

**ATTACHMENT 15975-A2\* - BUILDING LEVEL DIRECT DIGITAL CONTROL SYSTEM  
(BASE AND ALTERNATE)**

## PART 1 – GENERAL SCOPE

## 1.1 RELATED DOCUMENTS

- A. The provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as through bound herein.

## 1.2 SUMMARY

- A. This document contains the specification for a Building Automation System (BAS).
- B. The system shall provide the Direct Digital Control (DDC), Energy Management and Building Automation System (BAS) for the air conditioning, heating and ventilating systems, lighting controls and shall interface with other microprocessor based building subsystems as shown on the drawings and as specified.
- C. Related Work Specified Elsewhere:
  - 1. Section 15501 – Electrical Requirements for HVAC Equipment.
  - 2. Section 15504 – Motors
  - 3. Section 15542 – Variable Frequency Drives.
  - 4. Section 15558 – High Efficiency Condensing Boilers.
  - 5. Section 15683 – Air Cooled Water Chillers
  - 6. Section 15976 – Sequence of Operation.
  - 7. Section 15995 – HVAC Systems Commissioning
- D. Refer to Section 01230 for Alternates that may affect the Work of this Section.

## 1.3 SCOPE OF WORK

Contractor's Responsibilities: The Contractor shall furnish and install all necessary software and hardware, wiring, and control equipment in compliance with this specification.

- A. System Requirements
  - 1. Standard Material/Products: All material and equipment used shall be standard components, regularly manufactured and available, and not custom designed especially for this project
  - 2. Modular Design: The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.
  - 3. Performance: The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.
- B. Equipment
  - 1. System Hardware
    - The Contractor shall provide the following:
      - a. All sensing devices, relays, switches, indicating devices, and transducers, power supplies, interface modules, etc. required to perform all require functions.
      - b. All monitoring and control wiring.
      - c. Owner shall furnish remotely located database server hardware.
  - 2. System Software

The Controls Contractor shall provide the latest version of all software required to configure, monitor, link and program all components of the completed system. This software shall be capable of all system functions with out the need of access to any server based applications. The Controls Contractor shall provide the latest version of all third party software required (excluding computer operating system) and the BAS Server Software. The system shall be fully configured, including database, graphics, reports, alarm/events trends etc. The Graphical User Interface (GUI) shall be completely Web based as specified herein.

C. Codes and Regulations

1. Standards Authority. All electrical equipment and material, and its installation, shall conform to the current requirements of the following authorities:
  - a. Occupational Safety and Health Act (OSHA)
  - b. National Electric Code (NEC)
  - c. National Fire Code
  - d. Uniform Mechanical Code
  - e. Uniform Building Code
  - f. Uniform Plumbing Code
2. Product Applicable Standards. All distributed, standalone and unitary controllers supplied shall be in compliance with the following listings and standards:
  - a. UL916 for Open Energy Management (for U.S. and Canada)
  - b. FCC Part 15, Sub-Part B, Class A
  - c. CE Electro Magnetic Compatibility

1.4 GENERAL CONDITIONS

A. Correction of Work

1. Contractor's Responsibility. The Contractor shall promptly correct all work the Owner finds defective or failing to conform to the Contract Documents. The Contractor shall bear all cost of correcting such work.
2. During Warranty. If, within the warranty period required by the Contract Documents, any of the work is found to be defective in material or workmanship or not in accordance with the Contract Documents, the Contractor shall correct it promptly after receipt of notice from Owner to do so. Owner shall give notice promptly after discovery of the condition. Contractor shall notify owner within 24 hours of proposed corrections and schedule.

B. Coordination of Work During Construction

1. The Contractor shall protect the installed works by other trades.
2. The Contractor shall coordinate with other trades.
3. The Contractor shall repair any damage caused by his work to building(s) and equipment.
4. The contractor shall maintain functionality of all existing systems throughout the project.

C. Warranty: The Contractor shall warrant, from the date of final acceptance the Owner, that all systems, subsystems, component parts, application programs, and software are fully free from defective design, materials, and workmanship for a period of one year. Control System Hardware shall be warranted for a minimum period of two years.

1.5 SUBMITTALS, DOCUMENTATION, ACCEPTANCE AND TRAINING

**A. Submittals**

1. Shop Drawings. Shop drawings shall be submitted and shall consist of a complete list of equipment, software, materials, manufacturer's technical literature, cut-sheets, and installation instructions. Drawings shall contain proposed layout, complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, graphical sequence calculations, installation details, test and verification plan and any other details required to demonstrate that the system will function properly. Drawing Approval. Shop drawings shall be approved before any equipment is installed.
2. Proposed acceptance test procedure to be submitted to owner , engineer, commissioning agent for approval
3. As Built Drawings. All drawings, documentation and manuals shall be reviewed after the final system checkout and updated or corrected to provide 'as-built' drawings to show exact installation and configuration and programming. The system will not be considered complete until the 'as-built' documentation has received final approval.

**B. Documentation:** Operating and Maintenance (O&M) manuals for the system shall be made available electronically and in hard copy and include the following categories: User's Manual, Project Engineering Handbook, and Software Documentation. Submit four copies of system documentation directly after receipt of reviewed shop drawings.

1. BAS User's Manual shall contain as a minimum:
  - a. System overview
  - b. Networking concepts
  - c. Launching a web browser from a networked PC and login
  - d. Web Browser Graphical User Interface (GUI) screen menus and their definitions
  - e. Creating, modifying or deleting schedules
  - f. Uploading and downloading software to the field hardware
  - g. Creating historical trends, collecting trend data and generating trend graphs
  - h. Enabling and assigning alarms and messages to reporting actions/groups
  - i. Report generation and 'third party software'
  - j. Backing up software and data files
  - k. Creating, modifying or deleting control loop logic
2. Project Engineering Manual shall contain as a minimum:
  - a. System architecture overview and networking configuration
  - b. Hardware cut-sheets and product descriptions
  - c. The Contractor shall deliver 'as-built' drawings in accordance with Division 1. All drawings shall be reviewed after the final system checkout and updated to provide 'as-built' drawings. The system will not be considered complete until the 'as-built' drawings have received their final approval.
  - d. Installation, mounting and connection details for all field hardware and accessories
  - e. Commissioning, setup and backup procedures for all control modules/accessories, BAS server software, and database.
  - f. Listing of basic terminology, alarms/messages, error messages and frequently used commands or shortcuts.
3. BAS Software Documentation shall contain as a minimum:
  - a. The Contractor shall provide all Graphical Programs, detailing their application to specific HVAC equipment and electrical/mechanical subsystems, together with a glossary or icon symbol library detailing the function of each graphical icon. Revisions made as a result of the submittal process, during the installation, start-up or acceptance portion of the project, shall be accurately reflected in the "as-builts".
  - b. Graphical representation of the mechanical equipment hierarchy for the project including all equipment controlled by the BAS. For example: a VAV terminal box

