SECTION 25 20 00 – TERMINAL BUILDING AUTOMATION SYSTEM (BAS)

PART 1 – GENERAL

1.1 INTENT

A. The intent of this Section is to define the requirements for a terminal Building Automation System (BAS). BAS is the total integrated system of fully operational and functional elements, including, but not limited to, equipment, software, programming, and associated materials.

B. LAWA has designated the BAS for its Central Utilities Plant (Johnson Controls Metasys BACnet BAS with Wonderware Graphical User Interface) as the Facility Monitoring and Control System (FMCS) for LAX.

C. LAWA has designated an FMCS Systems Administrator (FMCS SA) to coordinate BACnet tie-in with all Terminal BAS Contractors and to perform all final termination verification and programming/integration into the FMCS.

1.2 SUMMARY

A. All work of this Section shall be coordinated and provided by a single BAS Contractor who shall be the primary manufacturer, installer, commissioner and ongoing service provider for the work.

B. The work of this Section shall be scheduled, coordinated and interfaced with the associated work of other trades.

C. If the BAS Contractor believes there are conflicts or missing information in the project documents, s/he shall promptly request, in writing, clarification and instruction from LAWA. In all cases, where conflicts in bid documents exist, the more extensive and costly alternative shall prevail with LAWA retaining the right to request a deduct change order to provide the lower cost alternative. Regardless, a fully functional BAS system shall be provided.

D. The BAS Contractor is responsible for integration of the BAS and FMCS systems. The BAS Contractor shall provide Point of Connection (POC) of the BAS and the FMCS. The BAS Contractor shall provide labor for a JCI Metasys certified technician for making all points in the BAS available to the FMCS SA to perform point mapping to schedules, trends, alarms and Wonderware GUI. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BAS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to LAWA.

1.3 QUALITY REQUIREMENTS

A. General Requirements

1. The BAS Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and long term

maintenance and service of total integrated building automation systems, of a recognized national manufacturer of building automation systems for no less than 15 years.

2. The BAS Contractor shall have experience providing BAS services for a large campus environment comparable to LAX and for clients / organizations with similar complexity and diversity of facilities.

3. The BAS Contractor shall have a branch facility within a 50-mile radius of the LAX site.

4. As evidence and assurance of the BAS Contractor's ability to support LAWA's system with service and parts, the contractor must have been in the BAS business for at least the last fifteen (15) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years within a 100 mile radius of the LAX site.

5. The BAS architecture shall consist of the products of a manufacturer regularly engaged in the production of building automation systems, and shall be the manufacturer's latest standard of design at the time of bid.

B. Safety Requirements

1. Provide a safety program in compliance with Sections 00 73 19, 01 35 23, and 01 66 00 of the Design and Construction Handbook.

C. Quality Management Program

1. Designate a competent and experienced employee to provide BAS Project Management. The designated Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the BAS Contractor. At minimum, the Project Manager shall:
   a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
   b. Manage the financial aspects of the BAS Contract.
   c. Coordinate as necessary with other trades.
   d. Be responsible for the work and actions of the BAS workforce on site.

D. Requirements of Regulatory Agencies

All work shall meet the requirements of local codes, ordinances, except where more strict requirements are specified. Codes and Standards which govern BAS work are as follows:

1. National Electric Code (NEC) and applicable local Electric Code.
2. Underwriters Laboratories (UL) listing and labels.
3. UL 916 Energy Management
4. NFPA 70 - National Electrical Code.
5. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.
6. Factory Mutual (FM).
7. American National Standards Institute (ANSI).
8. National Electric Manufacturer's Association (NEMA).
9. American Society of Mechanical Engineers (ASME).

10. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
11. Air Movement and Control Association (AMCA).
12. Institute of Electrical and Electronic Engineers (IEEE).
13. American Standard Code for Information Interchange (ASCII).
14. Electronics Industries Association (EIA).
15. Occupational Safety and Health Administration (OSHA).
16. American Society for Testing and Materials (ASTM).
17. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.
18. Americans Disability Act (ADA)
19. ASHRAE Standard 135 (BACnet)
20. LAWA Design & Construction Handbook

1.4 DEFINITIONS

Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.

Binary: A two-state system where an "ON" condition is represented by one discrete signal level and an "OFF" condition is represented by a second discrete signal level.

Control Sequence: A BAS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required attaining the defined operational control objectives.

Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BAS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

BAS Network: The total digital on-line real-time interconnected configuration of BAS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.

Node: A digitally programmable entity existing on the BAS network.

BAS Integration: The complete functional and operational interconnection and interfacing of all BAS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BAS as required by this Section.

Provide: The term "Provide" and its derivatives when used in this Section shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.

Furnish: The term "Furnish" and its derivatives when used in this Section shall mean supply at the BAS Contractor's cost to the designated third party trade contractor for installation. BAS

Contractor shall connect furnished items to the BAS, calibrate, test, commission, warrant and document.

Wiring: The term "Wiring" and its derivatives when used in this Section shall mean provide the BAS wiring and terminations.

Install: The term "Install" and its derivatives when used in this Section shall mean receive at the jobsite and mount.

Protocol: The term "protocol" and its derivatives when used in this Section shall mean a defined set of rules and standards governing the on-line exchange of data between BAS network nodes.

Software: The term "software" and its derivatives when used in this Section shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BAS industry for real-time, on-line, integrated BAS configurations.

The use of words in the singular in this Section shall not be considered as limiting when other indications in this Section denote that more than one such item is being referenced.

Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in this Section are for general information only and are to assist in the reading and interpretation of this Section.

The following abbreviations and acronyms may be used in describing the work of this Section:

ADC	-	Analog to Digital Converter
AHU	-	Air Handling Unit
AI	-	Analog Input
AN	-	Application Node
ANSI	-	American National Standards Institute
AO	-	Analog Output
ASCII	-	American Standard Code for Information Interchange
ASHRAE	-	American Society of Heating, Refrigeration and Air Conditioning Engineers
AWG	-	American Wire Gauge
CPU	-	Central Processing Unit
CRT	-	Cathode Ray Tube
CUP	-	Central Utility Plant
DAC	-	Digital to Analog Converter
DDC	-	Direct Digital Control
DI	-	Digital Input
DO	-	Digital Output
EEPROM	-	Electronically Erasable Programmable Read Only Memory
MPOE	-	Minimum Point of Entry
EMI	-	Electromagnetic Interference
FAS	-	Fire Alarm Detection and Annunciation System
FMCS	-	Facility Management Control System (located at CUP)
FMCS SA		Facility Management Controls System Administrator
GUI	-	Graphical User Interface

HOA	-	Hand-Off-Auto
ID	-	Identification
IEEE	-	Institute of Electrical and Electronics Engineers
I/O	-	Input/output
IT	-	Information Technology
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
MCC	-	Motor Control Center
NAE	-	Network Automation Engine (supervisory level device)
NC	-	Normally Closed
NO	-	Normally Open
OWS	-	Operator Workstation
OAT	-	Outdoor Air Temperature
PC	-	Personal Computer
RAM	-	Random Access Memory
RF	-	Radio Frequency
RFI	-	Radio Frequency Interference
RH	-	Relative Humidity
ROM	-	Read Only Memory
RTD	-	Resistance Temperature Device
SPDT	-	Single Pole Double Throw
SPST	-	Single Pole Single Throw
XVGA	-	Extended Video Graphics Adapter
TBA	-	To Be Advised
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TTD	-	Thermistor Temperature Device
UC	-	Unitary Controller
UPS	-	Uninterruptible Power Supply
VAC	-	Volts, Alternating Current
VAV	-	Variable Air Volume
VDC	-	Volts, Direct Current
WAN	-	Wide Area Network

1.5 BAS DESCRIPTION

A. The BAS shall be a complete BACnet system designed for connection to dedicated BAS IT network at LAX. This functionality shall extend into the equipment rooms. BAS Contractor shall be responsible for coordination with LAWA's engineering staff and LAWA the FMCS SA to ensure that the BAS will perform in the LAX environment without disruption to any of the other activities taking place on that LAN.

B. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BAS manufacturer for use as a building operations terminal.

C. Where necessary and as dictated elsewhere in these Specifications, servers shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions. All data stored will be through the use of a standard data base platform: Microsoft SQL Server.

