PART 1 - GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include but not necessarily be limited to the following:
1. Submit shop drawings of the entire control system components fully coordinated with major equipment suppliers' requirements. Provide proposed programming logic sequences of control functions on each system.
2. Installation of control components other than valves, dampers and sensing wells as required for a complete and workable system.
3. This Contractor shall furnish, install and coordinate the interlock and control wiring as specified and/or required for a complete and workable control system.
4. Controls dampers are specified and furnished in Section 233113 of these specifications. Provide damper actuators, wiring and conduit as required to operate all dampers as shown.
5. Upon completion of the installation, data entry and programming, provide complete validation and adjustment of specified control system through period of testing and Owner’s acceptance. The control contractor shall perform a point-to-point check out of all newly installed points to verify point existence, proper end to end connection and correct SI units with the Owners Representative.
6. The entire program and sequence of operation with the final points list shall be verified by the Control Contractor, the Owners Representative, and signed by both parties. A copy of the final program, sequence of operation, and points list shall be submitted to the Engineer for approval and inclusion with the operation and maintenance manuals.
7. Owner training on operation of the control system.
8. One-year warranty on workmanship and materials.
9. Interlocking of electrical systems and motors as shown on Drawings, except where specifically shown on electrical drawings.

1.3 RELATED WORK IN OTHER SECTIONS

A. Refer to Division 0 and Division 1 for related contractual requirements.

B. Provide certificates of calibration for all sensors required for control and monitoring including temperature and pressure.

C. Refer to Division 23 and the following sections for Mechanical or Electrical Provision.
1. Section 013300: Submittal Requirements
2. Section 230500: Basic HVAC Materials and Methods

3. Section 230593: Testing, Adjusting, and Balancing
4. Section 230901: Laboratory Airflow Control System
5. Section 230902: Variable Frequency Drives
6. Section 232113: HVAC Piping
7. Section 233113: Air Distribution
8. Section 237312: Custom Factory Air Handler
9. Division 26 – Electrical Materials and Methods
10. Division 28 – Electronic Safety and Security

D. Refer to Division 26 sections for Electrical Provisions. Sources of 120-volt electrical power as indicated on the electrical drawings and specifications for control system components furnished by this section. The controls contractor shall be responsible for all additional electrical distribution from these connection points to the control panels and other controls devices.

E. BAS contractor will furnish, but not install the following:
1. Air flow measuring stations: furnish to mechanical installer and coordinate per manufacturer's requirements.
2. Flow meters: furnish to mechanical installer and coordinate per manufacturer's requirements.
3. Flow switches: furnish to mechanical installer and coordinate per manufacturer's requirements.
4. Hydronic pressure and temperature sensor wells: furnish to mechanical installer and coordinate per manufacturer's requirements.
5. Control valves: furnish to mechanical installer and coordinate per manufacturer's requirements.

1.4 REFERENCE STANDARDS

A. Comply with all San Diego State University Campus Mechanical Standards For New Construction and Renovation Capital Projects Standards.

B. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
2. ANSI/ASHRAE Standard 135-2012, Lonworks.
3. California Building Code (CBC).
4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
5. California Electrical Code (CEC).
6. FCC Part 15, Subpart J, Class A.
7. EMC Directive 89/336/EEC (European CE Mark).
8. UL-864 UUKL listing for Smoke Controls for any equipment used in smoke control sequences.

C. State and federal regulations and codes in effect as of contract date.

D. Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work, and arrange for necessary approvals by the governing authorities.

1.5 WORK INCLUDED

A. Furnish a distributed logic Lonworks.-based control system, including a Windows 7 Professional, Windows Server 2008 R2 or SQL Server 2008 R2-compatible operator's workstation. The operator's workstation, all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2012, Lonworks. Provide all necessary Lonworks compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.

B. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.

C. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.

D. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.

E. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.

F. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

G. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.

H. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.

I. Provide a comprehensive operator and technician training program as described herein.

J. Provide as-built documentation, operator's terminal software, a software key for one additional computer, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

K. Provide new sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.

1.6 SYSTEM DESCRIPTION

A. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2012, Lonworks and achieved listing under the Lonworks. Testing Laboratories Lonworks - Advanced Workstation Software (B-AWS). This system is to control all mechanical equipment, including all unitary equipment such as VAV boxes, fan-coils, etc., and all air handlers, boilers, chillers,

and any other listed equipment using native Lonworks-compliant components. Non-Lonworks-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

B. Operator's workstation software shall use Windows 7 Professional, Windows Server 2008 R2 or SQL Server 2008 R2 as the computer operating system. The Energy Management and Control Lonworks protocols. Software functions delivered on this project shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, after-hours billing program, demand limiting, and a full suite of field engineering tools including graphical programming and applications.

C. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator's terminal. Operator's terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.

D. All application controllers for every piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller through Lonworks LAN.

E. Room sensors shall be provided with digital readout that allow the user to view room temperature, CO2 or relative humidity, adjust the room setpoint within preset limits and set desired override time. User shall also be able to start and stop unit from the digital sensor. Include all necessary wiring and firmware such that room sensor includes field service mode. Field service mode shall allow a technician to balance VAV zones and access any parameter in zone controller directly from the room sensor. Field service mode shall have the ability to be locked out.

1.7 APPROVED MANUFACTURERS

A. The base bid for controls shall be the Lonworks system. Approved BAS Manufacturers/Contractors include:
   1. Distech or approved equal
      As installed by an authorized Distech system integrator

1.8 QUALITY ASSURANCE

A. The BAS shall be designed, installed, commissioned, and serviced by contractor authorized and trained personnel. System provider shall have an in-place support facility within two (2) hours response time of the site with technical staff, spare parts inventory, and necessary test and diagnostic equipment.

B. The manufacturer and installer shall have a minimum of 5 years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project. A list of successful past projects of similar type, size and complexity shall be submitted. In addition, a reference list of names, addresses and telephone numbers of the design Engineer and the Owner's representative for each installation shall be provided. The references may be contacted and questioned about the timely delivery, installation,

operation and service received for each installation.

C. The contractor shall provide experienced project manager for this work, responsible for direct supervision of the design, installation, start-up and commissioning of the BAS system.

D. The Bidder shall be regularly engaged in the design, installation and maintenance of BAS systems and shall have demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project. Bidders shall provide a list of at least 10 projects, similar in size and scope to this project completed within the past 3 years.

E. Materials and equipment shall be manufacturer's latest standard design that complies with the specification requirements.

F. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.

G. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

H. Control system shall be engineered, programmed and supported completely by representative's local office that must be within 100 miles of project site.

I. Control components shall be products of the same manufacturer only, unless indicated otherwise and approved by Owner's representative. Example – all valves shall by one manufacturer and all temperature sensors shall be by one manufacturer.

1.9 SUBMITTALS

A. Drawings
1. The system supplier shall submit point-to-point engineered drawings, control sequence, and bill of materials for approval.
2. Drawings shall be submitted in a standard size of 11" x 17" (ANSI B), as a minimum.
3. Eight complete sets (copies) of submittal drawings shall be provided.
4. Drawings shall be available on CD-ROM.