- may be the source for increased cooling demand and require the primary VAV AHU to operate which, in turn, requires the chillers to operate.
- c. Detailed listing of all alarm and event messages programmed for designated mechanical/electrical equipment and required operator action.
- C. On Site documentation
1. At each controller provide a laminated diagram showing all connected control points, point naming, neuron i.d, and system name.
  2. At building main controller provide laminated diagram of entire controller network. Include device name, neuron id, and room location.
  3. Provide manual for local users describing method to access, monitor and schedule systems operation.
- D. Acceptance Test
1. Acceptance Testing. Upon completion of the installation, the Contractor shall start up the system and perform all necessary trending, scheduling calibration, testing, and debugging operations. The Contractor in the presence of the Owner's representative shall perform an acceptance test. Acceptance test procedure to be submitted, for approval no later than 4 weeks prior to testing. Submission of test procedure shall imply that systems are complete, functional and that contractor has verified performance. Successful completion of acceptance testing shall be required prior to substantial completion.
- E. System Training: For bidding provide \$20,000 allowance to provide following:
1. System Use Instructions: Controls Contractor shall provide full Computer Based Training (CBT) in addition to training of designated personnel in the operation, maintenance, and programming of the system.
    - a. Provide two four-hour sessions at the completed facility for basic graphical user interface training classes.
    - b. Provide factory training for six advanced graphic users and twelve system hardware technicians. Training sessions shall be a minimum of one week. Owner will provide cost of transportation, meals and lodging.
    - c. The contractor shall provide a detailed breakdown of costs for the specified training.
    - d. The contractor shall provide a credit back to the owner for any unused training.
    - e. No training above the initial allowance will be allowed without prior written authorization of the owner.

## PART 2 – PRODUCTS

2.1 MANUFACTURERS: Controls Contractors shall be factory authorized agent or dealer of control hardware and controls system interface.

### 2.2 BAS SERVER & WEB BROWSER GUI

#### 2.2.1 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-Windows 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 TCP/IP 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).

## 2.2.2 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. Zone Setpoint Adjustments: Color floor plans displayed via a web browser shall utilize a contiguous band of colors, as selected by Owner. Each corresponding actual zone temperatures shall vary color relative to the desired active setpoint. The ideal temperature shall be shown as a neutral (white, transparent) color band. Temperatures slightly warmer than ideal shall be shown in light red, and even warmer temperature band shall be shown in red. Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. Active Zone Graphic Setpoint Controls: Utilizing a mouse, it shall be possible to select occupied or unoccupied setpoints to increase or decrease heating and cooling setpoints. In addition, an operator may type the numeric value of the heating and cooling setpoints.
- G. 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.
- H. 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.
- I. 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).
- J. 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.

### 2.2.3 GRAPHICAL PROGRAMMING

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. 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.

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.

- A. **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.
  
- B. **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.

For each piece of HVAC equipment, the entire graphic program shall be displayed through the Web Browser GUI. The operator must have the ability to scroll or page through the entire 'live' graphic program as necessary. Piecemeal graphic programs that only show one part of HVAC equipment program at any one time are NOT acceptable. For example, when viewing an AHU live graphic program, the operator shall see as much of the AHU graphic program as practical, not just the Heating Coil control.

## 2.3 BAS SYSTEM HARDWARE

### 2.3.1 BAS SERVER HARDWARE

- A. Computer Configuration (Hardware Independent)
  - 1. Central Server. Owner shall provide a dedicated BAS server with configuration that includes the following components as a minimum:
  - 2. 1 GHz, PIII or higher CPU (or non-Intel platform equivalent to this) – Dual Processor
  - 3. 512Mb of RAM minimum.
  - 4. 10 gigabyte hard disk, 1.44M 3 ½" floppy drive, SVGA Card with 1024 x 768, 24-bit True Color, Back-up system 24X CD Rom Drive, SVGA Color Monitor, Keyboard and mouse
  - 5. Operating system for the server shall be Microsoft Windows XP or RedHat Linux 6.0.
  - 6. Internet Explorer 6.0 or later
  - 7. 10Base-T Ethernet Port
- B. Standard Client: The thin-client Web Browser BAS GUI shall be Microsoft Internet Explorer (6.0 or later) running on Microsoft 98, 2000, NT, XP. No special software shall be required to be installed on the PCs used to access the BAS via a web browser.

### 2.3.2 NETWORK ROUTERS & BRIDGES

The controller network shall use LonWorks as its native communication protocol. Network bridges and routers must be of a modular design to ensure reliability and system performance.

- A. The central system shall use the building Local Area Network (LAN) for communication. The communication between the Building level supervisory controller and the stand-alone controllers shall be LonWorks as the data link used between the controller's Proprietary protocols are NOT acceptable.
  - 1. Firmware Updates. The Building level supervisory controller shall allow firmware updates to be performed remotely.

### 2.3.3 STANDALONE CONTROLLERS

- A. General Purpose Multiple Application Controllers:
  - 1. General Purpose Multiple Application controllers must use LonWorks as the native communication protocol between controllers.
  - 2. General Specification. Each General Purpose Multiple Application Controller must be capable of standalone direct digital operation utilizing its own processor, non-volatile flash memory, input/output, and voltage transient and lightning protection devices. All non-volatile flash memory shall have a battery backup. Firmware revisions to the module shall be made from the BAS server or remotely over the Intranet or Internet. Controllers that require component changes to implement firmware revisions are NOT acceptable.
  - 3. Point Programming. All point data, algorithms and application software within a controller shall be custom programmable from the GUI.

