot" technology.

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

1. Federal Communications Commission (FCC), Rules and Regulations, Volume II -July 1986 Part 15 Class A Radio Frequency Devices.

2. FCC, Part 15, Subpart B, Class B

3. FCC, Part 15, Subpart C

4. FCC, Part 15, Subpart J, Class A Computing Devices.

5. UL 504 - Industrial Control Equipment.

6. UL 506 - Specialty Transformers.

7. UL 910 - Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air-Handling Spaces.

8. UL 916 - Energy Management Systems All.

9. UL 1449 - Transient Voltage Suppression.

10. Standard Test for Flame Propagation Height of Electrical and Optical - Fiber Cables Installed Vertically in Shafts.

11. EIA/ANSI 232-E - Interface Between Data Technical Equipment and Data Circuit Terminal Equipment Employing Serial Binary Data Interchange.

12. EIA 455 - Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices.

13. IEEE C62.41- Surge Voltages in Low-Voltage AC Power Circuits.

14. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.

   a. NEMA 250 - Enclosures for Electrical Equipment.

15. NEMA ICS 1 - Industrial Controls and Systems.

16. NEMA ST 1 - Specialty Transformers.

17. NCSBC Compliance, Energy: Performance of control system shall meet or surpass the requirements of ASHRAE/IESNA 90.1-1999.

18. CE 61326

19. C-Tick

20. cUL

1.6   SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:

1.   Actuator: Control device that opens or closes valve or damper in response to control signal.

2.   AI: Analog Input.

3.   AO: Analog Output.

4.   Analog: Continuously variable state over stated range of values.

5.   BMS: Building Management System.

6.   DDC: Direct Digital Control.

7.   Discrete: Binary or digital state.

8.   DI: Discrete Input.

9.   DO: Discrete Output.

10.   FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.

11.   FO: Fail open (position of control device or actuator). Device moves to open position on loss of control signal or energy source.

12.   GUI: Graphical User Interface.

13.   HVAC: Heating, Ventilating and Air Conditioning.

14.   IDC: Interoperable Digital Controller.

15. ILC: Interoperable Lon Controller.

16. LAN: Local Area Network.

17. OTN: Operational Technology Network

18. Modulating: Movement of a control device through an entire range of values, proportional to an infinitely variable input value.

19. Motorized: Control device with actuator.

20. NAC: Network Area Controller.

21. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.

22. NO: Normally open position of switch after control signal is removed; or the open position of a controlled valve or damper after the control signal is removed; or the usual position of a manually operated valve.

23. OSS: Operating System Server, host for system graphics, alarms, trends, etc.

24. Operator: Same as actuator.

25. PC: Personal Computer.

26. Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.

27. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.

28. PI: Proportional-Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controller variable (reset control).

29. PICS: BACnet Product Interoperability Compliance Statement.

30. PID: Proportional-Integral-Derivative control, control mode with continuous correction of final controller output element versus input signal based on proportional error, its time history (reset) and rate at which it's changing (derivative).

31. Point: Analog or discrete instrument with addressable database value.

32. WAN: Wide Area Network.

1.7 SUBMITTALS

A. Eight copies of shop drawings of the entire Integrated Platform including existing school(s) shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and

installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

B. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol. Though the Division 23 contractors shall provide these diagrams for their portions of work, the Master Systems Integrator shall be responsible for integrating those diagrams into the overall trunk cable schematic diagrams for the entire Virtual Local Area Network (VLAN).

C. Submittal shall also include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or owner.

D. Upon completion of the work, provide a complete set of 'as-built' drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Eight copies of the 'as-built' drawings shall be provided in addition to the documents on compact disk. The Division 25 contractor shall be responsible for as-builts pertaining to overall BMS architecture and network diagrams. All as built drawings shall also be installed into the integrated platform server in a dedicated directory.