B. System Documentation
1. Include the following in submittal package:
a. System configuration diagrams in simplified block format.
b. All input/output object listings and an alarm point summary listing.
c. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
d. Complete bill of materials, valve schedule with Cv, valve pressure drop at design flow, and damper schedule.
e. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
f. Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
g. For all system elements—operator's workstation(s), building controller(s), application controllers, routers, and repeaters—provide

Lonworks Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2012.

h. Provide complete description and documentation of any proprietary (non- Lonworks) services and/or objects used in the system.

i. A list of all functions available and a sample of function block programming that shall be part of delivered system.

C. Project Management

1. The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents, and shall indicate timing and dates for system installation, debugging, and commissioning.

1.10 WARRANTY

A. Warrant work as follows:

1. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Respond during normal business hours within 24 hours of Owner's warranty service request.
3. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
4. If Engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
5. Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
6. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

PART 2 - PRODUCTS

Shall Meet all of SDSU standard requirements per below:

A. Distech Controls. or approved equal. If a Distech Controls branded product or a Distech Controls product branded otherwise is used, it must be programmed and fully accessible by utilizing the Tridium AX plugins freely available on Distech's website. The provided controllers must not utilize any proprietary drivers or jar files

other than the ones provided directly from Distech and available for download by the campus. At the time of acceptance the controllers must use the latest stable firmware release from Distech.

B. Comply with all San Diego State University Campus Mechanical Standards For New Construction and Renovation Capital Projects Standards.

2.2 OPERATOR'S WORKSTATION

A. General structure of workstation interaction shall be a standard client/server relationship. Server shall be used to archive data and store system database. Clients shall access server for all archived data. Each client shall include flexibility to access graphics from server or local drive. Server shall support a minimum of 50 simultaneous clients.

B. Primary Operator Workstation Hardware
1. All workstations shall be general purpose microcomputer systems serving as an operator station in a cooperative processing server/client relationship with other connected work stations. The workstation shall consist of a high-speed central processing unit (CPU) with data storage facilities, high-resolution, 24", LCD monitor. Components shall be capable of operating in environments of 60°F to 105°F and relative humidity of 30% to 90%.
2. The CPU in each workstation shall be Intel Pentium IV, 2 GHz or higher, Core 2 Duo also acceptable.
3. Memory: 8 GB (minimum)
4. Hard Drive: 500GB (minimum) for the BAS operating software
5. Hard Drive: 1 TB (minimum) to be used for trend log archiving.
6. Display: Video card and monitor capable of displaying 1920 x 1080 pixel resolution or greater.
7. Network Support: Ethernet adapter (10/100 Mb with RJ-45 connector, or greater).
8. Keyboard: The keyboards shall be the enhanced 101 key, quiet, tactile type to match CCS.

C. Coordinate with existing Operator's Workstation on-site.

D. Displays
1. In general, the operator's workstation shall display all data associated with project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator's workstation shall display all data using three-dimensional graphic representations of all mechanical equipment.
2. A customized menu label (push-button) shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu label pushbuttons may be mixed on the same display to allow sub-displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A security level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.
3. The BAS displays shall have the ability to link to content outside of the BAS

system. Such content shall include but is not limited to: Launching external files in their native applications (for example, a Microsoft Word document) and launching a Web browser resolving to a specified Web address.

4. The BAS system shall have the ability to run multiple, concurrent displays windows showing continuously updated data.

E. Password Protection

1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator's assigned functions when user is logged on. This includes displays as outlined above.
2. Each operator's terminal shall provide security for a minimum of 200 users. Each user shall have an individual User ID, User Name, and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID shall be capable of accepting 8 characters or more, User Name shall be 0–29 characters, and Passwords must accept a minimum of 4 characters and be capable of accepting 8 characters or more.
3. System shall include an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.
4. The system shall permit the assignment of an effective date range, as well as an effective time of day, that the User IDs are permitted to authenticate.

F. Operator Activity Log

1. Operator Activity Log that tracks all operator changes and activities shall be included with system. System shall track what is changed in the system, who performed this change, date and time of system activity, and value of the change before and after operator activity. Operator shall be able to display all activity, sort the changes by user and also by operation. Operator shall be able to print the Operator Activity log display.
2. Log shall be gathered and archived to hard drive on operator's workstation as needed. Operator shall be able to export data for display and sorting in a spreadsheet.

G. Scheduling

1. Operator's workstation shall show all information in easy-to-read daily format including calendar of this month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority. Priority for scheduling shall be events, holidays and daily, with events being the highest.
2. Holiday and special event schedules shall display data in calendar format. Operator shall be able to schedule holidays and special events directly from these calendars.
3. Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.
4. Scheduling shall include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and history of previous starts. Each and every individual zone shall have optimum start time independently calculated based on all parameters listed. User shall input schedules to set time that occupied setpoint is to be attained. Optimum start feature shall calculate the startup time needed to match zone

temperature to setpoint. User shall be able to set a limit for the maximum startup time allowed.

H. Alarm Indication and Handling.

1. Operator's workstation shall provide audible, visual, printed, email or test means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s) currently running. Printout of alarms shall be sent to the assigned terminal and port. Alarm notification can be filtered based on the User ID's authorization level.
2. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator's terminal. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal, time and date of alarm acknowledgment, and identification of operator acknowledging alarm.
3. Alarm messages shall be in user-definable text (English or other specified language) and shall be delivered either to the operator's terminal, client or through remote communication using email (Authenticated SMTP supported).

I. Trendlog Information

1. System server shall periodically gather historically recorded data stored in the building controllers and store the information in the system database. Stored records shall be appended with new sample data, allowing records to be accumulated. Systems that write over stored records shall not be allowed unless limited file size is specified. System database shall be capable of storing up to 50 million records before needing to archive data. Samples may be viewed at the operator's workstation. Operator shall be able to view all trended records, both stored and archived. All trend log records shall be displayed in standard engineering units.
2. Software that is capable of graphing the trend logged object data shall be included. Software shall be capable of creating two-axis (X, Y) graphs that display up to 10 object types at the same time in different colors. Graphs shall show object values relative to time. Each trend log shall support a custom scale setting for the graph view that is to be stored continuously.
3. Operator shall be able to change trend log setup information. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics on which object is displayed.
4. System shall be capable of using Microsoft SQL as the system database.

J. Energy Log Information

1. System server shall be capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.
2. All data shall be stored in database file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.
3. Operator shall be able to change the energy log setup information as well.

This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.

4. System shall display archived data in tabular format form for both consumption and peak values. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.

K. Demand Limiting

1. System shall include demand limiting program that includes two types of load shedding. One type of load shedding shall shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding shall adjust operator selected control setpoints in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to system.
2. Binary shedding shall include minimum of five (5) priority levels of equipment shedding. All loads in a given priority level shall be shed before any loads in a higher priority level are shed. Load shedding within a given priority level shall include two methods. In one, the loads shall be shed/restored in a “first off-first on” mode, and in the other the loads are just shed/restored in a “first off-last on” (linear) fashion.
3. Analog shed program shall generate a ramp that is independently used by each individual zone or individual control algorithm to raise the appropriate cooling setting and lower appropriate heating setting to reduce energy usage.
4. Status of each and every load shed program shall be capable of being displayed on every operator terminal connected to system. Status of each load assigned to an individual shed program shall be displayed along with English description of each load.