4. Program Execution. Each General Purpose Multiple Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the BAS Server.
5. Self-Test Diagnostics. Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the BAS Server.
6. PID Loops. Each General Purpose Multiple Application Controller shall contain both software and firmware to perform full DDC Proportional, Integral, Derivative (PID) control loops and programs.
7. Digital Outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed
8. Universal Inputs shall be industry standard thermistors, rtd, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, 0-5vdc, dry contact - 0.5mA maximum current.
9. Analog Output shall be electronic, voltage mode 0-10VDC or current mode 4-20mA.
10. Enhanced Zone Sensor Input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator. The sensor shall provide a connection to the controller network for controller programming.

B. General Purpose Single Application Controllers

1. The General Purpose Single Application Controllers must use LonWorks as the native communication.
2. General Specification: General Purpose Single Application controllers must be capable of stand-alone DDC operation utilizing its own processor, nonvolatile flash memory, input/output, and voltage transient protection devices. Firmware revisions to the module shall be made from the BAS server or remote locations over the Internet. Controllers that require component changes to implement Firmware revisions are NOT acceptable.
3. Point Programming: All point data, algorithms, and application software within the controllers shall be custom programmable from the GUI.
4. Program Execution: Each General Purpose Single Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for the application program residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the database server.
5. Self-Test Diagnostics: Each controller shall include self-test diagnostics, enabling the controller to report malfunctions the BAS Server input.
6. PID Loops: Each General Purpose Single Application Controller shall contain both software and firmware to perform full DDC PID control loops.
7. Rooftop Mounting. The General Purpose Single Application Controllers shall be capable of being mounted directly in or on rooftop AHU equipment.
8. Operating Temperature. The General Purpose Single Application Controllers shall be capable of proper operation in an ambient temperature environment of -20°F to +150°F. (-28.9° to 65.6°C.).
9. Input-Output Processing:
10. Digital Outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed
11. Universal Inputs shall be industry standard thermistors, rtd, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, Dry Contact - 0.5mA maximum current.
12. Analog Electronic Outputs shall be voltage mode 0-10VDC or current mode 4-20mA.
13. Enhanced Zone Sensor Input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator. The sensor shall provide a connection to the controller network for controller programming.

- C. Unitary Controller Network (VAV TERMINALS)
1. Unitary Controllers
    - a. The Unitary Controllers shall use LonWorks as the native communications protocol between controllers on the unitary controller network.
    - b. Enhanced Zone Sensor Input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator. The sensor shall provide a connection to the controller network for controller programming.
    - c. Airflow Transducer. In order to provide reliable Pressure Independent VAV operation, Unitary Controllers for pressure independent VAV applications shall have airflow transducer for accurate air measurement.
    - d. Actuator. Each Unitary Controller for VAV applications shall have a direct coupled electronic actuator with the following features:
      1. The actuator shall provide on-off/floating point control with a minimum of 35 in-lb of torque, or greater if required due to terminal size or system pressure.
      2. The assembly shall mount directly to the damper operating shaft.
      3. The actuator shall not require any limit switches, and shall be electronically protected against overload.
      4. The actuator shall automatically stop when reaching the damper or actuator end position.
      5. A visual pointer for the position of the actuator.
      6. The assembly shall have an anti-rotational strap supplied with the assembly that will prevent lateral movement.
      7. The actuator may be an integral controller/actuator assembly or a matched controller/actuator pair
    - e. Visual Status. Each Unitary Controller and Unitary Controller Interface shall have LED indication for visual status of communication, power, and faults.
    - f. Standalone Algorithm. In the event of a loss of communication, each Unitary Controller shall control from a standalone algorithm, which maintains the assigned space temperature until communication with the Building level controller is restored.
    - g. Input/Output Processing:
      1. Digital outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, having a 1 Amp maximum current. Each relay shall be configured as normally open or normally closed, and provide a dry contact. Each unitary controller shall have a minimum of one spare programmable digital output.
      2. Universal inputs shall be dry contacts or 0-5VDC, 0-20ma dc or 0-20K Ohm input impedance.
      3. Enhanced Zone Sensor Input. The input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator. The sensor shall provide a connection to the controller network for controller programming.
      4. Analog output electronic, voltage mode 0-10VDC, current mode 0-20ma

#### 2.3.4 LOCAL OPERATOR KEYPAD DISPLAY

- A. Local Keypad Display (LOK)
1. General Purpose. Keypad and display shall be provided in each mechanical room. The LOK shall be capable of accessing 250 control parameters

2. Interface. The LOK shall comprise a minimum of four function keys and employ a backlit display for easy reading in poor lighting conditions. Each function key shall act as a 'hot-key' to menus comprised of control parameters. The display shall utilize English language descriptors rather than cryptic code and a menu penetration technique to access data. Clearly marked keys shall be used to move between menus and point descriptors listed in each menu. The LOK backlit display shall be a minimum 4 by 40 characters
3. Menu Language. The English language menus in the LOK shall be constructed using controller graphical programming language. Access to building control parameters shall be capable of being protected by a minimum of 2 levels of password entry.

- B. The specific control parameters for access at each LOK shall be coordinated as a submittal item.

### 2.3.5 BUILDING SYSTEMS INTEGRATION

- A. The BAS System shall establish a seamless interconnection with other building, electrical and/or mechanical subsystems as well as other manufacturers control systems using the LONTALK protocol. These systems shall be controlled, monitored and graphically programmed with the same Graphical Programming Language (GPL) used for all other control modules.
1. System Information. All system information and related documents shall be available to the BAS server.
  2. OEM Cooperation. Full cooperation by the Original Equipment Manufacturer (OEM) in this open protocol effort shall be a requirement for bidding this project.