1.8   SPECIFICATION NOMENCLATURE

a. Acronyms used in this specification are as follows:

FMCS- Facility Management and Control System
TCS- Temperature Control System
JACE- Java Application Control Engine
IDC- Interoperable Digital Controller
IBC- Interoperable BACnet Controller
GUI- Graphical User Interface
WBI- Web Browser Interface
POT- Portable Operator's Terminal
PMI- Power Measurement Interface
DDC- Direct Digital Controls
LAN- Local Area Network
WAN- Wide Area Network
OOT- Object Oriented Technology
PICS- Product Interoperability Compliance Statement

1.9   QUALITY ASSURANCE

A.   The SI shall have a full service DDC office within 50 miles of the job site. This office shall be staffed with applications engineers, software engineers and field technicians. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment.

B.   Single Source Responsibility of Supplier: The SI shall be responsible for the complete installation and proper operation of the control system. The SI shall exclusively be in the regular and customary business of design, installation and service of computerized building management systems similar in size and complexity to the system specified. The Master Systems Integrator shall be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years. All control panels shall be assembled by the Control System Contractor in a UL-Certified 508A panel shop.

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

1.10   PRE-INSTALLATION MEETINGS
A.   Convene minimum two weeks prior to starting work of this section.

1.11   DELIVERY, STORAGE AND HANDLING

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

1.12   JOB CONDITIONS

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

1.13   SEQUENCING

A.   Ensure that products of this section are supplied to affected trades in time to

prevent interruption of construction progress.

PART 2 – PRODUCTS

2.0 MANUFACTURERS

Tridium Niagara Framework Version N4

2.1 GENERAL

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

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

2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

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

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

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

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

E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.

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

2.3 INTEGRATION SOFTWARE
The Integration Software shall allow multiple Niagara-based JACE controllers, along with other IP-based controllers, to be networked together through the owner's network. This software shall provide real-time graphical information to standard Web-browser clients and provide server-level functions. These functions include centralized data logging/trending, alarming, tagging, archiving to external databases, alarming, dashboarding, system navigation, master scheduling, database management, and integration with other enterprise software applications through an XML interface (oBIX standard). Also, shall provide a comprehensive graphical engineering toolset for application development.

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

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

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

D. The web browser GUI shall provide a completely interactive user interface and shall provide a HTML5 experience that supports the following features as a minimum:
    1. Trending.
    2. Scheduling.
    3. Electrical demand limiting.
    4. Duty Cycling.
    5. Downloading Memory to field devices.
    6. Real time 'live' Graphic Programs.
    7. Tree Navigation.
    8. Parameter change of properties.
    9. Set point adjustments.
    10. Alarm / event information.

11. Configuration of operators.
12. Execution of global commands.
13. Add, delete, and modify graphics and displayed data.

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

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

G. Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:

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

H. Web Browser Graphical User Interface

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

2. Login: On launching the web browser and selecting the appropriate

domain name or IP address, the operator shall be presented with a login page that will require a login name and strong password. Navigation in the system shall be dependent on the operator's role-based application control privileges.

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

4. Action Pane: The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:
    a. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
    b. Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web browser. User shall have ability to save custom dashboards.
    c. Search: User shall have multiple options for searching data based upon Tags. Associated equipment, real time data, Properties, and Trends shall be available in result.
    d. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.
    e. Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).
    f. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
    g. Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have

ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.

   h. Logic - Live Graphic Programs: Shall be used to display' live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.

   i. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

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

   1. Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color.

   2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.

   3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.

   4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability. .

   5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
      a. Each piece of equipment monitored or controlled including each terminal unit.
      b. Each building.
      c. Each floor and zone controlled.

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

automatically downloaded with the ' Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

1. Schedules: Schedules shall comply with the LonWorks and BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:

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

2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.

3. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an ' individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the ' tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the ' tenant group'.

4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.

5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).

6. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

K. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by

selecting an ' Alarms' view. Alarms, and reporting actions shall have the following capabilities:

1. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.

2. Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.

3. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.

4. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.

5. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.

6. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A ' network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.

7. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.

8. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.

9. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:

   a. Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
   b. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
   c. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
   d. Write Property: The write property reporting action updates a property value in a hardware module.
   e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
   f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

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

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

3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.
4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and ' pan through' historical data by simply scrolling the mouse.
6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
7. Copy/Paste. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

M. Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges as specified:
1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of ' easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
   a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
   b. Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
   c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.

2. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

N. Graphical Programming

1. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. Any system that does not use a drag and drop method of graphical icon programming shall not be accepted. All systems shall use a GPL method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent

common logical control devices used in conventional control systems, such as relays, switches, high signal selectors etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

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

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

4.	GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:
    a.	Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
    b.	Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
    c.	Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
    d.	Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
    e.	Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
    f.	Parameter: A parameter shall be a value that may be tied to the input of a microblock.

g. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields, and shall contain 'push buttons' for the purpose of selecting default parameter settings.

h. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.

i. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.

j. Live Graphical Programs: The Graphic Programming software shall support a ' live' mode, where all input/output data, calculated data and set points shall be displayed in a ' live' real-time mode.

2.4 TAGGING

The purpose of tagging requirements data modeling standard is to provide a consistent, standardized methodology for naming and describing data points associated with the the IoT and Integrated Automation Topology for this project. This includes the facility automation systems, equipment systems, energy metering systems, other smart devices including mobile assets, and associated descriptive information known as metadata.

A. The Project Haystack standard shall be used for this project paired with a Building Location tagging Library. The building location tagging library shall include *Compass Directional,* which will be bi-directional (ie, NE, SW, NW, SE) and the *Building Level* (ie. 1st floor, 2nd floor, 3rd floor, etc..). The project haystack tagging libraries are embedded within the Niagara Software Platform. The building location tagging library shall be developed to work seamlessly with haystack and operate as an integrated solution for tagging.

B. Project-Haystack facilitates "mapping" of Haystack semantic tagging with other relevant standards. The Project Haystack data modeling standard for Buildings and Equipment systems shall use a simple metamodel based on the broadly accepted concept of "tags" shown below.

1. Tags: Tags are name/value pairs, associated with entities like AHUs, electric meters, etc. Tags are simple and dynamic, add structure, and provide the flexibility needed to establish standardized models of diverse systems and equipment. Tags are a modeling technique that allows easy customization of data models on a per-task, per-project or per-equipment basis, while retaining the ability to be interpreted by external applications

using a standard, defined methodology and vocabulary. Tags shall support the definition of the following essential data elements:

a. Entity: An Entity is an abstraction for a physical object in the real world. Entities include sites, facilities, equipment, sensor points, weather stations, etc. In software systems, an entity might be a modeled as a record in a database, an object in a building automation system, or maybe just a row in a csv file or spreadsheet.

b. Id: The id tag is used to model the unique identifier of an entity in a system using a Ref value type. Ref value types are determined by individual application. The scope of an entity may be undefined, but must be unique within a given system or project. This identifier may be used by other entities to cross-reference entities, associations, and systems.

c. Dis: The dis tag is used with entities to define display text used to describe an entity. Dis values are intended to be short (less than 30 or 40 characters), but fully descriptive of the entity for a human user.

2.5   INTEGRATION GATEWAY

1.   SYSTEM NETWORK CONTROLLER (SNC)

a. The system network controller (SNC) provided shall be a Java Application Control Engine(s) (JACE). The VYKON JACE 8000 shall connect to the owner's local network or wide area network depending on configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each JACE is capable communicate to LonMark/LonTalk (IDC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices within the existing Temperature Control Systems at each location.

b. The SNC shall be based on the Niagara 4 Framework, a Java-based framework developed by Tridium. Niagara 4 provides an open automation infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time over the Internet using a standard Web browser. Systems not developed on the Niagara4 Framework platform are not acceptable.