L. Tenant Activity

1. System shall include program that monitors after-hours overrides by tenants, logs that data, and generates a bill based on usage and rate charged for each tenant space. Tenant Activity program shall be able to assign multiple zones, from a list of every zone connected to system, to a particular tenant. Every zone is monitored for after-hour override usage and that data logged in server. Operator may then generate a bill based on the usage for each tenant and the rate charged for any overtime use.
2. Configuration shall include entry of the following information for use in logging and billing:
   a. Tenant’s contact name and address.
   b. One or multiple tenant zones that make up a total tenant space, including a separate billing rate for each separate zone.
   c. Minimum and maximum values an event duration and event limit.
   d. Property management information.
   e. Overall billing rate.
   f. Seasonal adjustments or surcharge to billing rate.
   g. Billing notification type such including, but not limited to printer, file and email.
   h. Billing form template.
   i. Logging shall include recording the following information for each

and every tenant event.

j. Zone description.

k. Time the event begins.

l. Total override time.

m. Limits shall be applied to override time.

3. A tenant bill shall be generated for a specific period using all the entered configuration data and the logged data. User with appropriate security level shall be able to view and override billing information. User shall be able to select a billing period to view and be able to delete events from billing and edit a selected tenant activity event's override time.

M. Reports

1. System server shall be capable of periodically producing reports of trend logs, alarm history, tenant activities, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.
2. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.

N. Configuration/Setup

1. Provide means for operator to display and change system configuration. This shall include, but not be limited to, system time, day of the week, date of daylight savings set forward/set back, printer termination, port addresses, modem port and speed, etc. Items shall be modified using understandable terminology with simple mouse/cursor key movements.

O. Field Engineering Tools

1. Operator's workstation software shall include field engineering tools for programming all controllers supplied. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from other types of blocks. User shall be able to select a graphical function block from menu and place on screen. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.
2. Programming tools shall include a real-time operation mode. Function blocks shall display real-time data and be animated to show status of data inputs and outputs when in real-time operation. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.
3. System shall automatically notify the user when a device that is not in the database is added to the network.
4. System shall include backup/restore function that will back up entire system to selected medium and then restore system from that media. The system shall be capable of creating a backup for the purpose of instantiating a new client PC.
5. The system shall provide a means to scan, detect, interrogate, and edit third-party Lonworks devices and Lonworks objects within those devices.

P. Workstation Hardware

1. Workstation/server computer minimum requirements
   a. Enterprise Server (supports heavy trending and/or alarm handling at very large sites using SQL Server)
   b. Windows 7 Professional, Windows Server 2008 R2, SQL Server 2008 R2
   c. Browser/client requirements: Most current versions of the following: Internet Explorer, Firefox, Safari (on Mac OS X).

Q. Software
1. At the conclusion of project, contractor shall leave with owner a DVD ROM that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This backup shall allow the owner how to completely restore the system in the case of a computer malfunction.

2.3 WEB INTERFACE

A. General
1. BAS supplier shall provide Web-based access to the system as part of standard installation. User must be able to access all displays of real-time data that are part of the BAS using a standard Web browser. Web browser shall tie into the network through owner-supplied Ethernet network connection. Web page host may be a separate device that resides on the BAS Lonworks network, but is not the BAS server for the control system. BAS server may be a separate computer from the Web page host device. The Web page software shall not require a per-user licensing fee or annual fees. The Web page host must be able to support simultaneous users with the ability to expand the system to accommodate an unlimited number of users.

B. Browser Technology
1. No special vendor-supplied software shall be needed on computers running browser. All displays shall be viewable and the webpage host shall directly access real-time data from the BAS Lonworks network. Data shall be displayed in real-time and update automatically without user interaction. User shall be able to change data on displays if logged in with the appropriate user name and password.

C. Communications
1. Web page host shall support Ethernet network connections. A network connection shall be used to gather real-time data from all the Lonworks devices that form the BAS. This network shall communicate using Lonworks, allowing the Web page host to gather data directly from units on the local LAN or from other projects connected over a WAN. This network shall also provide the connection to the BAS server for Web page generation.
2. An Ethernet connection shall provide the physical connection to the Internet or an IP-based WAN. It shall be the port that is used for the browser to receive Web pages and data from the Web page host.. The Web page host shall act as a physical barrier between the BAS network and the WAN or Internet connection that allows the browser to receive Web pages and data. The two separate network connections provide for a physical barrier to prevent raw Lonworks traffic being exposed on the IP network.
3. The Web page host shall provide for complete isolation of the IP and

Lonworks networks by not routing networking packets between the two networks.

D. Display of Data
1. Web page graphics shown on browser shall be replicas of the BAS displays. User shall need no additional training to understand information presented on Web pages when compared to what is shown on BAS displays. Web page displays shall include animation just as BAS displays. Fans shall turn, pilot lights shall blink, coils shall change colors, and so on.
2. Real-time data shall be shown on all browser Web pages. This data must be directly gathered using the Lonworks network and automatically updated on browser Web page displays without any user action. Data on the browser shall automatically refresh as changes are detected without re-drawing the complete display.
3. It shall be possible for user from browser Web page to change data if the user is logged on with the appropriate password. Clicking on a button or typing in a new value shall change digital data. Using pull-down menus or typing in a new value shall change analog data.
4. Data displays shall be navigated using pushbuttons on the displays that are simply clicked on with the mouse to select a new display. Alternatively, the standard back and forward buttons of the browser can be used for display navigation.

E. Time Schedule Adjustment
1. Web access shall allow user to view and edit all schedules in the system. This includes three types of schedules: standard, holiday and event. Display of schedules shall show interaction of all schedules on a single display so user sees an overview of how all work together. User shall be able to edit schedules from this display.
2. Display of all three schedule types must show all ON times for standard, holiday and event schedules in different colors on a given day. In addition, OFF times for each must also be shown in additional colors. User shall be able to select from standard calendar what days are to be scheduled and same display shall show all points and zones affected. User shall be able to set time for one day and select all days of the week that shall be affected as a recurrence of that same schedule for that given day.
3. Schedule list shall show all schedules currently defined. This list shall include all standard, holiday and event schedules. In addition, user shall be able to select a list that shows all scheduled points and zones.

F. Logging of Information
1. User shall use standard browser technology to view all trendlogs in system. User shall be able to view logged data in tabular form or graphical format. User shall be able to adjust time interval of logged data viewed and shall be able to adjust Y axis of data viewed in graphical format. User shall also be able to download data through the Web interface to local computer. Data shall be in CSV format.