### 2.3.6 FIELD HARDWARE/INSTRUMENTATION

- A. Input Devices:
1. Type & Accuracy. Temperature sensors shall be of the type and accuracy indicated for the application. Sensors shall have an accuracy rating within 1% of the intended use temperature range.
  2. Mixed Air Application. Sensors used for mixed air applications shall be the averaging type and have an accuracy of +1°F. (0.5°C). Sensors shall be of adequate length to accurately measure average temperature of coil or plenum area.
  3. Outside Air Temperature Sensors. Outside air temperature sensors accuracy shall be within +1°F. (0.5°C). Minimum operating span shall -50°F. to 150°F.
  4. Room Temperature Sensors. Room temperature sensors shall have an accuracy of +0.50°F. Minimum operating span shall 45°F. to 95°F.).
  5. Chilled Water and Condenser Water Sensors. Chilled water and condenser water sensors shall have an accuracy of +1.00°F. in their range of application. Minimum operating span shall be 0°F. to 125°F.
  6. Hot Water Temperature Sensors. Hot water temperature sensors shall have an accuracy of 1.0°F. Minimum operating span shall 0°F to 250°F.
- B. Pressure Instruments:
1. Differential Pressure and Pressure Sensors
  2. Pressure Switches
  3. Flow Switches
- C. Output Devices:
1. Control Relays
  2. Solid State Relays (SSR)
- D. Valve and Damper Actuators:
1. Electronic Direct-Coupled. Electronic direct-coupled actuation shall be provided.
  2. Actuator Mounting. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft.

3. Electronic Overload Sensing. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
4. Power Failure/Safety Applications. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
5. Spring Return Actuators. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.
6. Proportional Actuators. Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA control input and provide a 2 to 10VDC or 4 to 20mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is not acceptable.
7. 24 Volts (AC/DC) actuators. All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 20VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 20VA. Actuators operating on 230VAC shall not be acceptable.
8. Non-Spring Return Actuators. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators shall have a manual crank for this purpose.
9. Modulating Actuators. All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.
10. Conduit Fitting. Actuators shall be provided with a conduit fitting.
11. U.L. Listing. Actuators shall be Underwriters Laboratories Standard 873 listed.
12. Warranty. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a minimum 2-year manufacturer's warranty.
13. A single damper actuator shall operate no more than a four foot wide damper.

## 2.4 DDC SOFTWARE

### 2.4.1 OVERVIEW

The system shall continuously perform Direct Digital Control (DDC) functions at the local control module in a stand-alone mode. Using Graphical Programming, the operator shall be able to design and modify control sequence of operation and all tuning parameters.

- A. Minimum Function: Each control module shall perform the following functions:
  1. Identify, time/date stamp
  2. Execute all application programs specified
  3. Execute DDC algorithms
  4. Trend and store data
- B. Control Failure Mode: In the event of a control module failure, all points under its control shall be commanded to the failure mode. All DDC software shall reside in the respective control module.
  - a. Orderly Shutdown. Power failures shall cause the control module to go into an orderly shutdown with no loss of program memory.
  - b. Automatic Restart. Upon resumption of power, the control module shall automatically restart and print out the time and date of the power failure and restoration at the respective Workstation system.
  - c. Automatic Restart. The restart program shall automatically restart affected field equipment. The operator shall be able to define an automatic power up time delay for each piece of equipment under control.

## 2.5 APPLICATIONS SOFTWARE

### 2.5.1 GENERAL

All software application algorithms described below MUST reside at the local Building/Area level, Multi-Application, Single-Application, or Unitary Controller level. Systems that rely on a workstation PC, server or router to perform these functions are NOT acceptable. The following applications software shall be provided for the purpose of optimizing energy consumption while maintaining occupant comfort:

- A. Time of Day Scheduling (TOD): The system shall be capable of the following scheduling features:
  - 1. Schedule by Type. Scheduling by building, area, zone, groups of zones, individually controlled equipment and groups of individually controlled equipment. Each schedule shall provide beginning and ending dates and times (hours: minutes). A weekly repeating schedule, i.e. between 8:00 a.m. and 5:00 p.m., Monday through Friday shall constitute one schedule.
  - 2. Schedule in Advance. Dated schedules shall be entered up to 9 (nine) years in advance.
  - 3. Self-Deleting. Schedules shall be self-deleting when effective dates have passed.
  - 4. Leap Year. Leap years shall be adjusted automatically without operator intervention.
  
- B. Optimum Start/Stop (OSS)/Optimum Enable/Disable (OED): This application provides software to start and stop equipment on a sliding schedule based on the individual zone temperature and the heating/cooling capacity in °F. /hour of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable. Temperature compensated peak demand limiting shall remain in effect during morning start up to avoid setting a demand peak.
  
- C. Demand Limiting (DL) - Temperature Compensated: The DL application shall be capable of four separate times of day KW demand billing rate periods. The system shall be capable of measuring electrical usage from multiple meters serving one building and each piece of equipment being controlled on the LAN shall be programmable to respond to the peak demand information from its respective meter.
  - 1. Sliding Window. The demand control function shall utilize a sliding window method. The sliding window interval and increment shall be operator selectable in increments of one minute, up to 60 minutes.
  - 2. Setpoints for Defined Demand Level. The operator shall have the capability to set a initial setpoint and a maximum setpoint for each demand period. The initial setpoint shall automatically increase by a user defined increment if the electrical demand is above setpoint and all loads have been shed. The setpoint shall only increase to the maximum setpoint value.
  - 3. The DL program shall be capable of issuing digital commands in either a sequential or rotating sequence to shed electrical loads.
  - 4. Information Archiving. The system shall have the ability to archive demand and usage information for use at a later time. System shall permit the operator access to this information on a current day, month to date and a year to date basis.
  
- D. Unoccupied High/Low limit: The system shall allow the space temperature to drift down [up] within a preset [adjustable] unoccupied temperature range. The heating [cooling] shall be activated upon reaching either end of the High/low limit range and shall remain activated until the space temperature returns to the High/low limit range.
  - 1. Outside & Exhaust Air. The system shall close all outside air and exhaust air dampers and stop all exhaust fans during the unoccupied period
  - 2. Unoccupied Space Temperature. Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room.