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

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

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

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

E. The SNC shall be capable of executing application control programs to provide:
   1. Calendar functions
   2. Scheduling
   3. Trending
   4. Alarm monitoring and routing
   5. Time synchronization
   6. Integration of LonWorks, BACnet, and ModBus controller data
   7. Network management functions for all SNC, PEC and ASC based devices

F. The SNC must provide the following hardware features as a minimum:
   1. One Ethernet Port-10/100 Mdps
   2. One RS-232/485 port
   3. One LonWorks Interface Port – 78KB FTT-10A
   4. Battery Backup
   5. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)

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

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

I. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.
   1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
      a. Alarm,

  b. Return to normal,
  c. To default.
 2. Alarms shall be annunciated in any of the following manners as defined by the user:
  a. Screen message text,
  b. Email of complete alarm message to multiple recipients.
  c. Pagers via paging services that initiate a page on receipt of email message.
  d. Graphics with flashing alarm object(s).
 3. The following shall be recorded by the SNC for each alarm (at a minimum):
  a. Time and date
  b. Equipment (air handler #, accessway, etc.)
  c. Acknowledge time, date, and user who issued acknowledgement.
J. Programming software and all controller "Setup Wizards" shall be embedded into the SNC.

1.2 PROGRAMMABLE EQUIPMENT CONTROLLER (PEC)

A. HVAC control shall be accomplished using LonMark™ based devices where the application has a LonMark profile defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara AX Framework™, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

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

C. The PECs shall communicate with the SNC at a baud rate of not less than 78.8K baud. The PEC shall provide LED indication of communication and controller performance to the technician, without cover removal.

D. The following integral and remote Inputs/Outputs shall be supported per each PEC:
 1. Eight integral dry contact digital inputs.
 2. Any two digital inputs may be configured as pulse counters with a maximum pulse read rate of 15 Hz.
 3. Eight integral analog inputs (configurable as 0-10V, 0-10,000 ohm or, 20K NTC).
 4. Six integral 4-20 ma analog outputs.
 5. Eight integral 24 Vac Triac digital outputs, configurable as maintained or floating motor control outputs.

6. One integral 20 Vdc, 65-mA power supply for auxiliary devices.
7. If a 20 Vdc 65-mA power supply terminal is not integral to the ILC, provide at each PEC a separate, fully isolated, enclosed, current limited and regulated UL listed auxiliary power supply for power to auxiliary devices

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

F. PEC Controllers shall support the following control techniques:
1. Ten configurable general-purpose control loops that can incorporate Demand Limit Control strategies, Setpoint reset, adaptive intelligent recovery, and time of day bypass.
2. Ten general-purpose, non-linear control loops.
3. Eight start/stop Loops.
4. Thirty-two If/Then/Else logic loops.
5. Thirty six Math Function loops (MIN, MAX, AVG, SUM, SUB,SQRT, MUL, DIV, ENTHALPY).

1.3   ADVANCED UNITARY CONTROLLER

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

B. Minimum Requirements:
1. The controller shall be fully programmable with full functionality on any Niagara AX brand platform.
   a. Support downloads to the controller from any brand of Niagara AX platform.
   b. Support uploads from the controller to any brand of Niagara AX platform.
   c. Support simulation/debug mode of the controller.
   d. Maintain native GUI.
   e. Native function-block programming within the Niagara AX environment.
2. The controller shall be capable of either integrating with other devices or stand-alone operation.
3. The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second

processor for network communications. Controller memory minimum requirements include:

   a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
   b. FLASH Memory settings retained for ten years.
   c. RAM: 2 Kilobytes

4. The controller shall have an FTT transformer-coupled communications port interface for common mode-noise rejection and DC isolation.

5. The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.

   a. Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
   b. Accuracy: ±1 minute per month at 77° F (25° C).
   c. Power Failure Backup: 24 hours at 32° to 122° F (0° to 50° C).

6. The controller shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.

7. The controller shall have an internal DC power supply to power external sensors.

   a. Power Output: 20 VDC ±10% at 75 mA.