D. The work of the single BAS Contractor shall be as defined individually and collectively in all Sections of this Specification together with the associated Point Schedules and Drawings and the associated interfacing work as referenced in the related documents.

E. The BAS work shall include, but not be limited to, the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, performance bonding, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these documents which are required for the complete, fully functional and commissioned BAS.

F. Provide a complete, neat and workmanlike installation. System shall be installed by original equipment manufacturer (OEM) of the BAS products or manufacturer authorized dealer, by direct employees of the OEM or manufacturer certified technicians who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided.

G. Manage and coordinate the BAS work in a timely manner in accordance with LAWA-approved schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.

H. The BAS as provided shall incorporate, at minimum, the following integrated features, functions and services:
   1. Operator information, alarm management and control functions;
   2. Enterprise-level information and control access back to the FMCS;
   3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions;
   4. Diagnostic monitoring and reporting of BAS functions;
   5. Offsite monitoring and management access;
   6. Energy management; and
   7. Standard applications for terminal HVAC systems.

1.6 WORK BY OTHERS

A. General Contractor is responsible for the demarcation of work and responsibilities between the BAS Contractor and other related trades and for ensuring delivery of fully functional and integrated BAS.

1.7 SUBMITTALS

A. Provide submittals in accordance with Sections 01 33 00 and 01 78 00 of the Design and Construction Handbook.

B. In addition, provide the following:

   1. FMCS Integration Coordination Plan (detailing the timing in the project schedule above that the FMCS SA will be able to integrate the BAS into the FMCS and the

employee of the terminal BAS contractor that will be made available to coordinate this critical integration).

2. BAS network architecture diagrams including all nodes and interconnections.
3. Systems schematics, sequences and flow diagrams.
4. Points schedule for each point in the BAS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
5. Samples of Graphic Display screen types and associated menus.
6. Detailed bill of materials list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
7. Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
8. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
9. Details of all BAS interfaces and connections to the work of other trades.
10. Product data sheets or marked catalog pages including part number, photo and description for all products including software.
11. Sample thermostat (temperature sensor).

1.8 RECORD DOCUMENTATION

A. Provide Operation and Maintenance Manuals in accordance with Section 01 78 00 of the Design and Construction Handbook.

B. In addition, provide the following:
   1. Archive copy of all site-specific databases and sequences.
   2. BAS network diagrams, including integration to the FMCS.
   3. Interfaces to all third-party products and work by other trades.

C. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

D. After completion of all tests and adjustments the BAS Contractor shall provide a copy of all as-built information and product data to be installed on a LAWA-designated computer workstation or server.

1.9 WARRANTIES

A. Provide Warranties in accordance with Section 01 78 00 of the Design and Construction Handbook.

B. In addition, provide the following:

1. Provide a five-year labor and material warranty on the BAS.
2. If within sixty (60) months from the date of acceptance of product, upon written notice from LAWA, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BAS Contractor at the cost of the BAS Contractor.
3. Maintain an adequate supply of materials within 50 miles of LAX such that replacement of key parts and labor support, including programming.
4. Warranty work shall be done during hours designated by LAWA.

PART 2 – PRODUCTS

2.1 GENERAL DESCRIPTION

A. The BAS shall use BACnet open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BAS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications.

B. The BAS shall consist of the following:
1. Field Controller(s)
2. Terminal Controllers
3. Input/Output Module(s)
4. Portable Operator's Terminal(s)
5. Network processing, data storage and communications equipment
6. Other components required for a complete and working BAS

C. The BAS shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment as approved in writing by LAWA.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
2. The BAS shall maintain all settings and overrides through a system reboot.

E. Acceptable Manufacturers:
1. Johnson Controls
2. Siemens
3. Alerton

2.2 BAS ARCHITECTURE

A. Primary BAS Network
1. The primary BAS network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard “off the shelf” products available through normal PC vendor channels.

2. The BAS shall network multiple User Interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.

3. The primary BAS network will be compatible with other enterprise-wide networks. Where indicated, the primary BAS network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

B. Secondary BAS Network

1. Secondary BAS networks shall provide either "Peer-to-Peer," or Primary-Secondary communications, and shall operate at a minimum communication speed of 9600 baud.

2. DDC Controllers shall reside on the either primary or on the secondary BAS network. All controllers shall be tied into the system so that they can be accessed via the LAN network.

3. Secondary BAS network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.

4. The main equipment controllers shall reside only on the primary BAS network.

C. Integration

1. Hardwired

a. Analog and digital signal values shall be passed from one system to another via hardwired connections.

b. There will be one separate physical point on each system for each point to be integrated between the systems.

2. BACnet Protocol Integration - BACnet

a. The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

b. The ability to command, share point object data, changes of state (COS) data and schedules between the host and BACnet systems shall be provided.

2.3 USER INTERFACE

A. Dedicated User Interface.

1. Where indicated on plans the BAS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BAS to facilitate greater fault tolerance and reliability.

2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BAS Contractor and by other third party applications suppliers,

including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards:

a. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions

b. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports

c. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries

3. PC Hardware – One (1) desktop and two (2) latest laptop personal computers by major computer manufacturer (Hewlett Packard, Dell Corporation and Toshiba) shall be configured as follows:

a. Memory – 4 GB Minimum,

b. CPU– 2.8 GHz Clock Speed minimum

c. Hard Drive – 500GB free hard drive space minimum

d. Hard drive backup system – CD/RW, DVD/RW or network backup software provided by IT department

e. CD ROM Drive

f. Modem: Auto-dial telephone, 56,000 baud.

g. Ports – (1) Serial, (2) USB ports

h. Keyboard – Desktop PC 101 Keyboard and 3 Button Mouse

i. Monitor configuration
   1) Each Display – 22” Flat Panel Monitor
   2) 32 bit or higher color resolution
   3) Display card with multiple monitor support

j. LAN communications – Ethernet communications board

k. Built-in wireless 802.11 b/g/n LAN

l. Mouse: two-button optical type wireless.

4. Operating System Software

a. Windows 7 (32 bit)

b. Provide complete operator workstation software package, including any hardware or software keys. Include the original installation disks and licenses for all included software, device drivers, and peripherals.

c. Provide software registration cards to LAWA for all included software

d. The software shall run on the Microsoft Internet Explorer (7.0 or higher) browser supporting the following functions:
   1) Configuration
   2) Commissioning
   3) Data Archiving
   4) Monitoring
   5) Commanding

6) System Diagnostics

5. Peripheral Hardware

a. Reports printer:
1) Printer Make – Hewlett Packard DeskJet or equal
2) Print Speed – Black 32 ppm, Color 20 ppm
3) Print Resolution – Black 600 dpi, Color 300 dpi
4) Buffer – 64 K Input Print Buffer
5) Color Printing – Include Color Kit

B. Distributed Web Based User Interface

1. All features and functions of the dedicated User Interface previously defined in this Section shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the primary BAS network and conforming to the following Minimum hardware requirements and compliance with LAWA IMTG Standards, Policies and Procedures:

a. 4GB RAM

b. 2.8 GHz Clock Speed Pentium 4 Microprocessor

c. 100 GB Hard Drive.

d. 1024x768 minimum resolution display with 64K colors and 32 bit color

C. Site Management User Interface Application Components

1. Operator Interface

a. All Inputs, Outputs, Set points, and all other parameters as defined within Part 3 of this Section, or shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.

b. The User Interface software shall provide help menus and instructions for each operation and/or application.

c. The system shall support customization of the UI configuration and a home page display for each operator.

d. The system shall support user preferences in the following screen presentations:
1) Alarm
2) Trend
3) Display
4) Applications

e. All controller software operating parameters shall be displayed for the operator to view/modify from the User Interface. These include: set points, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.

f. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
1) User access for selective information retrieval and control command execution
2) Monitoring and reporting

3) Alarm, non-normal, and return to normal condition annunciation
4) Selective operator override and other control actions
5) Information archiving, manipulation, formatting, display and reporting
6) BAS internal performance supervision and diagnostics
7) On-line access to user Help menus
8) On-line access to current BAS as-built records and documentation
9) Means for the controlled re-programming, re-configuration of BAS operation and for the manipulation of BAS database information in compliance with the prevailing codes, approvals and regulations for individual BAS applications

g. The system shall support a list of application programs configured by the users that are called up by the following means:
   1) The Tools Menu
   2) Hyperlinks within the graphics displays
   3) Key sequences

h. The operation of the control system shall be independent of the User Interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

2. Alarms

a. Alarms shall be routed directly from controllers to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the User Interface shall, at the minimum, provide the following functions:
   1) Log date and time of alarm occurrence.
   2) Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.
   3) Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
   4) Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
   5) Provide select alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.

b. The BAS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions.

c. The BAS shall allow a minimum of 4 categories of alarm sounds customizable through user defined wav.files.

d. The BAS shall annunciate application alarms at minimum, as required by Part 3 of this Section.