3. Parameter Changes. Operator shall be able to define, modify or delete the following parameters.
  - a. Unoccupied High/Low limit setpoint temperature(s)
  - b. Temperature band for Unoccupied operation
- E. Timed Local Override (TLO): The system shall have TLO input points that permit the occupants to request an override of equipment that has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button (momentary contact). Equipment on Time: If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse. The system shall maintain a log of override usage. The log shall include, date, time and area of override.
- F. Space Temperature Control (STC): There shall be two space temperature setpoints, one for cooling and one for heating, separated by a dead band. Only one of the two setpoints shall be operative at any time. The cooling setpoint is operative if the actual space temperature has more recently been equal to or greater than the cooling setpoint. The heating setpoint is operative if the actual space temperature has more recently been equal to or less than the heating setpoint. There are two modes of operation for the setpoints, one for the occupied mode (example: heating = 72°F. or 22°C., cooling = 76°F. or 24.4°C.) and one for the unoccupied mode (example: heating = 55°F. or 12.7°C., cooling = 90°F. or 32°C.)
- G. Schedule. The occupied/unoccupied modes may be scheduled by time, date, or day of week.
- H. Color Code. Colors shall be generated to represent the comfort conditions in the space, and shall be displayed graphically at the operator station. (Discuss colors)
  1. If the actual space temperature is in the dead band between the heating setpoint and the cooling setpoint, the color displayed shall be white for the occupied mode, representing ideal comfort conditions. If in the unoccupied mode, the color displayed shall be gray representing 'after-hours' conditions.
  2. If the space temperature rises above the cooling setpoint, the color shall change to light red. Upon further rise beyond the cooling setpoint plus an offset, the color shall change to red. When space temperature falls below the heating setpoint, the color shall change to light blue. Upon further temperature decrease below the heating setpoint minus an offset, the color shall change to dark blue.
- I. Operator Definable. All set points and offsets shall be operator definable. When in the occupied mode, start-up mode, or when heating or cooling during the night setback unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.
- J. Optimum Start. An optimum start-up program transitions from the unoccupied set points to the occupied set points. The optimum start-up algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope (AI: Space Temperature).

## 2.6 FIELD SENSORS AND DEVICES

- 2.6.1 GENERAL: Provide all remote sensing points and instrumentation as required for the systems. All sensors shall have accuracies as stated.
- 2.6.2 FIELD WIRING for each digital device shall be two or three conductor No. 18 AWG, or larger twisted sets of copper conductors 300 volts, thermoplastic. When line voltage is present in conduits or wiring trays the insulation on all conductors shall be 600 volts. For multi-conductor wire having four or more conductors, wire size shall be not less than No. 20 AWG solid copper. Concealed accessible wiring may be installed as properly supported cable. Provide protective sleeves at wall and floor penetrations. Concealed inaccessible locations and mechanical rooms shall have wiring installed in properly sized conduit.
- 2.6.3 SAFETY/STATUS SWITCHES
- A. Snap action SPDT switches shall operate from a neoprene slack diaphragm, corrosion-resistant stainless steel diaphragm or copper diaphragm capable of being adjusted through the total pressure range. Switches shall withstand at least twice the working pressure of the system including any standing head, and have a temperature range exceeding the worst case liquid and ambient temperature range conditions. Provide a NEMA 4 enclosure for the switch assembly. For ease of service and maintenance, install the switch with a 3 valve manifold piped in copper to pressure taps in the liquid lines.
  - B. Current sensing relay shall be used for pump motor status. The current sensing relay shall be adjustable within three ranges; .1-6amps, 6-40amps and 40-200amps. Contact rating shall be .15amps at 30VDC.
  - C. Differential air pressure switches shall be piped in parallel across fans for positive indication of flow. Static pressure sensing tips shall be used for both high and low inputs. Pressure range shall be adjustable between .07 and 1.0" W.C. Snap acting contact shall be rated at 300 VA at 120 VAC.
- 2.6.4 SENSOR ACCURACY

Sensors are only one element in the overall system accuracy to which the CU can respond. That response includes alarm decision, value display, value calculation on which analog values must be multiplied, subtracted, square rooted, etc. As such, the system end-to-end accuracies are herein stated.

Sensors that have a tendency to drift with age shall be supplied with self-correcting circuits. The following range/ accuracies are required:

- ± .5 for the air temperatures.
- ± 1.0 for water temperatures.
- ± 0.5 for water temperatures in the range 40 - 55 F.
- KWH and KW monitoring within 1.0% of full scale value.
- ± 2.0 psig for water or steam pressure in the range of 0 - 200 psig.
- ± 1.0% of full scale value for potential or current transducers.
- ± 3.0% for 0-100% RH,

Sensors for differential temperature readings to be used in BTU calculations shall be a matched pair with a differential accuracy of plus or minus 0.1 degrees F.

- A. Space Temperature Sensors in corridor areas shall have a temperature range of -40 to 160 degrees F. The sensor shall be stainless steel plate with a thermistor thermally bonded to back, with fully insulated gasket and nylon mounting screws.
- B. Duct Temperature Sensors shall have an insertion measuring probe 6 inches long with a temperature range of -40 to 250 degrees F. The sensor shall include a utility box and gasket to prevent air leakage and vibration noise. For all mixed air and coil discharge air applications, install bendable averaging duct sensors with a minimum 5 foot long sensor element. Element shall provide adequate coil coverage.
- C. Liquid Immersion Temperature Sensors shall have a temperature range of -40 to 250 degrees F.
- D. Outside Air Temperature and Humidity Sensors (separate devices) shall be mounted in the outdoors where natural air flow occurs, away from any artificial affect from mechanical sources. The temperature range shall be -40 to 220 degrees F. the humidity sensor span shall be 0 – 100% RH. The sensors shall be independent devices, designed for exterior application; provide all required shielding.
- E. Duct Relative Humidity Sensors shall be duct-mounted devices that produce a linear output over the complete range of 0-100% RH. A thin film polymer sensing element shall respond quickly to changes in humidity and shall be protected from contamination by a sintered filter. The sensor shall be factory calibrated with periodic field recalibration capability. The sensor shall be mounted in a duct probe assembly and be installed only after the construction or renovation area is free of contamination.
- F. Space Relative Humidity Sensors: The sensor shall be an analog precision capacitance type relative humidity detector. Sensing element shall be rated for the relative humidity range 0-100%.

#### 2.6.5 TEMPERATURE AND HUMIDITY SENSORS

- A. Temperature Sensors: The following shall apply to temperature sensors:

Stem or tip sensitive types.

Sensing elements shall be hermetically sealed.

Stem and tip construction shall be 304 stainless steel.

All external trim material shall be corrosion resistant designed for the intended application.

Thermometer wells shall be stainless steel. Heat transfer compounds shall be compatible with the sensors. All piping system sensors shall be installed in thermowells.