8. The controller shall have a visual indication (LED) of the status of the devise:

   a. Controller operating normally.
   b. Controller in process of download.
   c. Controller in manual mode under control of software tool.
   d. Controller lost its configuration.
   e. No power to controller, low voltage, or controller damage.
   f. Processor and/or controller are not operating.

9. The minimum controller Environmental ratings

   a. Operating Temperature Ambient Rating: -40° to 150° F (-40° to 65.5° C).
   b. Storage Temperature Ambient Rating: -40° to 150° F (-40° to 65.5° C).
   c. Relative Humidity: 5% to 95% non-condensing.

10. The controller shall have the additional approval requirements, listings, and approvals:

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

  f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission)
11. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
12. The controller shall have a mix of digital inputs (DI), digital Triac outputs (DO), analog outputs (AO), and universal inputs (UI).
  a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO)
  b. Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
  c. Input and Output wiring terminals shall be designated with color coded labels.
  d. Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA)
13. The controller shall provide for "<u>user defined</u>" Network Variables (NV) for customized configurations and naming using Niagara AX Framework™.
  a. The controller shall support 62 Network Variables with a byte count of 31 per variable.
  b. The controller shall support 1,922 separate data values.
14. The controller shall provide **"<u>continuous</u>"** automated loop tuning with an Adaptive Integral Algorithm Control Loop.
15. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined in Section 4.
  a. Discharge air control and low limit
  b. Pressure-dependent dual duct without flow mixing.
  c. Variable air volume with return flow tracking.
  d. Economizer with differential enthalpy.
  e. Minimum airflow coordinated with CO_2.
  f. Unit ventilator cycle (1,2,3) 2-pipe.
  g. Unit ventilator cycle (1,2,3) 2-pipe with face/bypass.
  h. Unit ventilator cycle (1,2,3) 4-pipe.
  i. Unit ventilator cycle (1,2,3) 4-pipe with EOC valve.

1.4 ADVANCED VARIABLE AIR VOLUME CONTROLLER

  A. The advanced VAV controller platform shall be designed specifically for room-level VAV control – pressure-independent air flow control, pressure dependent damper control, supply and exhaust pressurization/de-pressurization control; temperature, humidity, complex CO_2, occupancy, and emergency control. Equipment includes: VAV terminal unit, VAV terminal unit with reheat, Series fan powered terminal unit, Parallel fan powered terminal unit, Supply and Exhaust air volume terminals, and

Constant volume dual-duct terminal unit. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara AX Framework™, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. Minimum Requirements:

1. The controller shall be fully programmable with full functionality on any Niagara AX brand platform.
   a. Support downloads to the controller from any brand of Niagara AX platform.
   b. Support uploads from the controller to any brand of Niagara AX platform.
   c. Support simulation/debug mode of the controller.
   d. Maintain native GUI.
   e. Native function-block programming within the Niagara AX environment.

2. The controller shall be capable of either integrating with other devices or stand-alone room-level control operation.

3. The controller shall have an internal velocity pressure sensor.
   a. Sensor Type: Microbridge air flow sensor with dual integral restrictors.
   b. Operating Range: 0 to 1.5 in. H2O (0 to 374 Pa).
   c. Accuracy: ±2% of full scale at 32° to 122° F (0° to 50° C); ±1% of full scale at null pressure.

4. The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications.
   a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
   b. FLASH Memory settings retained for ten years.
   c. RAM: 2 Kilobytes

5. The controller shall have an FTT transformer-coupled communications port interface for common mode-noise rejection and DC isolation.

6. The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
   a. Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
   b. Accuracy: ±1 minute per month at 77° F (25° C).
   c. Power Failure Backup: 24 hours at 32° to 122° F (0° to 50° C).

7. The controller shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.

8. The controller shall have an internal DC power supply to power external sensors.

      a.   Power Output: 20 VDC ±10% at 75 mA.

9. The controller shall have a visual indication (LED) of the status of the devise:
   a. Controller operating normally.
   b. Controller in process of download.
   c. Controller in manual mode under control of software tool.
   d. Controller lost its configuration.
   e. No power to controller, low voltage, or controller damage.
   f. Processor and/or controller are not operating.