3. Reports and Summaries

a. Reports and Summaries shall be generated and directed to the User Interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:
   1) All points in the BAS
   2) All points in each BAS application
   3) All points in a specific controller
   4) All points in a user-defined group of points
   5) All points currently in alarm
   6) All points locked out
   7) All user defined and adjustable variables, schedules, interlocks and the like.

b. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.

c. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.

d. Provide a focused set of reports that includes essential information required for effective management of energy resources within the facility. Energy reports shall be configurable from a LAWA-selected and approved predefined, preconfigured templates. Requirements include, but shall not be limited to:
   1) Energy Overview
   2) Load Profile
   3) Simple Energy Cost
   4) Consumption
   5) Equipment Runtime
   6) Electrical Energy
   7) Energy Production
   8) Reports shall be selectable by date, time, area and device. Each report shall include a color visual summary of essential energy information.

4. Schedules

a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
   1) Weekly schedules
   2) Exception Schedules
   3) Monthly calendars

b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.

c. It shall be possible to define one or more exception schedules for each schedule including references to calendars.

d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.

e. Schedules and Calendars shall comply with ASHRAE SP135/ BACnet Standard.

f. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.

g. The Controllers shall have capability to configure and implement optimal start and stop programming based on existing indoor and outdoor environmental conditions as well as equipment operating history

5. Password

a. Multiple-level password access protection shall be provided to allow the user/manager to User Interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.

b. Each user shall have the following: a user name (accept 24 characters minimum), a password (accept 12 characters minimum), and access levels.

c. The system shall allow each user to change his or her password at will.

d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.

e. A minimum of six levels of access shall be supported individually or in any combination as follows:
1) Level 1 = View Data
2) Level 2 = Command
3) Level 3 = Operator Overrides
4) Level 4 = Database Modification
5) Level 5 = Database Configuration
6) Level 6 = All privileges, including Password Add/Modify

f. A minimum of 100 unique passwords shall be supported.

g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.

h. Operators shall be further limited to only access, command, and modify those buildings, systems, and subsystems for which they have responsibility.

i. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

6. Screen Manager

a. The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

7. Dynamic Color Graphics

a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.

b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.

c. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.

d. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a User Interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
   1) All graphics shall be fully scalable
   2) The graphics shall support a maintained aspect ratio.
   3) Multiple fonts shall be supported.
   4) Unique background shall be assignable on a per graphic basis.
   5) The color of all animations and values on displays shall indicate the status of the object attribute.
   6) Graphics that represent buildings or systems shall allow natural links and transitions between related detailed tabular views of data that complement the graphic.

e. Operation from graphics – It shall be possible to change values (set points) and states in system controlled equipment directly from the graphic.

f. Floor Plan graphics – The User Interface shall provide graphic applications that summarize conditions on a floor. Floor plan graphics shall indicate thermal comfort using dynamic colors to represent zone temperature deviations from zone set point(s). Floor plan graphics shall display overall metrics for each zone in the floor.

8. Historical trending and data collection

   a. Each Controller shall store trend and point history data for all analog and digital inputs and outputs, as follows:

      1) Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:
         i. Defined time interval
         ii. Upon a change of value

      2) Each Controller shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

   b. Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time scheduled basis.

   c. The system shall provide a configurable data storage subsystem for the collection of historical data. Data can be stored in SQL database format.

9. Trend data viewing and analysis

a. Provide a trend viewing utility that shall have access to all database points.

b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.

c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends

d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.

e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. The Display shall support the user's ability to change colors, sample sizes, and types of markers.

10. Database Management

a. Where a separate SQL database is utilized for information storage the System shall provide a Database Manager that separates the database monitoring and managing functions by supporting two separate windows.

b. Database secure access shall be accomplished using standard SQL authentication including the ability to access data for use outside of the Building Automation application.

c. The database managing function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
   1) Backup
   2) Purge
   3) Restore

d. The Database management function shall support four tabs:

   1) Statistics – shall display Database Server information and Trend, Alarm (Event), and Audit information on the BAS Databases.

   2) Maintenance – shall provide an easy method of purging records from the BAS Server trend, alarm (event), and audit databases by supporting separate screens for creating a backup prior to purging, selecting the database, and allowing for the retention of a selected number of day's data.

   3) Backup – Shall provide the means to create a database backup file and select a storage location.

   4) Restore – shall provide a restricted means of restoring a database by requiring the user to log into an Expert Mode in order to view the Restore screen.

e. The database monitoring functions shall be accessed through Microsoft Windows and shall continuously read database information once the user has logged in.

f. The System shall provide user notification via taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.

g. The Monitoring Settings window shall have the following sections:

   1) General – Shall allow the user to set and review scan intervals and start times.

2) Email – Shall allow the user to create and review e-mail and phone text messages to be delivered when a Warning or Alarm is generated.

3) Warning – shall allow the user to define the Warning limit parameters, set the Reminder Frequency, and link the e-mail message

4) Alarm – shall allow the user to define the Alarm limit parameters, set the Reminder Frequency, and link the e-mail message.

5) Database login – Shall protect the system from unauthorized database manipulation by creating a Read Access and a Write Access for each of the Trend, Alarm (Event) and Audit databases as well as an Expert Mode required to restore a database.

h. The System shall provide user notification via Taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.

11. Demand Limiting and Load Rolling

a. The BAS shall:

1) Provide a Demand Limiting and Load Rolling program for the purpose of limiting peak energy usage and reducing overall energy consumption.

2) Support both Sliding Window and Fixed Window methods of predicting demand.

3) Support three levels of sensitivity in the Sliding Window demand calculations for fine tuning the system.

i. Low Setting – Sheds loads later and over the shortest amount of time. Maximizes the time the equipment is on.

ii. Medium Setting – Sheds loads earlier over a longer amount of time than the Low Setting. Increases the time the equipment is on and decreases the probability of exceeding the Tariff Target over the Low Setting.

iii. High Setting – Sheds loads earlier over a longer amount of time than the Medium Setting to minimize the probability of exceeding the Tariff Target.

4) Have both a Shed Mode and a Monitor Only Mode of operation.

i. When the Shed Mode is engaged, the BAS shall actively control the Demand.

ii. When the Monitor Mode is engaged, the BAS will simulate the shedding action but will not take any action.

5) Support a Maximum Shed Time for each load as determined by the user. The BAS shall restore the load before the Maximum Shed time has expired.

6) Support a Minimum Shed Time for each load as determined by the user. The BAS shall not restore the load sooner than the Minimum Shed Time has expired.

7) Support a Minimum Release Time for each load as determined by the user. The BAS shall not shed the load until it has been off for the Minimum Release time.

8) Support three user defined options if the meter goes unreliable.

i. Shedding – The currently shed loads will be released as their Maximum shed times expire.

ii. Maintain the Current Shed Rate – The BAS will use the Demand Limiting shed rate that was present when the meter went unreliable.

iii. Use Unreliable Meter Shed Rate – the BAS will control to a user defined Unreliable Shed Rate target.

b. The Demand Limiting program shall:

1) Monitor the energy consumption rate and compare it to a user defined Tariff Target. The system shall maintain consumption below the target by selectively shedding loads based upon a user defined strategy.

2) Be capable of supporting a minimum of 10 separate Load Priorities. Each load shall be user assigned to a Load Priority.