#### 2.6.6 PRESSURE

- A. Air pressure transmitter shall universally measure very low static or differential pressure using a variable capacitance technique. Static pressure shall measure in ranges from 0 to 10 inches water column. Operating pressure span and either unidirectional or bidirectional measurement shall be field selectable. Transmitter accuracy, including non-linearity, hysteresis and

non-repeatability shall be within 1% of full scale. Pressure transducers shall have LCD display.

2.6.7 POWER METERING:

- A. Electrical demand shall be from pulsing dry contacts provided by Owner and installed by the Utility Company at the power meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the Utility Company.
- B. Gas usage in cubic feet per hour shall be from pulsing dry contacts provided by the Utility Company at the gas meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the utility company.
- C. Water usage in gallons per hour shall be monitored from pulsing dry contacts provided by installation of a water meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the water meter. The water meter shall be equal to DLJ water meter with contact head and registers.

2.6.8 SURGE AND LIGHTNING PROTECTION

- A. Line voltage protection: The CUs shall be powered by 120 VAC circuits provided with surge protection. This protection is in addition to any internal protection provided by the manufacturer. The protection shall be a 40-120s manufactured by MCG surge protection Inc. or an approved equal. The protector shall have power and protection illuminated indicators. The unit shall be warranted for 10 years. For all CU locations with telephone modem, a DLP4.9-60 (as manufactured by MCG surge protection or equal) shall be used to provide telephone line protection. A grounding conductor, (minimum 12 awg), shall be brought to each control panel from either a system grounding point or the ground bus in a breaker panel. Conduit grounds will not be acceptable.
- B. Inter-unit Communications: All panel to panel data networks that are routed outside or between buildings shall be protected by a DLP-20G-6V5 (as manufactured by MCG surge protection or equal). The protection device shall match the voltage levels of the inter-unit communications network.

2.6.9 FINAL CONTROL ELEMENTS AND OPERATORS

- A. Valves: Controls subcontractor shall be responsible for selection of the proper control valves including line size, pressure rating, flow-coefficient, shutoff rating and allowable leakage factor. Valves 2 1/2 inches and larger shall have minimum 125 psig cast-iron body and shall have stainless steel stems and Flanged connections with field replaceable packing. Valves smaller than 2 1/2 inches shall be constructed of brass with screwed connections, stainless steel stems and field replaceable packing. Ball Valves 2" and less shall have forged brass or bronze bodies rated for a minimum 250 psi, bronze or reinforced Teflon®seats, equal percentage flow characteristics in 2-W applications, liner or constant flow in 3-W applications, a spring loaded Teflon®, EPDM or dual EPDM o-ring packing, and stainless steel or brass stems. Butterfly valves shall have a fully lugged, drilled and tapped, cast iron body. Flanges shall meet ANSI 125/150 standards. The one-piece body shall have an extended neck allowing clearance for flanges and piping insulation. The disc shall be stainless steel and provide bi-directional bubble-tight close off in either direction. The flow characteristic shall be modified equal percentage for 2-way and linear for 3-way valves. Furnish a cartridge type, non-collapsing, EPDM seat. The disk shall have full 360-degree concentric seating. The shaft shall be supported at multiple (minimum three) locations. No gaskets shall be required between the valve and flange faces. Three-way butterfly valves shall utilize independent actuators for each valve body; connecting linkage is not acceptable.
- B. Maximum Pressure Drop through Valve:
1. Modulating Water Flow Control: Greater of 10 feet of water or the pressure drop through the apparatus.
  2. Two position water valves shall be line size.
- C. Dampers: Control dampers shall be opposed blade (except where two-position action is indicated) with interlocking gasketed edges, jamb seals and ball type oilite bearings. Blades and frames shall have galvanized finish. Frames shall not be less than 5" X 1/2" X 16 gauge channel iron and shall be reinforced to form a rigid assembly. Blades shall be 16 gauge with maximum blade width of 10".
- Dampers over four feet high or wide, or over 16 sq. ft. shall be built in two or more sections with interconnections on every other blade. Gasket material shall be molded neoprene or approved equal. Damper leakage shall not exceed 6.0 CFM/SF at 1" SP, fully closed.
- D. Actuators: Actuators shall be electronic, low voltage (24 VAC/VDC), NEMA 2 rated for all applications. Two- position may utilize 120 VAC actuators. Actuators shall have UL, CSA and ISO 9001 certification and approvals. Actuators shall have a minimum operating range of -22° to 122°F. Optional auxiliary switches shall be available if required by the sequence. Actuators shall be fully modulating/proportional, floating/tri-state, or two-position as required. Pulse width modulation is unacceptable. Actuators shall have visual position indicators. Proportional actuators shall be field programmable to operate in sequence with other devices without additional transducers. All actuators except two-position shall be capable of providing a constant rotation rate independent of the load. Actuators used on dampers or valves shall be designed to directly couple to a stem, shaft or ISO style-mounting pad. Damper actuators or damper actuators adapted for use with control valves shall utilize V-bolt toothed V-clamp shaft fastening technique. Single point, bolt, or single screw type shaft fastening techniques for circular or round damper or valve shafts is unacceptable.
- E. Computer generated Mylar labels shall be provided so as to properly identify all control components.

#### 2.6.10 VARIABLE VOLUME TERMINAL CONTROL UNIT

- A. Provide PID control for damper and valve control.
- B. The Room Sensor for VAV terminal units shall have a digital display of room temperature and setpoint, set-point adjustment and push button override with status indicator.
- C. The VAV terminal unit discharge sensor shall be an insertion type probe.

2.6.11 CO2 SENSORS

- A. CO2 sensor shall utilize Non-dispersive infrared technology (NDIR) repeatable. Sensor repeatability shall be +/- 20 ppm. 0-2000. Sensor accuracy shall be <= 75 ppm over 0-1500 ppm range. Sensor shall employ reference channel design for long-term stability. Field-selectable 4-20mA/0-5V/0-10V output with LCD display equal to Veris CD series.