10. The minimum controller Environmental ratings:
    a. Operating Temperature Ambient Rating: 32° to 122° F (0° to 50° C).
    b. Storage Temperature Ambient Rating: 32° to 122° F (0° to 50° C).
    c. Relative Humidity: 5% to 95% non-condensing.

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

12. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).

13. The controller shall provide an integrated actuator option.
    a. Actuator type: Series 60 Floating.
    b. Rotation stroke: 95° ±3° for CW or CCW opening dampers.
    c. Torque rating: 44 lb-in. (5 Nm).
    d. Run time for 90° rotation: 90 seconds at 60 Hz.

14. The controller shall have four digital inputs (DI), eight digital Triac outputs (DO) or six digital Triac outputs (DO) with Integrated Actuator, three analog outputs (AO), and six universal inputs (UI).
    a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
    b. Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
    c. Input and Output wiring terminals shall be designated with color coded labels.

15. The controller shall provide for **"<u>user defined</u>"** Network Variables (NV) for customized configurations and naming using Niagara AX Framework™.

a. The controller shall support a range of Network Variables to 62 with a byte count of 31 per variable.
b. The controller shall support 1,922 separate data values.
16. The controller shall provide **"<u>continuous</u>"** automated loop tuning with an Adaptive Integral Algorithm Control Loop.
17. The controller shall have a loop execution response time of 1 second.
18. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined in Section 4.
   a. VAV terminal unit.
   b. VAV terminal unit fan speed control.
   c. Series fan.
   d. Parallel fan.
   e. Regulated air volume (room pressurization/de-pressurization).
   f. CV dual-duct
   g. Room CO2 control
   h. Room Humidity
   i. TOD occupancy sensor stand-by setpoints

1.5   OTHER CONTROL SYSTEM HARDWARE

A. Motorized control dampers that will not be integral to the equipment shall be furnished by the Control System Contractor. Control damper frames shall be constructed of galvanized steel, formed into changes and welded or riveted. Dampers shall be galvanized, with nylon bearings. Blade edge seals shall be vinyl. Blade edge and tip seals shall be included for all dampers. Blades shall be 16-gauge minimum and 6 inches wide maximum and frame shall be of welded channel iron. Damper leakage shall not exceed 10 CFM per square foot, at 1.5-inches water gauge static pressure.
B. Control damper actuators shall be furnished by the Control System Contractor. Two-position or proportional electric actuators shall be direct-mount type sized to provide a minimum of 5 in-lb torque per square foot of damper area. Damper actuators shall be spring return type. Operators shall be heavy-duty electronic type for positioning automatic dampers in response to a control signal. Motor shall be of sufficient size to operate damper positively and smoothly to obtain correct sequence as indicated. All applications requiring proportional operation shall utilize truly proportional electric actuators.
C. Control Valves: Control valves shall be 2-way or 3-way pattern as shown and constructed for tight shutoff at the pump shut-off head or steam relief valve pressure. Control valves shall operate satisfactorily against system pressures and differentials. Two-position valves shall be 'line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (unless otherwise noted or scheduled on the drawings). Valves with sizes up to and including 2 inches shall be "screwed"

configuration and 2-1/2 inch and larger valves shall be "flanged" configuration. All control valves, including terminal unit valves, less than 2 inch shall be globe valves. Electrically-actuated control valves shall include spring return type actuators sized for tight shut-off against system pressures (as specified above) and, when specified, shall be furnished with integral switches for indication of valve position (open-closed). Pneumatic actuators for valves, when utilized, shall be sized for tight shut-off against system pressures (as specified above).

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

E. All control valves 2 ½" or larger shall have position indication. All hot water control valves shall be Normally-Open arrangement; all chilled water control valves shall be Normally-Closed arrangement.