3) Be capable of supporting a minimum of 12 separate Tariff Targets defining the maximum allowed average power during the current interval.

c. The Load Rolling program shall:

1) Sum the loads currently shed and compare it to a user defined Load Rolling Target. The BAS shall maintain consumption below the target by selectively shedding loads based upon a user defined Load Priority.

2) Be capable of supporting a minimum of 10 separate Load Priorities. Each load shall be user assigned to a Load Priority.

3) Be capable of supporting a minimum of 12 separate Tariff Targets defining the amount of power by which the demand must be reduced.

d. Provide the user with a Load Tab that displays all of the Demand Limiting and Load Rolling parameters for any selected load.

e. Provide the user with a Load Summary that displays all of the loads associated with the Demand Limiting and Load Rolling programs. Status Icons for each load shall indicate:
1) Load is Offline
2) Load is Disabled
3) Load is Shed
4) Load is Locked
5) Load is in Comfort Override

f. The Load Summary shall include a Load Summary Runtime view listing the following load conditions:
1) Load Priority
2) Shed Strategy
3) Load Rating
4) Present Value
5) Ineligibility Status

6) Active Timer
7) Time Remaining
8) Last Shed Time

12. Other Utilities Software

a. The BAS shall be capable of supporting any other LAWA-approved utilities software, including, but not limited to Energy Star and Maximo.

2.4 DDC SYSTEM CONTROLLERS

A. Unitary Controller (UC)

1. General

a. The facility BAS shall include BTL-listed, microprocessor-based, direct digital control UCs.

b. UCs shall provide control of HVAC and other integrated controllable functions. Each controller shall have its own control programs and shall continue to operate in the event of a failure or communication loss to its associated DDCP.

c. UCs shall be provided for variable air volume (VAV) boxes and fan coil units as required to satisfy the sequences of operation.

d. VAV box UCs shall be provided with 120/24 Volt transformers (or as required/coordinated with mechanical specifications for operation) to the VAV box manufacturers for factory mounting.

e. UCs shall be programmable from either the FMCS workstations or by the Portable Terminal Unit connected locally. The necessary hardware and software required for communication with the UC, from either the FMCS (Servers) or via a Portable Operator Terminal Unit, shall be provided including licensing requirements.

f. The BACnet Protocol Implementation Statement shall be submitted for each type of the UC.

2. Components

a. Memory: Control programs shall be stored in battery backed-up RAM and EPROM. Each system controller shall have a minimum of 64 MB of user RAM memory and 64 MB of EPROM.

b. Communication Ports: UCs shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the DDCP online. It shall be possible from a service port on any UC to view, enable /disable, and modify values of any point or program on any controller on the local field bus, any DDCP or any UC on a different field bus.

c. I/O: Each UC shall support the addition of the following types of inputs and outputs:

1) Digital inputs for status and alarm contacts;

2) Counter inputs for summing pulses from meters;

3) Thermistor inputs for measuring temperatures in space, ducts, and thermo wells;

4) Analog inputs for pressure, humidity, flow, and position measurements;

5) Digital outputs for on and off equipment control; and

6) Analog outputs for valve and damper position control, and capacity control of primary equipment.

d. Expandability: Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two modules shall be added to the base UC before additional power is required.

e. Networking: Each UC shall be able to exchange information on a peer-to-peer basis with other Stand-alone Digital Control Units during each field bus scan. Each UC shall be capable of storing and referencing global variables (on the LAN) with or without any FMCS workstations online. Each UC shall be able to have its program viewed and/or enabled/disabled either locally through a BAS Portable Operator's Terminal or through a FMCS workstation.

f. Indicator Lamps: UCs shall have an optional, LED indication of CPU status, and field bus status.

g. Real-Time Clock. A UC shall have a real-time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The real-time clock shall provide the following information: time of day, day, month, year, and day of week. Each UC shall receive a signal, every hour, over the network from the DDCP that synchronizes all UC real-time clocks.

h. Automatic Restart after Power Failure: Upon restoration of power, the UC shall automatically and without human intervention, update all monitored functions; resume operation based on current, synchronized time and status; and implement special startup strategies as required.

i. Battery Back-Up: Each UC shall have at least three (3) years of battery backup to maintain all volatile memory. System shall be interfaced with the building UPS System.

j. Alarm Management.

1) For each system point, alarms can be created based on high and low limits or conditional expressions. All alarms shall be tested each scan of the UC and can result in the display of one or more alarm messages or reports.

2) Up to eight (8) alarms can be configured for each point in the controller, enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered.

3) Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.

4) If communication with the DDCP is temporarily interrupted, the alarm shall be buffered in the UC. When communications return, the alarm shall be transmitted to the DDCP if the point is still in the alarm condition.

B. System Software

1. General
    a. All necessary software to form a complete operating system as described in this specification shall be provided.
    b. The software programs specified in this section shall be provided as an integral part of the DDC controller and shall not be dependent upon any higher level computer for execution.
2. Control Software Description:
    a. Pre-Tested Control Algorithms: The DDC controllers shall have the ability to perform the following pre-tested control algorithms:
        1) Two Position Control
        2) Proportional Control
        3) Proportional plus Integral Control
        4) Proportional, Integral, plus Derivative Control
        5) Automatic Control Loop Tuning
    b. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
    c. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
    d. Power fail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation. (i.e. - Restart of equipment following the return to normal condition after equipment shutdown by the Fire Alarm System).
    e. Sequential Start: Provide sequential start for all equipment. After a power failure, and after restoration of normal power, equipment shall start per a predetermined sequence as programmed via the BAS.
3. Energy Management Applications: DDC controllers shall have the ability to perform any or all of the following energy management routines:
    a. Time-of-Day Scheduling
    b. Calendar Based Scheduling
    c. Holiday Scheduling
    d. Temporary Schedule Overrides
    e. Optimal Start/Optimal Stop
    f. Night Setback Control
    g. Enthalpy Switch Over (Economizer)
    h. Peak Demand Limiting
    i. Energy Usage & Demand
    j. Fan Speed/CFM Control
    k. Heating/Cooling Interlock
    l. Supply Air Reset
    m. Chilled Water Reset

n. Condenser Water Reset
o. Hot Water Reset
p. Chiller Sequencing

4. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. Programs shall be applied to building equipment as described in the Execution portion of this specification.

5. Custom Process Programming Capability: DDC controllers shall be able to execute custom, job-specific processes defined by the operator, to automatically perform calculations and special control routines.

   a. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:

      1) Any system-measured point data or status
      2) Any calculated data
      3) Any results from other processes
      4) User-Defined Constants
      5) Arithmetic functions (+,-,*, /, square root, exponential, etc.)
      6) Boolean logic operators (and, or, exclusive or, etc.)
      7) On-delay/Off-delay/One-shot timers

   b. Process Triggers: Custom processes may be triggered based on any combination of the following:

      1) Time interval
      2) Time of day
      3) Date
      4) Other processes
      5) Time programming
      6) Events (e.g., point alarms)
      7) Restart of equipment following the return to normal condition after equipment shutdown by the Fire Alarm System (FAS)

6. Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from any and all other DDC controllers on the local area network. In addition, a single process shall be able to issue commands to points in any and all other DDC panels on the local area network.

7. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer.

8. Custom Process Documentation: The custom control programming feature shall be self-documenting. All interrelationships defined by this feature shall be documented via graphical flowcharts and English language descriptors.

9. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC controller shall perform distributed independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network. Each analog input shall have associated alarm and pre-alarm (warning) levels that are software adjustable. Provide a minimum of one high alarm, one high warning alarm, one low alarm and one low warning alarm level per analog input.

    a. Point Change Report Description: All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

    b. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Each DDC shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point as well as be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

    c. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices or PC disk files used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

    d. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a minimum 65-character alarm message to more fully describe the alarm condition or direct operator response. Each standalone DDC shall be capable of storing a library of at least 250 Alarm Messages which are assignable to any number of points in the panel.

    e. Auto-Dial Alarm Management: In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

    f. Transaction Logging: Operator commands and system events shall be automatically logged to disk in Personal Computer industry standard database format. Operator commands initiated from Direct-connected workstations, dial-up workstations, and local DDC panel Network Terminal devices shall all be logged to this transaction file. This data shall be available at the Operator Interface Workstation (OIW). Facility shall be provided to allow the user to search the transaction file using standard database query techniques, including searching by dates, operator name, data point name, etc. In addition, this transaction file shall be accessible with standard third party database and spreadsheet packages.