2.6.12 AIR FLOW MONITORING STATIONS

- A. **ACCEPTABLE MANUFACTURERS**  
 Subject to compliance with requirements of this Section, provide products that comply with this specification by one of the following vendors:
  - 1. EBTRON, Inc. Model GTL116-PC (basis of design)
  - 2. Alternatives requesting acceptance as "equals" less than 60 days prior to bid date or products submitted in non-conformance with the requirements of this specification will not be considered.
    - a) For any product to be considered for substitution a written section-by-section detailed exceptions/compliance document shall be submitted to the Engineer before any approval will be considered.
- B. **AIRFLOW/TEMPERATURE MEASUREMENT DEVICES**  
 Provide airflow/temperature measurement devices (ATMD) where indicated on the plans.
  - 1. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices indicated on the plans.  
 Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.
    - 1. Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
    - 2. Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
    - 3. The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.
    - 4. The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.
    - 5. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.
    - 6. Devices using chip-in-glass or diode-case chip thermistors are not acceptable.
    - 7. Devices using less than two thermistors in each sensor assembly are not acceptable.
    - 8. Devices using platinum wire RTDs are not acceptable.
    - 9. Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
    - 10. Pitot tubes and arrays are not acceptable.

11. Vortex shedding devices are not acceptable.
- C. All Sensor Probes
1. Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.
  2. Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
  3. Airflow accuracy shall be +/-2% of Reading over the entire operating airflow range.
    - a) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
  4. Temperature accuracy shall be +/-0.15° F over the entire operating temperature range of -20° F to 160° F.
  5. The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
  6. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
  7. Each sensor assembly shall not require matching to the transmitter in the field.
  8. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

D. Duct and Plenum Probes

1. Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
2. Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
  - a) Insertion mounted through the side or top of the duct
  - b) Internally mounted inside the duct or plenum
  - c) Standoff mounted inside the plenum
3. The number of sensor housings provided for each location shall be as follows:

Duct or Plenum Area (sq.ft.)	Total # Sensors / Location
<2	4
2 to < 4	6
4 to < 8	8
8 to <16	12
>=16	16

4. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

E. Transmitters

1. The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.
2. The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.
3. The transmitter shall have a power switch and operate on 24 VAC (isolation not required).

- a) The transmitter shall use a switching power supply fused and protected from transients and power surges.
- b) The transmitter shall use “watch-dog” circuitry to assure reset after power disruption, transients and brown-outs.
- 4. All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.
- 5. The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be installed at a location that is protected from weather and water.
- 6. The transmitter shall be capable of communicating with other devices using the following interface options:
  - a) Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)
  - b) LonWorks Free Topology
  - c) The ATMD shall be UL listed as an entire assembly.
- 1. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer’s placement requirements.

F. **INSTALLATION**

- A. Install airflow / temperature measurement devices in accordance with manufacturer’s instructions at the locations indicated on the plans.
  - 1. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.
- B. Install labels and nameplates to identify control components.

G. **ADJUSTING**

- A. Duct and plenum devices shall not be adjusted without approval from the consulting mechanical engineer.

2.6.13 **WATER FLOW METERING**

- A. Provide Water Flow meters equal to Onicon F-1210 Dual Turbine.

2.6.14 **WATER DIFFERENTIAL PRESSURE SENSOR**

- A. Sensor shall have three switch selectable ranges: (5, 10, 25, 50)
- B. Sensor shall have test mode to produce full-scale output automatically.
- C. Sensor shall have provision for zeroing by pushbutton or digital input.
- D. Sensor shall have field selectable outputs of 0-5v, 0-10v, and 4-20ma.
- E. Sensor shall have two pressure sensors.
- F. Sensor shall operate from 24vdc or 24vac. (AC power applies to operation in voltage mode only)
- G. Sensor housing shall be powder-coated steel.

- H. Sensor shall have NEMA 4 rating.
- I. Sensor shall have a port swap feature.
- J. Sensor accuracy shall be +/-1% FS combined linearity, hysteresis, and repeatability.
- K. Sensor overpressure ratings shall be 2x max. FS range proof and 5x max. FS range burst.
- L. Sensor shall be provided with LCD display.

Provide pressure differential transmitter equal to Veris PWL-N-04 with Kele BVA enclosure. Provide pressure gauge upstream and downstream of transmitter.

## 2.7 MISCELLANEOUS CONTROLS

### 2.7.1 LIGHTING CONTROL

The Control Subcontractor shall provide the number of outputs for lighting control as indicated on the drawings. These loads will be controlled based on time-of-day and special scheduling supplied by Owner. The Control Subcontractor shall also connect to a dry contact point in the school's security system. The Control Subcontractor shall provide all wiring between the DDC system and the light and security contact. All power wiring to lighting contacts shall be by the Electrical Contractor. Lighting and security contact are supplied by others.

### 2.7.2 FIRE ALARM

Smoke detectors are supplied and wired by Electrical Contractor. Electrical Contractor shall supply and install a relay near each motor controller to shut down the unit. Central fire alarm panel shall be provided with one contact output to the DDC system to indicate system trouble or alarm. Wiring required for alarm points shall be provided by the Control Subcontractor.

### 2.7.3 MAINTENANCE MANAGEMENT

The DDC system shall measure and record run time for all start/stop points in the system. Based upon the accumulated run time provide maintenance messages on the interval recommended by the equipment manufacturers.

Any digital input point that is used for maintenance purposes (i.e. Fan Status) shall also generate a maintenance message.

### 2.7.4 TROUBLE ALARMS

The Control Subcontractor shall establish a trouble high and trouble low alarm limit for each analog input and annunciate a corresponding alarm message.

### 2.7.5 MODIFICATION

All software setpoints, limits, alarms, messages, schedules, sequences, etc., as specified herein are to provide an initial setup of the control system. The Control Subcontractor shall provide software customization that may be required to adapt the DDC system to accurately respond to actual building

parameters and installed equipment. Further, these software functions shall be readily modifiable by the Owner's personnel as changes in building operation dictate.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. General: Work schedule shall be in accordance with Division 1.
- B. Wiring: The term wiring is construed to include furnishing of wire, conduit, miscellaneous material and labor to install a working system. Outdoor installations shall be of weatherproof construction or in NEMA 3R or 4 enclosures. Wiring shall be yellow jacketed No. 18 TSP for inputs and outputs. Wiring shall be purple jacketed No. 18 TSP or Cat 5 for communication bus.
- C. Routing: Except for short apparatus connections, run conduit parallel to or at right angles to the building structure. Conceal conduit in finished spaces. Do not run conduit concealed under insulation or inside ducts. Mount control devices, and conduit located on ducts or apparatus with external insulation on stand-off support to avoid interference with insulation.