G. Alarm Handling
1. Web interface shall display alarms as they occur. User shall be able to acknowledge alarms using browser technology. In addition, user shall be able to view history of alarm occurrence over a user-selected time frame. In addition, those alarms may be filtered for viewing per user-selected options.

A single selection shall display all alarms that have not been acknowledged.

H. Web Page Generation
1. Web pages shall be automatically generated from the BAS displays that reside on the BAS server. User shall access Web page host through the network and shall initiate a Web page generation utility that automatically takes the BAS displays and turns them into Web pages. The Web pages generated are automatically installed on the Web page host for access using any computer's standard browser. Any system that requires use of an HTML editor for generation of Web pages shall not be considered.

I. Password Security and Activity Log
1. Access through Web browser shall utilize the same hierarchical security scheme as BAS system. User shall be asked to log on once the browser makes connection to Web page host. Once the user logs in, any and all changes that are made shall be tracked by the BAS system. The user shall be able to change only those items he or she has authority to change. A user activity report shall show any and all activity of the users who have logged in to the system, regardless of whether those changes were made using a browser or through the BAS workstation.

J. Lonworks Communication
1. Web server shall directly communicate to all devices on the BAS network using Lonworks protocol. No intermediate devices shall be necessary for Lonworks communication.

2.4 BUILDING NETWORK CONTROLLER

A. Building Network Controller
1. Lonworks Conformance
a. Building Network Controller shall be approved by the Lonworks Testing Laboratories as meeting the Lonworks Building Controller requirements.

B. Building network controller modules shall provide normal 7-day scheduling, holiday scheduling and event scheduling.
1. Logging Capabilities
a. Logs shall be supported in the building network controller. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
b. Logs may be viewed both on-site or off-site using WAN or remote communication.
c. Building network controller shall periodically upload trended data to networked operator's workstation for long-term archiving if desired.
d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
2. Alarm Generation
a. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
b. Each alarm may be dialed out as noted elsewhere.
c. Alarm log shall be provided for alarm viewing. Log may be viewed

on-site at the operator's terminal or off-site using remote communications.

d. Controller must be store alarms as Lonworks event enrollment objects, with system destination and actions individually configurable.

3. Demand Limiting
   a. Demand limiting of energy shall be a built-in, user-configurable function. Each controller module shall support shedding of up to 200 loads using a minimum of two types of shed programs.
   b. Load shedding programs in building controller modules shall operate as defined in Section 2.1 Demand Limiting of this specification.
4. Tenant Activity Logging
   a. Tenant aActivity logging shall be supported by building network controller module.
   b. Tenant aActivity logging shall function as defined in Section 2.1 Tenant Activity Logging of this specification.

C. Ethernet – MS/TP Module
1. Ethernet – MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
2. All communication with operator's workstation and all application controllers shall be through Lonworks. Building controller Ethernet – MS/TP module shall incorporate as a minimum, the functions of a 2-way Lonworks router. Controller shall route Lonworks messages between the high-speed LAN (Ethernet 10/100MHz) and MS/TP LAN. Ethernet – MS/TP module shall also route messages from all other building controller modules onto the Lonworks Ethernet network.
   a. MS/TP LAN must be software-configurable from 9.6 to 76.8Kbps.
   b. The RJ-45 Ethernet connection must accept either 10Base-T or 100Base-TX Lonworks over twisted pair cable (UTP).

D. MS/TP Module
1. MS/TP module shall support every listed function in this specification and the following.
2. Building controller MS/TP module communications shall be though Lonworks MS/TP LAN to all advanced application and application-specific controllers. MS/TP module shall also route messages to Ethernet – MS/TP module for communication over WAN.
   a. MS/TP LAN must be software configurable from 9.6 to 76.8Kbps.
   b. Configuration shall be through RS-232 connection.

E. Power Supply Module
1. Input for power shall accept between 17–30VAC, 47–65Hz.
2. Power supply module shall include rechargeable battery for orderly shutdown of controller modules including storage of all data in flash memory and for continuous operation of real-time clocks for minimum of 20 days.

F. Modbus Module
1. Modbus Module shall support every function as listed in this specification
2. Building Controller Modbus module communications shall be via one of three types of ports: EIA-485, EIA-422 or RS-232 connection. Modbus module shall convert Modbus data into Lonworks objects. Modbus module

shall also route messages to Ethernet-MS/TP module for Lonworks Ethernet communication over WAN.

a. Modbus Module shall support ASCII or RTU Modbus communication at 9600 or 4800 baud.
b. EIA-422 and EIA-232 connection shall support one connection of Modbus unit.
c. EIA-485 connection shall support connection of up to 247 Modbus units.
d. Configuration shall be via RS-232 connection.

3. Lonworks Translation
   a. All Modbus data shall be translated into Lonworks objects by the Modbus module. All configuration tools shall be supplied to assure data is translated as necessary to the correct format and value.
   b. Standard Lonworks object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

2.5 APPLICATION CONTROLLERS – GENERAL

A. All application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

B. All program sequences shall be stored on board controller in memory. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed Lonworks LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.

C. Provide all application controllers with a minimum of 10% spare points for analog input, analog output, digital input and digital output signals.

2.6 APPLICATION CONTROLLERS –AIR HANDLER OR CENTRAL PLANT

A. Provide one or more native Lonworks application controllers to adequately cover all objects listed in object list. All controllers shall interface to building controller through MS/TP LAN using Lonworks protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-

Lonworks controllers shall be used.

B. Programming of application controller shall be completely modifiable in the field over installed Lonworks LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator's terminal section.

C. Application controller shall include support for intelligent room sensor. Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode, based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

D. Schedules
   1. The controller shall support a minimum of three (3) Lonworks Schedule Objects and have a real-time clock on board with battery backup to maintain time through a power loss.

E. Logging Capabilities
   1. Controller shall support a minimum of 50 trend logs. Any object in the controller (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
   2. Controller shall periodically upload trended data to system server for long-term archiving if desired. Archived data stored in (MS Jet Database or SQL) database form and shall be available for use in third-party spreadsheet or database programs.

F. Alarm Generation
   1. Alarms may be generated within the controller for any object change of value or state (either real or calculated). This includes things such as analog object value changes, and binary object state changes.
   2. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
   3. Controller must be able to handle up to 25 alarm setups stored as Lonworks event enrollment objects, with system destination and actions individually configurable.

G. The packaging of the controller shall provide operable doors to cover the terminals once installation is complete. The housing of the controller shall provide for DIN rail mounting and also fully enclose circuit board.

2.7 APPLICATION CONTROLLER – UNITARY MECHANICAL EQUIPMENT

A. Provide one native Lonworks application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using Lonworks protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

2.8 APPLICATION CONTROLLER - VAV BOX—SINGLE DUCT

A. Provide one native Lonworks application controller for each VAV box that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using Lonworks protocol. No gateways shall be used. Controllers shall include on board CFM flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.

B. On board flow sensor shall be microprocessor-driven and pre-calibrated at the factory. All factory calibration data shall be stored in non-volatile memory. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. All calibration parameters shall be adjustable through intelligent room sensor. Operator's workstation, portable computers, and special hand-held field tools shall not be needed for field calibration.