10. Historical Data and Trend Analysis: A variety of historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways:

a. Continuous Point Histories: Standalone DDC's shall store Point History Files for all analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be stored for the past 24 hours to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point.

b. Control Loop Performance Trends: Standalone DDC's shall also provide high resolution sampling capability in one-second increments for verification of control loop performance.

c. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 2 hours shall be provided. Each standalone DDC shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 5000 data samples.

d. Data Storage and Archiving: Trend data shall be stored at the Standalone DDC's, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file format compatible with Third Party personal computer applications.

11. Runtime Tantalization: Standalone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.

    a. The Tantalization routine shall have a sampling resolution of one minute or less.

    b. The user shall have the ability to define a warning limit for Runtime Tantalization. Unique, user-specified messages shall be generated when the limit is reached.

12. Analog/Pulse Tantalization: Standalone DDC's shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

    a. Tantalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons. etc.).

    b. The Tantalization routine shall have a sampling resolution of one minute or less.

    c. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

13. Event Totalization: Standalone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event Totalization shall be performed on a daily, weekly, or monthly basis.

    a. The Event Tantalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

    b. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

C. VAV TERMINAL UNIT CONTROLLER (VAV - UC)

1. General: Ship VAV UC Controllers to terminal box manufacturer's factory for controller mounting prior to shipping to site. Coordinate with Box manufacturer.
2. The VAV UC shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units.
3. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.
4. The VAV UC shall be a configurable digital controller with an integral differential pressure transducer. It shall be compatible with 3 wire (incremental) and proportional damper actuators.
5. The VAV UC shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
6. Each VAV UC shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
7. The VAV UC shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
8. Each VAV UC shall have tune control algorithms to improve control and controller reliability through reduced actuator duty cycle. The VAV UC shall provide the ability to download and upload UC configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
9. UC control set point changes initiated over the network shall be written to UC non-volatile memory to prevent loss of set point changes and to provide consistent operation in the event of communication failure.
10. The VAV UC firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.
11. The VAV UC shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
12. The VAV UC shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow set points.
13. The VAV UC shall be capable of direct electronic connection to a balancing hood. Connection shall be through a port located on the room sensor, or directly at the controller. As an alternative, software balancing tools shall be provided that will run in a hand-held Palm Pilot type PC (such as the 3COM Palm Pilot or IBM Workpad). The balancing tools shall allow adjustment of airflow set points and parameters, and provide permanent upload of the values entered to the UC. The Palm Pilot shall connect to the terminal unit through the room sensor port.
14. The VAV UC performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each

control loop's sample interval, which may be used to continuously monitor and document system performance. The UC shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.

a. Absolute temperature loop error.
b. Signed temperature loop error.
c. Absolute airflow loop error.
d. Signed airflow loop error.
e. Average damper actuator duty cycle.

15. The VAV UC shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:

a. Unreliable space temperature sensor.
b. Unreliable differential pressure sensor.
c. Starved box.
d. Insufficient cooling.
e. Insufficient heating.

16. The VAV UC shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow based on the percent of outdoor air in the primary air stream.

17. The VAV UC shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

18. The VAV UC shall be compatible with the U.S. EPA Energy Star Buildings recommendations for fan energy reduction via demand-based static pressure reset down to 2/3 of duct static pressure set point, "VSD 2/3 Reset."

19. Inputs:

a. Analog inputs shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

1) 0-10 VDC Sensors
2) 4-20 mA Sensors
3) 1000ohm RTDs
4) NTC Thermistors

b. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input "bouncing."
c. For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.

20. Outputs

a. Analog outputs shall provide the following control outputs:

1) 0-10 VDC
2) 4-20 mA

b. Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.

c. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.

2.5 FIELD DEVICES

A. Input/Output Module **(IOM)**

1. The Input/Output Module (IOM) provides additional inputs and outputs for use in the UC.
2. The IOM shall communicate with the UC over the Bus.
3. The IOM shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
   a. The IOM shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
   b. The IOM shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
   c. A BACnet Protocol Implementation Conformance Statement shall be provided for the UC or FC.
   d. The Conformance Statement shall be submitted 10 days prior to bidding.
4. The IOM shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
5. The IOM shall have a minimum of 4 points to a maximum of 17 points.
6. The IOM shall support the following types of inputs and outputs:
   a. Universal Inputs - shall be configured to monitor any of the following:
      1) Analog Input, Voltage Mode
      2) Analog Input, Current Mode
      3) Analog Input, Resistive Mode
      4) Binary Input, Dry Contact Maintained Mode
      5) Binary Input, Pulse Counter Mode
   b. Binary Inputs - shall be configured to monitor either of the following:
      1) Dry Contact Maintained Mode
      2) Pulse Counter Mode
   c. Analog Outputs - shall be configured to output either of the following
      1) Analog Output, Voltage Mode
      2) Analog Output, current Mode
   d. Binary Outputs - shall output the following:
      1) 24 VAC Triac
   e. Configurable Outputs - shall be capable of the following:
      1) Analog Output, Voltage Mode
      2) Binary Output Mode
7. The IOM shall include troubleshooting LED indicators to identify the following conditions:
   a. Power On

b. Power Off

c. Download or Startup in progress, not ready for normal operation

d. No Faults

e. Device Fault

f. Normal Data Transmission

g. No Data Transmission

h. No Communication

B. Terminal Controller (TC)

1. The TC shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters or other similar equipment, pressure dependent Variable Air Volume System or other similar zoning type systems employing reheat including local hydraulic reheat valves, two pipe fan coil, cabinet unit heater or other similar equipment with single-speed fan control.

2. The TC shall communicate over the Field Controller Bus using BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.

3. The TC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

   a. The TC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).

   b. A BACnet Protocol Implementation Conformance Statement shall be provided for the TC.

   c. The Conformance Statement shall be submitted 10 days prior to bidding.

4. The TC shall support remote read/write and parameter adjustment from the web based User Interface through a Network Automation Engine.

5. The TC shall include an intuitive User Interface providing plain text messages.

   a. Two line, 8 character backlit display

6. The TC shall provide the flexibility to support any one of the following inputs:

   a. Integral Indoor Air Temperature Sensor

   b. Duct Mount Air Temperature Sensor

   c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator

   d. Two configurable binary inputs

7. Provide the flexibility to support any one of the following:

   a. Three Speed Fan Control

   b. Two On/Off

   c. Two Floating

   d. Two Proportional (0 to 10V)

8. The TC shall provide a minimum of six (6) levels of keypad lockout.
9. The TC shall provide the flexibility to adjust the following parameters:
    a. Adjustable Temporary Occupancy from 0 to 24 hours
    b. Adjustable heating/cooling deadband from 2º F to 5º F
    c. Adjustable heating/cooling cycles per hour from 4 to 8
10. Where required by application and indicated on plans or room schedules provide the TEC with an integral Passive Infra-Red (PIR) occupancy sensor.
11. The TC shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.
12. The VMA shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units. It shall address both single and dual duct applications.
13. The VMA shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
    a. The VMA shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
    b. A BACnet Protocol Implementation Conformance Statement shall be provided for the VMA.
    c. The Conformance Statement shall be submitted. The VMA shall communicate over the FC Bus using BACnet Standard protocol SSPC-135, Clause 9.
14. The VMA shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.
15. The VMA shall be a configurable digital controller with integral differential pressure transducer. All components shall be connected and mounted as a single assembly that can be removed as one piece.
16. The VMA shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
17. The controller shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
18. Each controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
19. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
20. Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
21. The controller shall provide the ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be

loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.

22. Control set point changes initiated over the network shall be written to VMA non-volatile memory to prevent loss of set point changes and to provide consistent operation in the event of communication failure.