Run wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing. Rack connections bridging a cabinet door along the hinge side and protect from damage.

- D. Field Materials:
  - 1. Sensors and Controls: Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity. Label or code each field wire at each end. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
    - a. Temperature sensors: Temperature sensors shall be readily accessible and adaptable to each type of application in such a manner as to permit for quick, easy replacement and servicing without special tools or skills. Mount duct sensors in locations to sense the correct temperature of the air only, within the vibration and velocity limits of the sensing element. Mount extended surface element, when used, securely within the duct and position to measure the best average temperature. Thermally isolate elements from brackets and supports to respond to air temperature only. Securely seal duct penetrations. Install pipe sensors in top of pipe for horizontal runs and at a positive slope on vertical runs to prevent condensation from flowing to sensor head.
    - b. Temperature sensing elements installed in liquid systems shall be installed in thermowells.
    - c. Relative humidity sensors shall have air guards when installed in air flows of more than 15 meters per minute across the sensor element.
    - d. Pressure Instruments:  
Pressure sensors (all types) installed on liquid lines shall have drains. Pressure sensors installed on steam lines shall have drains and siphons. All pressure sensors shall have valves for isolation, venting, and taps for calibration. Pressure sensors shall be verified by calibration. Differential

pressure sensors shall have nulling valves. Pressure switches (all types) installed on liquid lines shall have drains. Pressure switches installed on steam lines shall have drains and siphons. All pressure switched shall have valves for isolation, and taps for calibration. Pressure switches shall be adjusted to proper setpoint, and shall be verified by calibration. Differential pressure switches shall have nulling valves. Switch contact ratings and duty shall be selected for the application. The duct static-pressure sensing element, (tap or pitot tube), shall be located approximately two-thirds of the distance from the supply fan to the end of the duct with the greatest pressure drop. Do not locate adjacent to branches, transitions, elbows, etc. Provide taps for transmitter calibration.

- e. Install potential and current transformers in NEMA enclosures. Current transformer leads shall be shorted when they are not connected to the measurement circuits.
- f. Install relays and contactors in NEMA enclosures. H-O-A switches and override switches shall be installed so that controls function through the automatic position. Safety and fire or life safety interlocks shall function through both hand and automatic switch positions.
- g. Damper Actuators:  
Outside air, return air, and relief dampers shall have individual actuators unless installed on factory assembled mixing boxes.  
Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

E. Signal Transmission System Equipment:

- 1. General: Install all system components in accordance with the National Electrical Code and the manufacturer's recommendations; fuse and ground them properly.
  - a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
  - b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 12 inches long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.
  - c. Cable Runs: Keep cable runs as short as possible. connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter. Use vinyl tape, sleeves, or grommets to protect cables from abrasion or damage. Allow extra length for vibration at points where they pass around sharp corners, through walls, and panel cabinets.
  - d. Grounding: Ground system per manufacturer's requirements for proper and safe operation.

F. Field Test and Inspections

- 1. System Equipment: Upon completion of installation of each piece of equipment, field-inspect and mechanically and electrically test equipment for proper function.

2. Field Materials: Upon completion of installation of each piece of equipment, field-inspect and mechanically and electrically test equipment for proper function.
3. Signal Transmission System Equipment:
  - a. Ground Rod Tests: Before any wire is connected to the ground rods, use a portable ground testing instrument to test each ground or group of grounds.

G. Graphics Content:

1. Floor plans
  - a. Show overall floor plan, with major zones defined
  - b. Links: Floor plan of each major HVAC zone, Main heating /cooling plant, demand limiting, service screen, miscellaneous point screen (domestic HW, lighting, etc.)
  - c. Display points: status all major zones, status of heat/cooling plants, current electrical demand,
  - d. Edit, Override values: override occupancy of entire building, master space setpoint override,
  - e. Sequence of operations
2. Zones
  - a. Show large scale floor plan with all rooms; indicate areas of temperature control and sensor location. Room number shall be shown. Show small scale key plan
  - b. Links: main floor plan or other zones (from key plan), heat/cool plants, AHU, VAV terminals (from zone floor plan).
  - c. Display points: space temperatures, zone occupancy command,
  - d. Edit, Override values:
  - e. As-built Sequence of Operations
3. Main heating/cooling plant
  - a. Show each system depicting major elements (pumps, boilers chillers, etc), piping and interconnections. Graphic should represent as-built condition of system.
  - b. Links: Main floor plan, heating to cooling, cool to heat, VFD, boiler detail, chiller detail.
  - c. Display points: status, command, and alarm condition of each item of equipment, VFD shall display commanded status and speed, actual speed and alarm condition, all temperatures, flow in gpm if specified for project.
  - d. Edit, Override values:
  - e. As built Sequence of operations
4. Variable Frequency Drives
  - a. For LONworks connected VFD
  - b. Links: main floor plan, heat/cool plant
  - c. Display points: all drive configuration properties, speed setpoint, drive speed, drive current, drive power, drive run hours, drive status drive fault reset, reset counters,
  - d. Provide ability to modify drive input variables.
  - e. Edit, Override values:
  - f. As-built Sequence of operations

5. Air Handling Units
  - a. Show all components of system,
  - b. Links: Floor plan of HVAC zone, Main heating /cooling plant, demand limiting, service screen,
  - c. Display points: status all control points, temperatures of heat/cooling plants, current electrical demand, active setpoints, economizer mode
  - d. Edit, Override values: override occupancy of zone, edit/override setpoints
  - e. As-built sequence of operations
  
6. Service Screen
  - a. Provide table type screen with active points to force operations:
  - b. Force all heating or cooling valves 100% open (2 points)
  - c. Force all terminals to max and min (schedule value) flow. 1 point per air handling unit system.
  - d. Display totalized VAV flows 1 point per air handling unit
  - e. Force all outdoor air dampers closed.
  
7. Miscellaneous LONworks devices:
  - a. Provide table type screen containing all Lonmark required variables.
  - b. Submit list of optional variables with proposed displayed variables for approval.
  
8. Override summary:
  - a. Provide table type screen showing most recent override values.
  - b. Provide link to trended override values.

END OF SECTION 15975