C. Provide duct temperature sensor at discharge of each VAV box that is connected to controller for reporting back to operator's workstation.

D. VAV shall be capable of supporting dual maximum air flows for heating and cooling.

2.9 AUXILLIARY CONTROL DEVICES

A. Temperature Sensors
1. Duct mount, indoor
a. Veris TF series, 10K ohm, type II thermistor with stainless steel probe and junction box, Dwyer Instruments TE Series, or equal.
2. Duct mount, outdoor
a. Veris TF series 10K ohm, type II thermistor with stainless steel probe and weather-tight junction box, Dwyer Instruments TE Series, or equal.
3. Outside air
a. Veris TO series 10K ohm, type II thermistor with stainless steel probe encased in durable radiation shield with weather-tight junction box, Dwyer Instruments TE Series with Weather proof enclosure and radiation solar shield PN TE-RND-B, or equal.
4. Pipe insertion
a. Veris TIG series 10K ohm, type II thermistor with corrosion resistant stainless steel probe, thermowell, and standard or weather-tight junction box as required, Dwyer Instruments TE Series with SS Probe and Nema 4X enclosure, or equal.
5. Averaging
a. Veris TA series 10K ohm, type II thermistor encased in flexible copper tubing to enhance response time, or equal. Provide with standard or weather-tight junction box as required. Mounting of tubing shall utilize AA64 mounting clips.

B. Intelligent Room Temperature Sensor with LCD Readout
1. Sensor shall contain a backlit LCD digital display and user function keys along with temperature sensor. Controller shall function as room control unit and allow occupant to raise and lower setpoint, and activate terminal unit for override use-all within limits as programmed by building operator. Sensor shall also allow service technician access to hidden functions as described in sequence of operation.
2. The intelligent room sensor shall simultaneously display room setpoint,

room temperature, outside temperature, and fan status (if applicable) at each controller. This unit shall be programmable, allowing site developers the flexibility to configure the display to match their application. The site developer should be able to program the unit to display time-of-day, room humidity and outdoor humidity. Unit must have the capability to show temperatures in degrees Fahrenheit or Centigrade.

3. Override time may be set and viewed in half-hour increments. Override time countdown shall be automatic, but may be reset to zero by occupant from the sensor. Time remaining shall be displayed. Display shall show the word "OFF" in unoccupied mode unless a function button is pressed.
4. See sequence of operation for specific operation of LCD displays and function keys in field service mode and in normal occupant mode. Provide intelligent room sensors as specified in point list. Field service mode shall be customizable to fit different applications. If intelligent room sensor is connected to VAV controller, VAV box shall be balanced and all air flow parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.

C. Wireless Wall Sensor
1. Wireless wall sensor shall use solid-state sensor and shall be packaged in aesthetically pleasing enclosure. Sensor shall provide override function, warmer/cooler dial for set point adjustment. Override time shall be stored in controller and be adjustable on a zone-by-zone basis. Adjustment range for warmer/cooler lever shall also be stored in EEPROM on controller. All programmable variables shall be available to field service tool through wall sensor port. There shall be a mechanical means the lock the wall sensor to the base to prevent theft and vandalism.
2. Wireless wall sensor shall have a battery life of five (5) years with alkaline batteries and 7.5 years with lithium batteries. A low battery indication shall be signaled to the controller prior to the battery being exhausted. The wireless sensor shall run on industry standard AA style batteries.
3. The wireless range in open air shall meet or exceed 3000 feet. The strength of the wireless signal must be indicated at the wireless sensor to aid in placement and trouble shooting. The receiver shall have a wireless communications received light that indicates the proper communication is occurring.
4. The wireless wall sensor and receiver must be paired in an addressable means to facilitate easy replacement and reassignment.

D. Humidity Sensors
1. Wall mount:
   a. Veris HW series humidity, 2% accuracy thin film capacitive replaceable sensor element, LED display, Dwyer Instruments RHP-W Series or equal.
2. Outside air:
   a. Veris HO series humidity sensor, 2% accuracy thin film capacitive replaceable sensor element, with weatherproof housing, Dwyer Instruments RHP-W Series, or equal.
3. Duct:
   a. Veris HD series humidity sensor, 2% accuracy thin film capacitive replaceable sensor element, with die cast metal housing, Dwyer Instruments RHP-W Series, or equal.
4. Wall mount, with temperature:

a. Veris HW series combination humidity and temperature sensor, 2% accuracy thin film capacitive replaceable sensor element , LED display, push button override and setpoint slider, Dwyer Instruments RHP-W Series or equal.

5. OSA, with temperature:
   a. Veris HO series combination humidity and temperature sensor, 2% accuracy thin film capacitive replaceable sensor element, with weatherproof housing, Dwyer Instruments RHP Series Outdoor Humidity/Temperature Sensor, or equal.
6. Duct, with temperature:
   a. Veris HD series combination humidity and temperature sensor, 2% accuracy thin film capacitive replaceable sensor element, with die cast metal housing, Dwyer Instruments RHP Duct Humidity/Temperature Sensor, or equal.
7. High limit switch :
   a. Honeywell H6045A1002 duct mount hygrostat with insertion probe, adjustable trip dial, and NO and NC contacts, or equal.

E. Dewpoint Sensors
1. Wall mount:
   a. Kele Vaporstat 9002 wall mount dew point transmitter with non-dispersive infrared sensor and blank cover, or equal. Accuracy +/- 3.6° F.

F. Moisture Senor, pipe, strap on:
   a. Honeywell model HSS-DPS early warning dew point switch, strap on, with status light with NO and NC alarm terminals, or equal.

G. CO2 Sensors
1. Room, wall mount
   a. Veris CWE series with non-dispersive infrared sensor, repeatable to +/- 20 ppm, Dwyer CDT Series, or equal.
2. Outdoor and Duct
   a. Veris CDE series with non-dispersive infrared sensor, repeatable to +/- 20 ppm, Dwyer CDT Series, or equal.

H. CO2, Humidity, Temperature Combined Sensor (Duct and Wall)
1. Veris C Series Deluxe Duct and Wall CO2 sensor with set point slider and LCD display, or equal.
   a. CO2 sensor with non-dispersive infrared sensor, repeatable to +/- 20 ppm.
   b. Humidity Sensor digitally profiled thin-film capacitive, plus or minus 2% RH.
   c. Temperature Sensor: Thermistor

I. Leak Detector
1. Condensate pan overflow detection:
   a. Veris SD-R01 detector, 24V AC, with automatic reset, and 14 foot cable, Dwyer Instruments WD3 Water Leak Detector, or equal.

J. Differential pressure transmitters: Duct, building static, and water pressure
1. Duct Static Pressure Transmitter
   a. Veris PX series differential pressure transducer with selectable

range, +/- 1% accuracy, with push button auto-zero, LCD display, Dwyer Instruments MS2, or equal.