23. The controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.

24. The controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.

25. The controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow set points.

26. Controller performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The VMA shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.

    a. Absolute temperature loop error

    b. Signed temperature loop error

    c. Absolute airflow loop error

    d. Signed airflow loop error

    e. Average damper actuator duty cycle

27. The controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:

    a. Unreliable space temperature sensor

    b. Unreliable differential pressure sensor

    c. Starved box

    d. Actuator stall

    e. Insufficient cooling

    f. Insufficient heating

28. The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The VMA would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.

29. The controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow Based on the percent of outdoor air in the primary air stream.

30. The controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires

reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

31. Inputs:

    a. Analog inputs with user defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

        1) 0-10 VDC Sensors

        2) 1000ohm RTDs

        3) NTC Thermistors

    b. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input "bouncing."

    c. For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.

    d. Provide side loop application for humidity control.

32. Outputs

    a. Analog outputs shall provide the following control outputs:

        1) 0-10 VDC

        2) 4-20 mA.

    b. Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.

    c. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.

33. Application Configuration

    a. The VMA shall be configured with a software tool that provides a simple Question/Answer format for developing applications and downloading.

34. Sensor Support

    a. The VMA shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.

    b. The VMA shall support an LCD display room sensor.

    c. The VMA shall also support standard room sensors as defined by analog input requirements.

    d. The VMA shall support humidity sensors defined by the AI side loop.

C. Installation, testing, and calibration of all devices shall be provided to meet the system requirements.

2.6 INPUT DEVICES

A. General Requirements:

1. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.

2. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 10k ohm type 2 thermistor, platinum RTD.

3. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Chilled Water	± .5°F.
Room Temp	± .5°F.
Duct Temperature	± .5°F.
All Others	± .75°F.

B. Room Temperature Sensors

1. Room sensors shall be constructed for either surface or wall box mounting.

2. Room sensors shall have the following options when specified:

a. Set point reset slide switch providing a ±3 degree (adjustable) range.

b. Individual heating/cooling set point slide switches.

c. A momentary override request push button for activation of after-hours operation.

d. Analog thermometer.

C. Room Temperature Sensors with Integral Display

1. Room sensors shall be constructed for either surface or wall box mounting.

2. Room sensors shall have an integral LCD display, humidity sensor and four button keypad with the following capabilities:

a. Display room and outside air temperatures.

b. Display and adjust room comfort set point.

c. Display and adjust fan operation status.

d. Timed override request push button with LED status for activation of after-hours operation.

e. Display controller mode.

f. Password selectable adjustment of set point and override modes.

g. Display room humidity.

D. Thermo Wells

1. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.

2. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.

3. Thermo wells and sensors shall be mounted in a threadolet or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.

4. Thermo wells shall be constructed of 316 stainless steel.

E. Outside Air Sensors

1. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
2. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
3. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

F. Duct Mount Sensors

1. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
2. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
3. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

G. Averaging Sensors

1. For ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.
2. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment
3. Acceptable Manufacturers: Alerton, Johnson Controls, Siemens

H. Humidity Sensors

1. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
2. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
3. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg. F unless specified elsewhere.
4. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with steatite fittings and stainless steel bushings.
5. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
6. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

7. Acceptable Manufacturers: Veris Industries, and Mamac.

I. Differential Pressure Transmitters

1. General Air and Water Pressure Transmitter Requirements:

   a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

   b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.

   c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Mechanical Contractor and LAWA permanent, easy-to-use connection.

   d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

2. Low Differential Water Pressure Applications (0” - 20” wc)

   a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.

   b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

      1) .01-20” wc input differential pressure range.

      2) 4-20 mA output.

      3) Maintain accuracy up to 20 to 1 ratio turndown.

      4) Reference Accuracy: +0.2% of full span.

   c. Acceptable Manufacturers: Setra and Mamac.

3. Medium to High Differential Water Pressure Applications (Over 21” wc)

   a. The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:

      1) Differential pressure range 10” wc to 300 psi.

      2) Reference Accuracy: $\pm$1% of full span (includes non-linearity, hysteresis, and repeatability).

   b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

   c. Acceptable Manufacturers: Setra, Mamac, Rosemount.

4. Building Differential Air Pressure Applications (-1" to +1" wc)
    a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
    b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
        1) -1.00 to +1.00 wc input differential pressure ranges. (Select range appropriate for system application)
        2) 4-20 mA output.
        3) Maintain accuracy up to 20 to 1 ratio turndown.
        4) Reference Accuracy: +0.2% of full span.
    c. Acceptable Manufacturers: Johnson Controls, Siemens and Setra.
5. Low Differential Air Pressure Applications (0" to 5" wc)
    a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
    b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
        1) (0.00 - 1.00" to 5.00") wc input differential pressure ranges. (Select range appropriate for system application.)
        2) 4-20 mA output.
        3) Maintain accuracy up to 20 to 1 ratio turndown.
        4) Reference Accuracy: +0.2% of full span.
    c. Acceptable Manufacturers: Johnson Controls, Siemens and Setra.

6. Indoor Air Quality (CO2) Sensors- Wall and Duct Mounted
    a. Provide indoor air quality sensors to monitor Carbon Dioxide (CO2). The sensors shall be of microprocessor-based photo-acoustic type with heated stannic dioxide semiconductor.
    b. The CO2 sensors shall have no more than 1% drift during the first year of operation and minimal drift thereafter so that no calibration will be required.
    c. The units shall be wall or duct mounted type as indicated on plans and in the sequence of operation.
    d. Wall mounted sensors shall be provided with white plastic cover, without LED indicators.

e. Duct mounted sensors shall be provided with LED indicators in a dust proof plastic housing with transparent cover.

f. The sensor shall meet the following requirements:

1) Operating voltage: 24 VAC +/- 20%

2) Frequency: 50/60 Hz

3) Power consumption: max. 6 VA

4) CO2 measuring range:0 – 2000 ppm

5) Tolerance: +/- 100 ppm

6) Output: 0 – 10 VAC

7) Calibration: none required

8) Permissible air velocity in duct: <26.2 Ft/s.

9) The sensors shall be model: Siemens QPA63 Series, Johnson Controls, Honeywell or approved equal

7. Carbon Monoxide (CO) Transmitter

a. Sensor assemblies to be rated general purpose and suitable for N.E.C. installation. (NEMA 1 enclosure).

b. Carbon monoxide analyzer shall be capable of measurement in the range of 0-500 parts per million with 4-20 mA output. (7000 to 9000 square feet per sensor).

c. Operating temperature: -15 deg C to 40 deg C

d. Stability: ±1%

e. Repeatability: less than ±2% full scale

f. Manufacturer: Sensor shall be Brasch gas detector or as approved by the Engineer

8. Medium Differential Air Pressure Applications (5” to 21” wc)

a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressures transmitters shall be provided that meet the following performance requirements:

1) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.

2) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 psig.

3) Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).

b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

c. Acceptable manufacturers: Johnson Controls, Siemens and Setra.

J. Flow Monitoring

1. Air Flow Monitoring

a. AHU Fan Inlet Air Flow Measuring Stations

1) At the inlet of each fan and near the exit of the inlet sound trap, airflow sensors which continuously monitor the fan air volumes and system velocity pressure shall be provided. The AHU air flow measuring stations and the transmitters are to be provided and installed by the AHU manufacturer.

2) Each sensor shall be surface mount type. Unit shall be capable of monitoring and reporting the airflow and temperature at each fan inlet location through two or four sensing circuits. If a static pressure manifold is used, it shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as $\pm$ 20° in the approaching air stream.

3) Devices creating fan performance degradation, resulting in additional energy consumption, caused from pressure drop associated with probes or mounting apparatus in the center of the fan inlet are not allowed. The device shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Sensor circuit casings shall be constructed of U.L. 94 flame rated high impact ABS and include a stainless steel thermistor cap that maintains the precise calibrated flow over the heated and ambient measurement points. Each sensor circuit shall consist of two ceramic base, glass encapsulated, thermistors for measuring ambient temperature and velocity. Circuit shall be designed for operation in a wide range of environments, including high humidity and rapid thermal cycling.