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

G. Duct-mounted and Outside Air Temperature Sensors: 20,000-ohm thermistor temperature sensors with an accuracy of ± 0.2ºC. Outside air sensors shall include an integral sun shield. Duct-mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of -40 to 160 degrees F. The sensor shall include a utility box and a gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 - foot long sensor element. These devices shall have accuracy of 0.5 degrees, F., over the entire range.

H. Humidity sensors shall be thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140 degree F. Sensors shall be selected for wall, duct or outdoor type installation as appropriate.

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

Input voltage shall be 20 to 30 VAC or DC. Output shall be 0 - 10 VDC. Sensor shall be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure.

J. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point.

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

L. Differential Air Pressure Switches: Provide SPDT type, UL-approved, and selected for the appropriate operating range where applied. Switches shall have adjustable setpoints and barbed pressure tips.

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

N. Temperature Control Panels: Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. All electrical devices within a control panel shall be factory wired. Control panel shall be assembled by the BMS in a UL-Certified 508A panel shop. A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.

O. Pipe and Duct Temperature sensing elements: 20,000-ohm thermister temperature sensors with and accuracy of ±1% accuracy. Their range shall be -5- to 250 deg. F. Limited range sensors shall be acceptable provided they are capable of sensing the range expected for the point at the specified accuracy. Thermal wells with heat conductive gel shall be included.

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

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

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

S. Transducers: Differential pressure transducers shall be electronic with a 4-20 mA. output signal compatible to the Direct Digital Controller. Wetted

parts shall be stainless steel. Unit shall be designed to operate in the pressure ranges involved.

T. Control Power Transformers: Provide step-down transformers for all DDC controllers and devices as required. Transformers shall be sized for the load, but shall be sized for 50 watts, minimum. Transformers shall be UL listed Class 2 type, for 120VAC/24VAC operation.

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

PART 2   BAS SERVER & WEB BROWSER GUI

2.1   SYSTEM OVERVIEW

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

B. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft and Netscape Navigator browsers (6.0 or later versions), and Windows as well as non-Window operating systems. No special software, other than free public domain programs such as "JAVA VIRTUAL MACHINE" shall be required to be installed on PC's used to access the BAS via a web browser.

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

D. The web browser GUI shall provide a completely interactive user interface and must offer and be configured with the following features as a minimum:
1. Trending
2. Scheduling
3. Electrical demand limiting
4. Duty Cycling
5. Downloading Memory to field devices
6. Real time 'live' Graphic Programs
7. Tree Navigation
8. Parameter change of properties
9. Setpoint Adjustments

10. Alarm / Event information
11. Configuration of operators
12. Execution of global commands
13. Add, delete, and modify graphics and displayed data

E. Software Components: All software shall be the most current version. All software components of the BAS system software shall be provided and installed as part of this project .BAS software components shall include:
1. Server Software, Database and Web Browser Graphical User Interface
2. System Configuration Utilities for future modifications to the system, and controllers.
3. Graphical Programming Tools
4. Direct Digital Control software
5. Application Software
6. Any required third party software
7. If licensing credits are required provide a minimum of 10% additional to as built control system requires.

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

G. Database Open Connectivity: The BAS server database shall allow real time access of data via the following standard mechanisms:
1. Open protocol standard like SOAP
2. OLE/OPC (for Microsoft Client's/Server platform only)
3. Import/Export of the database from or to XML (eXtensible Mark-up Language)

H. Communication Protocol(s): The native protocol for the BAS server software shall be TCPIP over Ethernet. Proprietary protocols over TCP/IP are NOT acceptable.

I. Thin Client – Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:
1. Web Browser's for PC's: Only a 5.5 or later browser (Explorer/Navigator) will be required as the GUI, and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet.
2. Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP)

2.2   WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and

intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events.

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

C. *Navigation: Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.*

1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.

2. Groups View shall display Scheduled Groups and custom reports.

3. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

D. *Action Pane: The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:*

1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial   building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content, and other valid HTML elements. The data on each graphic page shall automatically refresh.

2. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.

3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree).

4. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.

5. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling

6. Logic - Live Graphic Programs: Shall be used to display' live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.

7. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

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

1. Display Size: The GUI workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color.

2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.

3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone's actual comfort condition changes.

4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.

5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
   a. Each piece of equipment monitored or controlled including each terminal unit
   b. Each building
   c. Each floor and zone controlled

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

1. Schedules: Schedules shall comply with the LonWorks standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
   a. Types of schedule shall be Normal, Holiday or Override
   b. A specific date,
   c. A range of dates,
   d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any)
   e. Wildcard (example, allow combinations like second Tuesday of every month).
2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
3. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group – who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'
4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler, and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
6. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules, and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

G. ***Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Alarms' view. Alarms, and reporting actions shall have the following capabilities:***
   1. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report, and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the

system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.

2. Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.

3. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.

4. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.

5. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.

6. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A 'network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.

7. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement, and total number of Alarms in the BAS Server database.

8. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.

9. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:

   a. Print: Alarm information shall be printed to the BAS server's PC or a networked printer.

   b. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.

   c. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm

through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).

d. Write Property: The write property reporting action updates a property value in a hardware module.

e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.

f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

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

1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.

2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.

3. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.

4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.

5. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.

6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.

7. Copy/Paste. The operator must have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

I. ***Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:***

1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language'

privileges. Roles shall be defined in terms of View, Edit and Function Privileges.

  a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.

  b. Edit Privileges shall comprise: Setpoint, Tuning and Logic, Manual Override, and Point Assignment Parameters.

  c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print, and Alarm/Event Maintenance.

2. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

2.3   GRAPHICAL PROGRAMMING

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

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

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

D. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:

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

2.4   LONWORKS NETWORK MANAGEMENT

A. Systems requiring the use of third party LonWorks network management tools shall not be accepted.
B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
C. The Network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.
D. These tools shall provide the ability to "learn" an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.

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

2.5 PORTABLE OPERATOR'S TOOL (LAPTOP COMPUTER)

A. The laptop computer shall consist of an Intel Pentium based laptop computer (**minimum processing speed of 2.0 GHz with 2 GB RAM and a 80-gigabyte minimum hard drive**). It shall include a CD-ROM drive, and appropriate connectors and cables for communication with the Ethernet network.

PART 3 INSTALLATION

3.1 GENERAL

A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.
B. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.
C. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.
D. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

3.2 WIRING

A. All electrical control wiring = to the control panels shall be the responsibility of the Control System Contractor.
B. All wiring shall be in accordance with the Project Electrical Specifications (Division 16), the National Electrical Code and any applicable local codes. All control wiring shall be installed in raceways.

PART 4 **PROJECT CLOSEOUT**

4.1   ACCEPTANCE TESTING

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

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

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

4.2   OPERATOR TRAINING

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

B. The Control System Contractor shall provide 40 hours of comprehensive training in two separate sessions (80 hours total) for system orientation, product maintenance and troubleshooting, programming and engineering, if not provided under a previous contract at the site using the same brand and type of controllers within the previous 3 years.

C. The Control System Contractor shall provide 16 hours (total) of instruction to the owner's designated personnel on the operation of the BMS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BMS shall include, but not be limited to; the overall operation program, equipment functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation

4.3   WARRANTY PERIOD SERVICES

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

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

C. Maintenance of Computer Software Programs: The Control System Contractor shall maintain all software during the warranty period. In addition, all factory or sub-vendor upgrades to software shall be added to the systems, when they become available, at no additional cost. New products are not considered upgrades in this context.

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

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

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

4.4 WARRANTY ACCESS

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

4.5 OPERATION & MAINTENANCE MANUALS

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

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 BAS 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 SI 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. 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.

D. 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).

E. 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.

WARRANTY AND MAINTENANCE

A. All components, system software, and parts furnished and installed by the SI 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 BSI at no charge during normal working hours during the warranty period. Materials furnished but not installed by the SI 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 request for warranty service within 24 standard working hours.

TRAINING

A. The SI 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.

END OF SPECIFICATION