2. Building Static Pressure Transmitter
   a. Veris PX series differential pressure transducer with selectable range, +/- 1% accuracy, with push button auto-zero. Provide with AA05 ceiling mount static pressure pick up, LCD display, Dwyer Instruments MS2, or equal.
3. Water differential pressure transmitter
   a. Veris PW2 series differential pressure transmitter, wet/wet, switch selectable pressure ranges, jumper selectable port swap, LCD display and NEMA 4 enclosure, Dwyer Instruments MS2, or equal.

K. Differential pressure switches
1. Filter differential pressure switch for status
   a. Dwyer Series ADPS adjustable differential pressure switch, dual scale adjustable knob, silicone diaphragm and NEMA 13 enclosure, or equal.
2. Duct static pressure hi-low pressure safety switch for fan shut down
   a. Dwyer Series 1900MR with adjustable trip and manual reset, or equal.

L. Current Sensors
1. Current sensing switch for fans, pumps, etc.:
   a. Hawkeye Hx08 series current switch with split core, adjustable trip, pilot light, self-gripping split core housing and mounting bracket, Dwyer Instruments Series CCS, or equal.
2. Current sensing switch for VFD's:
   a. Hawkey H614 Automatic VFD current switch split core, self-learning adjustable trip, pilot light, self-gripping split core housing and mounting bracket, or equal.
3. Current sensing switch with relay for fan start
   a. Hawkeye H 900 series current switch with split core, integral relay, adjustable trip, pilot light, self-gripping split core housing and mounting bracket, or equal.
4. Current sensing transmitter
   a. Hawkeye H921 current sensing transmitter with self-gripping split core, preset slide switches, and removable mounting bracket, or equal.
5. Current sensing transmitter with relay for fan start
   a. Hawkeye H931 current sensing transmitter with integral relay, slide switches, self-gripping split core, and removable mounting bracket, or equal.

M. Flow Meters – Liquid:
1. Onicon System 10-LON BTU meters with electromagnetic full-bore flow sensor.

N. Flow Meters Natural Gas
1. Onicon F-5100 Series thermal mass flow meter, in-line or flanged as required, or equal. Provide with D-100 totalizing display module with Lonworks interface.

O. Flow Meters Steam

1. Steam: Onicon F-2500 series vortex flow meter, integral 1,000 Ohm platinum RTD for precise temperature measurement, pressure transducer for instantaneous pressure measurement, flow straightener, ANSI class 300 flanges, or equal.

P. Airflow Measuring Arrays
1. Provide one thermal dispersion airflow/temperature measurement device (ATMD) at each location indicated on the plans, schedules and/or control schematics.
2. Each ATMD shall consist of one to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.
3. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.
4. The velocity-weighted average temperature output performance of the ATMD is preferred to that of the specified temperature measuring device (TMD), when the location of the ATMD and TMD are effectively the same.
5. Outside Air Measurement:
   a. Provide a minimum outside airflow measuring station in a straight duct section upstream from the minimum outside air dampers and interfacing control for providing an electronic signal for use by the control contractor in controlling a minimum outside airflow. On outdoor mounted air handling units, outside airflow measurement station is to be factory mounted on the intake side of the outside air intake (upstream of the damper).
6. Sensor Performance:
   a. Fan Installation:
      1) Installed airflow accuracy: +/- 3% to 10% of reading with +/- 0.25% repeatability.
      2) Sensor probe performance: +/- 2% of reading, 0-5000 fpm, 0.15°F temperature accuracy +/-.
   b. Outside Air/duct Installation:
      1) Installed airflow accuracy: +/- 2% of reading with +/- 0.25% repeatability.
      2) Sensor probe performance: +/- 2% of reading, 0-5000 fpm, 0.15°F temperature accuracy +/-.
7. Transmitter:
   a. Flow measuring array to include a transmitter for flow and temperature analog output signal for the building energy management system to be user selectable in either 4-20 mA or 0-10VDC. Coordinate signal output with controls installer.
   b. Transmitter to include an analog airflow gauge to provide direct analog readout in cfm. Mount on the outside of the air handler if air handler is located in a mechanical room. Mount in a NEMA 3R control cabinet if located outside.
   c. Device to provide switch selectable Modbus or Johnson N2 outputs.
   d. Device to be UL listed.
   e. The transmitter shall be powered by 24 VAC, shall include over-voltage and over-current protection, and shall include watchdog circuitry to ensure continuous operation following power failures and/or brown- outs.
   f. The transmitter shall determine the airflow rate and temperature of

each sensing node prior to averaging.

g. The transmitter shall include self-diagnostics and other features to ensure reliability and continued operation despite a limited failure. The transmitter shall automatically detect sensor damage and correctly calculate the average using the remaining functional sensor nodes, while reporting a system fault over the network and by local visual indication.

h. All integrated circuits shall be industrial rated for operation down to -40°F (-40°C).

j. The environmental operating temperature limits for the transmitter shall be -20°F to 120°F (-28.8°C to 48.8°C).

k. The system shall be factory tested prior to shipment and not require calibration or adjustment over the life of the equipment when installed in accordance to manufacturer's guidelines.

l. The Sensors shall be calibrated to NIST traceable standards.

8. Airflow measuring station to be by Ebtron, KURZ, Fluid Components and Sierra Instruments or equal.

Q. BTU Meters

1. Onicon System-10-BAC BTU meter with Lonworks interface with matched temperature sensors and thermo-wells, NEMA 13 wall mount enclosure, or equal. Provide with Onicon F-1100 single turbine insertion flow meter, or Onicon F-3500 electromagnetic flow meter, 316 stainless steel, weather tight aluminum enclosure, and standard or copper installation kit including 1" full port bronze ball valve, close nipple, and branch outlet.

2.10 ACTUATORS

A. Electronic Actuators

1. Manufactured, brand labeled or distributed by Belimo, or equal.
2. Size for torque required for damper seal at load conditions.
3. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
4. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
5. Overload protected electronically throughout rotation.
6. Fail-Safe Operation: Mechanical, spring-return mechanism
7. Electronic Fail-Safe Operation: Incorporate a visual indication of the fail safe status on the face of the actuator. The power fail position shall be field adjustable between 0 to 100% in 10o increments. The electronic fail safe shall have a 2-10 second adjustable operational delay.
8. Power Requirements (Spring Return): 24-V ac, maximum 10 VA at 24-V ac or 8 W at 24-V dc (running). Maximum 1 VA at 24-V ac or 1 W at 24-V dc (holding).
9. Proportional Actuators shall be fully programmable through an onboard EEPROM by using an external cable and software interface.
10. Temperature Rating: -22 to +122ºF.
11. Housing: Minimum requirement NEMA type 2 mounted in any orientation. .
12. Agency Listings: ISO 9001, cULus, CE or CSA
13. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.