4) Acceptable manufacturers are: Johnson Controls, Air Monitor Corp., Tek-Air Systems, Inc., or Dietrich Standard.

b. Single Probe Air Flow Measuring Sensor

1) The single probe airflow-measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a hot wire anemometer and utilize two temperature sensors and a heater element temperature. The other sensor shall measure the downstream air temperature. The temperature differential shall be directly related to airflow velocity.

c. Duct Air Flow Measuring Stations

1) Furnish and install, at locations shown on plans or as in accordance with schedules, an equalized air measuring probe system piped to a high performance pressure transducer or an electronic type airflow temperature measuring station.

2) Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the

ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.

3) Assembly shall be AMCA tested and capable of measuring a range from 70 to 5,000 FPM (22 to 2224 MPM).

4) Equalized air measuring assembly shall measure to ±3% average and consist of 6063T5 extruded aluminum step sensing blade(s) with anodized finish, plenum-rated polyethylene pressure tubing, brass barbed fittings, mounting hardware and a glass-on-silicone capacitance sensor pressure transducer capable of measuring up to six field-selectable pressure ranges up to 1 inch wc

5) The transducer shall be accurate to ±1% of full scale and be contained in a National Electrical Manufacturer's Association (NEMA) 4 (IP-65) enclosure. Transducer shall be factory mounted and piped to high and low pressure ports through fittings made of brass.

6) All sensor tubing shall terminate in solid brass barbed fittings.

7) Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.

8) Air straightener shall be provided for sizes over 17 square feet (1.6 sq meters).

9) Airflow measuring station assemblies shall be fabricated of galvanized steel or aluminum casing of appropriate thickness for slip fits or with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air direction analyzer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 6000 feet per minute. This air direction analyzer and parallel cell honeycomb suppressor shall provide 98% free area, equalize the velocity profile, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.

10) Electronic air measuring station shall be capable of monitoring and reporting the airflow and temperature at each measuring location through one or more measuring probes containing multiple sensor points and a control transmitter that communicates with the BAS.

11) Probe(s) shall be constructed of an airfoil shaped aluminum extrusion containing the sensor circuit(s).

12) Each sensor circuit shall consist of coated thermistors, for temperature and velocity, mounted to a Printed Circuit Board (PCB).

13) Probe multiplexer circuit(s) shall include a microprocessor that collects data from each PCB and digitally communicates the average airflow and temperature of each probe to a microprocessor based control transmitter.

14) Multiplexer board shall be encased to prevent moisture damage.

15) Shielded CAT5e communications cable shall be Underwriters Laboratories Inc.® (UL) plenum-rated with RJ45 terminal connectors. Dust boot covers and gold-plated contacts shall link probes to electronic controller.

16) Control transmitter shall be capable of processing independent sensing points and shall operate on a fused 24 VAC supply.

17) Control transmitter shall feature a 16 x 2 character alphanumeric LCD screen, digital offset/gain adjustment, continuous performing sensor/transmitter diagnostics, and a visual alarm to detect malfunctions.

18) All electronic components of the assembly shall be Restriction of Hazardous Substances (RoHS) Directive compliant.

19) Installation Considerations

i. The maximum allowable pressure loss through the Flow and Static Pressure elements shall not exceed .065" wc at 1000 feet per minute, or .23" wc at 2000 feet per minute. Each unit shall measure the airflow rate within an accuracy of plus 2% as determined by U.S. – GSA certification tests, and shall contain a minimum of one total pressure sensor per 36 square inches of unit measuring area.

ii. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

iii. Where control dampers are shown as part of the airflow measuring station, parallel blade precision controlled volume dampers integral to the station and complete with actuator, and linkage shall be provided.

iv. Stations shall be installed in strict accordance with the manufacturer's published requirements, and in accordance with ASME Guidelines affecting non-standard approach conditions.

20) All air measuring devices shall be tested according to AMCA Standard 610

21) Acceptable manufacturers: Johnson Controls, Air Monitor Corp., Tek-Air, and Dietrich Standard.

d. Static Pressure Traverse Probe

1) Duct static probes shall be provided where required to monitor duct static pressure. Acceptable manufacturers: Cleveland Controls

2. Water Flow Monitoring

a. Water flow meters shall be electromagnetic type with integral microprocessor-based electronics. The meter shall have an accuracy of 0.25%.

b. Acceptable manufacturers: Onicon

K. Power Monitoring Devices

1. Current Measurement (Amps)

a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.

b. Current Transformer – A split core current transformer shall be provided to monitor motor amps.

1) Operating frequency – 50 - 400 Hz.

2) Insulation – 0.6 Kv class 10Kv BIL.

3) UL recognized.

4) Five amps secondary.

5) Select current ration as appropriate for application.

6) Acceptable manufacturers: Veris Industries

c. Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:

1) 6X input over amp rating for AC inrushes of up to 120 amps.

2) Manufactured to UL 1244.

3) Accuracy: +.5%, Ripple +1%.

4) Minimum load resistance 30kOhm.

5) Input 0-20 Amps.

6) Output 4-20 mA.

7) Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

8) Acceptable manufacturers: Veris Industries

L. Refrigerant Leak Detectors

1. The refrigerant leak detector shall be a standalone device and shall provide a SPDT output to directly energize the refrigeration room exhaust ventilation fans. The detector shall include a sensor or sensors connected to a control panel. Two relay contacts at the control panel shall provide trouble and alarm indication to the Facility Management System. The alarm relay contact shall also directly energize the exhaust fans.

2. The refrigerant leak detector shall sense the type of refrigerant used in the specified chillers. Multiple sensors shall be required to detect different refrigerants and/or

provide proper sensing coverage for the area of the refrigeration room.

3. Acceptable manufacturers, MSA Instruments

M. Status and Safety Switches

1. General Requirements

a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BAS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. Current Sensing Switches

   a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.

   b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.

   c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

   d. Acceptable manufacturers: Veris Industries

3. Air Filter Status Switches

   a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.

   b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.

   c. Provide appropriate scale range and differential adjustment for intended service.

   d. Acceptable manufacturers: Cleveland Controls

4. Air Flow Switches

   a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

   b. Acceptable manufacturers: Cleveland Controls

5. Air Pressure Safety Switches

   a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.

   b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.

   c. Acceptable manufacturers, Cleveland Controls

6. Water Flow Switches

   a. Water flow switches shall be equal to the Johnson Controls P74.

7. Low Temperature Limit Switches

a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.

b. The sensing element shall be a minimum of 22 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.

c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

d. The low temperature limit switch shall be Johnson Controls A70, Honeywell, and Siemens.

8. BTU Monitoring Devices

a. BTU Meter: (Chilled water and Hot Water Applications): Provide an ONICON System-10 BTU Meter. The BTU meter shall provide the following information via both an integral LCD and via serial network communications (protocol conforming to BACnet): Energy Total, Energy Rate, Flow Total, Flow Rate, Supply Temperature and Return Temperature. Each BTU meter shall be factory programmed for its specific application, and shall be re-programmable using the front panel keypad (no special interface device or computer required). Provide the following with each BTU meter application:

b. Temperature sensors: Temperature sensors shall be loop-powered current based (mA) sensors and shall be bath-calibrated and matched (NIST* traceable) for the specific temperature range for each application. The calculated differential temperature used in the energy calculation shall be accurate to within $\pm 0.15^{0}$F (including the error from individual temperature sensors, sensor matching, input offsets, and calculations).

c. Ultrasonic Flow Meter: The flow meter shall be a clamp-on, dual channel or dual path transit-time precluding the requirement of penetrating into the pipe. The dual channel operating mode shall be capable of acting as two independent meters with the ability to perform math functions between the two channels (add or subtract). The dual path operating mode will eliminate the effects of flow profile distortion, cross flow or swirl errors caused by upstream interference or pumping irregularities. The flow meter shall be completely microprocessor based utilizing the transit-time flow measurement technique. The flow meter shall employ the phase detection multiple pulse transmit principle in conjunction with multiple frequency axial beam transducer technology to insure operation on liquids with solids and/or bubbles. In addition, the flow meter shall incorporate an alternate Doppler method measurement mode for highly aerated or heavy solid bearing liquids.