B. Actuators with torque requirements exceeding 360 inch pounds

1. Manufactured, brand labeled or distributed by Belimo, or equal.

2. The combination of valve and actuator shall meet the close-off requirements as specified in Section 2.16.H – Butterfly Valves.
3. Coupling: ISO 5211 mounting standards.
4. Overload Protection: A self-resetting thermal switch embedded in the motor.
5. Manual Override: Actuator shall be equipped with a hand wheel or shaft for manual override to permit operation of the actuator in the event of an electrical power failure
6. Power Requirements: 24VAC, 120VAC, or 230VAC single phase.
7. Auxiliary Switches: 2 SPDT rated 3A at 250 VAC.
8. Temperature Rating: -22 to +150ºF.
9. Duty Cycle Rated 75% minimum.
10. Housing: Minimum requirement NEMA type 4X/ IP67 with an industrial quality coating. Actuator shall have an internal heater to prevent condensation within the housing. A visual indication beacon shall indicate position status of the device.
11. Agency Listing: ISO, CE, CSA
12. The manufacturer shall warrant for 2 years from the date of production.

2.11 CONTROL VALVES

A. Manufacturer:
1. Manufactured, brand labeled or distributed by Belimo, or equal.

B. Control Valve Actuators:
1. Size for valve close off at 150 percent of total system (head) pressure for two-way valves; and 100 percent of pressure differential across the valve or 100 percent of total system (pump) head differential pressure for three-way valves.
2. Coupling: directly couple and mount to valve stem, shaft ISO-style direct-coupled mounting pad.
3. Non- spring return actuators shall have manual override
4. Spring return actuators of 90 inch-pounds or above shall have manual override.

C. Control Valves:
1. Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
2. Sizing (Water):
   a. Two-Position: Line size or size using a pressure differential of 1 psi.
   b. Two-Way Modulating: Size for a pressure differential across the valve of 4 psi at design flow, or twice the load pressure drop at design flow.
   c. Three-Way Modulating: Size for a pressure differential across the valve of not more than 4 psi at design flow
3. Sizing (Steam):
   a. Two-Position: Line size or sized using 10% of inlet gauge pressure.
   b. Modulating: 15 psig or less inlet steam pressure, the pressure drop shall be 80% of inlet gauge pressure. Higher than 15 psig inlet steam pressure the pressure drop shall be 42% of the inlet absolute pressure.
4. Close-Off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system head

pressure for two-way valves and 150 percent of the design pressure differential across the three-way valves.

5. The control valve assembly shall be provided and delivered from a single manufacturer as a complete assembly.

D. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional (except as noted).

E. Pressure Independent Control Valves

1. NPS 2 and Smaller: Forged brass body rated at no less than 400 PSI, chrome plated brass ball and stem, female NPT ends, dual EPDM lubricated O-rings and a brass or TEFZEL characterizing disc for equal percentage characteristic.
2. NPS 2-1/2 through 6: GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats, and a stainless steel flow characterizing disc.
3. The control valve assembly shall have an integral magnetic flow meter Magnetic flow meter to accurately control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSID across the valve with a valve body accuracy of +/- 5% variance due to differential pressure fluctuation or +/- 10% total assembly error incorporating differential pressure fluctuation, .manufacturing tolerances and valve hysteresis
4. Flow Characteristics: NPS 1/2” through 2” Equal percentage characteristic. NPS 2-1/2” through 6” capable of Equal percentage or Linear characteristic (field programmable).
5. All proportional actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
6. Actuators for 3-wire floating (tri-state) and on 2 position (on/off) on 1/2” to 1” pressure independent control valves shall fail in place.
7. Water Coil optimization 2-1/2” through 6” shall be accomplished by utilizing Belimo’s energy meter (a pressure independent control valve assembly) with two integral temperature sensors providing feedback of coil inlet and coil outlet water temperature; and integral magnetic flow meter for control and to provide actual analog flow feedback. Valve assembly to have built in intelligence to control pressure independently and a Delta T Manager mode to mitigate low delta T syndrome by referencing an internally programmed design delta T setpoint. Valve assembly shall be capable of communicating data by means of Lonworks MS/TP, Lonworks I/P and TCP IP. Data to include, but not be limited to, inlet and outlet coil water temperatures, valve position, absolute flow, absolute valve position, absolute power and heating/cooling energy in BTU/hr. Valve assembly shall be capable of trending and storing up to 13 months of data on the actuator. Trended data on actuator to be retrievable via TCP IP or direct connect and download to *.csv file format.
8. The manufacturer shall provide a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).
9. The control valve shall require no maintenance and shall not include replaceable cartridges.
10. NPS 2” and smaller pressure independent control valves for individual coil

control shall be provided as part of a pipe package supplied by the valve manufacturer. The supply side of the coil shall contain an integrated isolation ball valve/manual air vent with strainer/shut-off valve/drain with pressure/temperature test ports. The return side shall contain a union fitting with a pressure/temperature test port, pressure independent control valve, and integrated isolation ball valve/manual air vent with a pressure/temperature test port. Shut-off valves as an integrated part of the pressure independent control valve are prohibited. A braided stainless flexible hose shall be provided for each coil supply and return connection for all pipe packages.

F. Characterized Control Valves:
1. NPS 1/2” and smaller for Terminal Units : Nickel plated forged brass body rated at no less than 600 psi WOG Water oil gas, chrome plated brass Stainless steel stem is an option ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-Ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc.
2. NPS 1” through 2”: Nickel-plated forged brass body rated at no less than 400 psi, stainless steel ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc.
3. NPS 2-1/2” through 6”: GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball, stainless steel blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring package design, PTFE seats, and a stainless steel flow characterizing disc.
4. Flow Characteristics: Equal percentage characteristics.
5. Six-way control valve used for chilled beam applications shall have the following characteristics:
   a. NPS 1/2” and 3/4”: Nickel plated forged brass body rated at no less than 600 psi, dual chrome plated brass ball and blowout proof stems, and female NPT end fittings. Each three-way portion of the 6-way valve body shall have EPDM O-Ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc.
   b. The six-way control valve shall be controlled by a rotary actuator for managing two media in a modulating application. The valve shall be closed to all flow at mid-rotation.

G. Butterfly Valves – Resilient Seat:
1. NPS 2 to 12: Valve body shall be full lugged cast iron 200 psig body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize an internal spline. The shaft shall be supported at four locations by RPTFE bushings.
2. NPS 14 and Larger: Valve body shall be full lugged cast iron 150 psig body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize a dual-pin method to prevent the disc from settling onto the liner. The shaft shall be supported at four locations by RPTFE bushings.
3. Sizing:
   a. Two-Position: Line size or size using a pressure differential of 1 psi.
   b. Modulating: 4 psig or twice the load pressure drop, whichever is more. Size for the design flow with the disc in a 60-degree-open-

position and a design velocity not to exceed 12 feet per second.

4. Close-Off Pressure Rating: NPS 2-12" 200 psi bubble tight shut-off. NPS 14 and larger, 150 psi bubble tight shut-off.

H. Butterfly Valves – High Performance:

1. Valve body shall be full lugged carbon steel ANSI Class 150 [300] body with a 316 stainless steel disc without a nylon coating, RTFE seat, and be ANSI Class 150300 flange standards. Blowout-proof shaft shall be 17-4ph stainless steel and shall be supported at four locations by glass-backed TFE bushings. Valve packing shall be Chevron TFE and shall include fully adjustable packing flange and separable packing gland. Valve body shall have long stem design to allow for 2" insulation (minimum). Valve face-to-face dimensions shall comply with API 609 and MSS-SP-68. Valve assembly shall be completely assembled and tested, ready for installation.
2. Sizing:
   a. Two-Position: Line size or size using a pressure differential of 1 psi.
   b. Modulating: 4 psig or twice the load pressure drop, whichever is more. Size for the design flow with the disc in a 60-degree-open-position with the design velocity less than 32 feet per second.
3. Flow Characteristics: Modified equal percentage, unidirectional.
4. Close-Off Pressure Rating: 150 psi bubble tight shut-off.
5. Media Temperature Range: ANSI Class 150 limitations.
6. Max Differential Pressure: 285 psi @ 100 deg F for ANSI 150 (725 psi @ 100 deg F for ANSI 300).

2.12 DOMESTIC WATER SECURITY VALVES

A. Manufacturer:

1. Automatic Security Valves, or equal.

B. Scope: connect to BAS for automatic opening and closing of domestic cold water supply to building.

C. Control Valve Actuator:

1. High torque actuator, fast opening and closing to control incoming domestic cold water service.
2. NEMA 6P waterproof enclosure.
3. UL listed.
4. Power supply input:100–240 volts, 60 Hz, 1 amp maximum. Output 18 volts, 2.22 amps.
5. BAS feedback signals for valve open or closed.
6. 12 VDC trigger contact to open valve.

D. Control Valve:

1. 316 stainless steel, 3-piece construction for body, ball and stem.
2. Equipped with a manual handle for emergency override.
3. Pressure rated to 600 psi, minimum.
4. Full port ball valve.
5. Threaded for sizes 1/2" to 2".
6. Low lead and certified for potable water use per UPC and NSF/ANSI 61.

2.13 ENCLOSURES

A. All controllers, power supplies and relays shall be mounted in enclosures.

B. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment.

C. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.

D. Outdoor enclosures shall be NEMA 3R.

E. Enclosures shall have hinged, locking doors.

F. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 0.125 inches thick and appropriately sized to make label easy to read.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the owner’s representative in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 INSTALLATION (GENERAL)

A. Install in accordance with manufacturer's instructions.

B. Provide all miscellaneous devices, hardware, software, interconnections, installation, and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

3.3 LOCATION AND INSTALLATION OF COMPONENTS

A. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum 3 feet of clear access space in front of units. Obtain approval on locations from owner’s representative prior to installation

B. Wall mounted temperature sensors will typically be mounted directly above or below light switches and comply with ADA height requirements. Coordinate with owner, architect and other trades to assure proper mounted locations prior to installation.

C. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture, and high or low temperatures.

D. Identify all equipment and panels. Provide permanently mounted tags for all panels.

E. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections, and sized to suit pipe diameter without

restricting flow.

3.4 CONDUIT

A. Conduit Requirements: all conduit shall with comply with minimum requirements of local authority having jurisdiction.
   1. Low voltage wiring in concealed areas may be plenum rated. Low voltage wiring in exposed areas shall be enclosed in conduit.
      a. All low voltage wiring exposed to weather shall be installed in conduit.
      b. Low voltage wiring in exposed areas, such as in mechanical, electrical, or service rooms, shall be installed in EMT conduit up to 10 feet above finished floor.
   2. All low voltage control wiring shall be enclosed in conduit

B. Provide conduit for low voltage wring in walls for all wall mounted sensors, CO2 sensors, humidity sensors, etc. Conduit shall be run to 6” above the ceiling and shall terminate with a bushing installed on the conduit end.

C. Provide conduit for low voltage wiring above inaccessible ceilings.

D. Conceal all conduits, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 6 in. from high-temperature equipment (i.e.-such as flues or high temperature pipes).

E. Conduit must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

F. Secure conduits with conduit clamps fastened to the structure and spaced according to code requirements. Conduits and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.

G. Size of conduit and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer’s recommendations and CEC requirements, except as noted elsewhere.

3.5 LOW VOLTAGE INTERLOCKING AND CONTROL WIRING

A. All control and interlock wiring shall comply with California electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

B. All low-voltage wiring shall meet CEC Article 725 Class 2 requirements. Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.

C. Do not install Class 2 wiring in conduits containing Class 1 wiring. Boxes and panels containing line voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

D. Unless otherwise noted, power wiring for all valve and damper actuators is Class 2. If the BAS contractor desires to substitute 120 V actuators, the BAS contractor shall

provide all Class 1, 120V wiring and conduit at own expense.

E. Contractor shall provide step-down transformers as necessary.

F. Install insulated bushings on all conduit ends and openings to enclosures. Seal top end of vertical conduits.

G. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block. Wire nuts are not acceptable.

H. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

I. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

J. Use color-coded conductors throughout with conductors of different colors.

K. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

L. The contractor shall terminate all communications, control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

3.6 COMMUNICATION WIRING

A. The contractor shall adhere to the wiring requirement previously listed.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling

C. Do not install communication wiring in conduits and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer’s instructions.

G. All runs of communication wiring shall be unspliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on

"Communications Circuits, Cable, and Protector Grounding."

J. Lonworks MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
   1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
   2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
   3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
   4. An MS/TP EIA-485 network shall have no T connections.

K. All Ethernet cabling, routers, hubs and switches for connecting 230900 furnished and installed control panels, servers and clients to the building owner's Ethernet network are the responsibility of the BAS contractor.

3.7 FIELD SERVICES

A. Prepare and start logic control system under provisions of this section.

B. Start up and commission systems. Allow sufficient time for startup and commissioning prior to placing control systems in permanent operation. Provide all labor and services as necessary to support testing and verification by third party commissioning authority.

C. Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service for one year or as specified.

D. Provide owner's representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

3.8 PROJECT RECORD DOCUMENTS

A. Project Record Documents: Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:
   1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD 2006 (or newer) compatible files on optical media and as 11" x 17" prints.
   2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Part 3: "Control System Demonstration and Acceptance."
   3. Operation and Maintenance (O & M) Manual.
   4. As-built versions of submittal product data.
   5. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
   6. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data,

overriding computer control, and changing setpoints and variables.

7. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
8. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
9. Documentation of all programs created using custom programming language including setpoints, tuning parameters, and object database.
10. Graphic files, programs, and database on magnetic or optical media.
11. List of recommended parts with part numbers and suppliers.
12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
14. Licenses, guarantees, and warranty documents for equipment and systems.
15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

3.9 TRAINING

A. Provide application engineer to instruct owner in operation of systems and equipment.

B. Provide system operator’s training to include (but not be limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data, execution of commands and request of logs. Provide this training to a minimum of three persons.

C. Provide on-site training above as required, up to 16 hours as part of this contract.

D. Provide tuition for at least one individual to attend for a one-week factory training class. If applicable, costs for travel, lodging and meals will be the responsibility of the owner.

3.10 DEMONSTRATION

A. Demonstrate complete operating system to owner's representative.

B. Provide certificate stating that control system has been tested and adjusted for proper operation.

END OF SECTION