d. The flow meter shall provide automatic transducer spacing utilizing a Universal Mounting Frame or mounting track. The meter shall also provide automatic Reynolds Number and liquid sonic velocity variation compensation and live zero flow as well as the ability to zero flow automatically at programmed intervals. The flow meter shall have the ability to indicate flow rate, flow velocity, total flow, signal strength, liquid sonic velocity, Reynolds Number and liquid aeration level for both channels and paths. The flow meter shall also have the ability to be programmed to compensate for specific upstream profile disturbances. The

flow meter shall be equipped with an integral front panel keypad and multifunction 240 x 128 pixel LCD display with the ability of displaying both channels and paths simultaneously. In addition, the flow meter shall provide self and application diagnostics to isolate any fault conditions to either equipment failure or abnormal process conditions. The flow meter shall have full HELP menu routines corresponding to all levels of programming and operation.

e. The flow meter electronics shall be housed in a NEMA 4X enclosure and powered by 115 VAC, 60 Hz. One (1) isolated 4 to 20 ma DC and one (1) 0 to 5,000 Hz. pulse output proportional to flow shall be provided for each channel or the average of both paths. In addition, the unit shall provide one (1) 0 to 10 volt output and four (4) SPDT alarm relays assignable to flow velocity, liquid sonic velocity, signal strength or liquid aeration. An internal 250 KB data logger shall be provided to allow storage of all measured and calculated variables and alarms. A bi-directional RS-232 connection shall be provided to allow remote programming and interrogation.

f. The flow meter shall have an accuracy of ±1% of flow over a ±40 fps flow range. Repeatability shall be 0.1% of flow with a flow sensitivity of 0.001 fps at any flow rate including no flow conditions.

g. Flow meters that employ amplitude detection/correlation routines or use a single frequency transducer design will not be acceptable. Shear mode flow meters or meters utilizing wetted transducers or electrodes, or flow-measuring techniques other than previously described will not be acceptable.

h. By use of either transit-time or Doppler modes of operation, the flow meter shall be capable of measuring all liquids in full sonically conductive pipes. Flow meters that simply offer standalone transit-time or Doppler measurement modes are not acceptable.

i. The furnished flow meter shall be Controlotron, Model 1010DN, Panametrics or as approved by the Engineer.

2.7 OUTPUT DEVICES

A. Actuators

1. General Requirements

a. Damper and valve actuators shall be electronic and/or pneumatic, as specified.

2. Electronic Damper Actuators

a. Electronic damper actuators shall be direct shaft mount.

b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, or a gear release to allow manual positioning.

c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 22 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper assembly shall be wired back to the BAS Controller.

d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds.

e. Acceptable manufacturers: Belimo, Mamac.

3. Electronic Valve Actuators

a. Electronic valve actuators shall be manufactured by the valve manufacturer.

b. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

c. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized based on the valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

f. Acceptable manufacturers: Belimo

B. Control Relays

1. Control Pilot Relays
    a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
    b. Mounting Bases shall be snap-mount.
    c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
    d. Contacts shall be rated for 10 amps at 120VAC.
    e. Relays shall have an integral indicator light and check button.
    f. Acceptable manufacturers: Johnson Controls, Honeywell, ASCO or Lectro
2. Lighting Control Relays
    a. Lighting control relays shall be latching with integral status contacts.
    b. Contacts shall be rated for 20 amps at 277 VAC.
    c. The coil shall be a split low-voltage coil that moves the line voltage contact armature to the ON or OFF latched position.
    d. Lighting control relays shall be controlled by:
        1) Pulsed Tri-state Output – Preferred method.
        2) Pulsed Paired Binary Outputs.
        3) A Binary Input to the BAS shall monitor integral status contacts on the lighting control relay. Relay status contacts shall be of the “dry-contact” type.
    e. The relay shall be designed so that power outages do not result in a change-of-state, and so that multiple same state commands will simply maintain the commanded state. Example: Multiple OFF command pulses shall simply keep the contacts in the OFF position.

C. Control Valves (PICV)
1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the BAS contractor, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Section.
2. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer’s recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 psi. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 psi. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than

5 psi. Valves for terminal reheat coils shall be sized for a 2 psig pressure drop, but no more than a 5 psi drop.

3. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.

4. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.

5. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

6. Acceptable manufacturers: Belimo

D. Electronic/Pneumatic Transducers

1. Pneumatic transducers shall provide:

   a. Output: 3-Div 22 psig.

   b. Input: 4-20 mA or 0-10 VDC.

   c. Manual output adjustment.

   d. Pressure gauge.

   e. External replaceable supply air filter.

   f. Acceptable manufacturers: Mamac

E. Local Control Panels

1. All control panels shall be constructed by a UL certified panel manufacturer, incorporating the BAS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with sub-panel, hinged door, and lock.

2. In general, the control panels shall consist of the DDC controllers and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function.

3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.

4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed 300-volt service and provide adequate clearance for field wiring.

5. All wiring shall be neatly installed in plastic trays or tie-wrapped.

6. A 120 volt convenience outlet, fused on/off power switch, and required transformers shall be provided in each enclosure.

F. Power Supplies

1. Required AC or DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
2. Input: 120 VAC +10%, 60Hz.
3. Output: 24 VAC or VDC as required.
4. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
5. A power disconnect switch shall be provided next to the power supply.

G. Thermostats

1. Electric room thermostats of the heavy-duty type shall be provided by Mechanical Contractor for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

PART 3 – EXECUTION

3.1. BAS SPECIFIC REQUIREMENTS

A. Programming

1. All terminal BAS programming (excluding the FMCS) shall be by a LAWA approved contractor listed below.
   a. Johnson Controls: Main Office 562.594.3200
   b. Siemens Industry: Main Office 714.761.2200
   c. Alerton Climatec: Office 949.474.0955
2. The technician shall be experienced in programming the system and have certificates demonstrating that they have completed the required training courses

B. Provision of Supervisory Controllers

1. When installing new control devices and points ensure that the Controller serving the area has sufficient capacity. If Controller utilization is over 80% provide and install a new any required point expansion modules.

C. Tenant Sub Metering

1. Each service in a tenant space shall be metered and BACnet connection of pulsed output from the meter shall be tied into the BAS for tenant billing purposes. Metered services shall include:

a. Heating Hot Water – Onicon electromagnetic BTU Meter with BACnet connection

b. Chilled Water – Onicon electromagnetic BTU Meter with BACnet connection

c. Gas – Meter shall be provided by the Section 22000 plumbing contractor with a BACnet connection or pulsed output.

d. Electricity – Meter shall be provided by the Electrical Contractor with a BACnet connection.

D. Graphic Displays

1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

E. Actuation / Control Type

1. Primary Equipment

a. Controls shall be provided by equipment manufacturer as specified herein.

b. Each damper and valve actuation shall be electric.

2. Air Handling Equipment

a. Each air handers shall be controlled with dedicated HVAC-DDC Controller

b. The AHU BAS controls shall be factory installed.

c. All damper and valve actuation shall be electric.

3. Terminal Equipment:

a. Each terminal Units (VAV, UV, etc.) shall be controlled with dedicated electric damper and valve actuation.

b. All Terminal Units shall be controlled with HVAC-DDC Controller)

c. Terminal unit BAS controls shall be factory installed.

F. The BAS system shall monitor common alarm, common trouble and common supervisory condition from the Fire Life Control System.

3.2. INSTALLATION PRACTICES

A. BAS Wiring

1. All low voltage conduit, wiring, accessories and wiring connections required for the installation of the Building Automation System, as herein specified, shall be provided by the BAS Contractor. All wiring shall comply with the requirements of applicable portions of Design and Construction Handbook Electrical Section and all local and national electric codes, unless specified otherwise in this section.

2. All BAS wiring materials and installation methods shall comply with BAS manufacturer recommendations.

3. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BAS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BAS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

4. Class 2 Wiring

   a. All Class 2 (24VAC or less) wiring shall be installed in conduits. The VAV shall be supplied with 24VAC power.

5. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.

6. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

7. Notify LAWA FMCS SA within 72 hours of when terminal BAS contractor is acknowledging that the BAS data is available to be integrated into the FMCS. Terminal BAS BACnet system shall be fully capable of auto-discovery by the FMCS BACnet system.

B. BAS Line Voltage Power Source

1. 120-volt AC circuits used for the Building Automation System shall be taken from panel boards and circuit breakers provided by Electrical Contractor.

2. Circuits used for the BAS shall be dedicated to the BAS and shall not be used for any other purposes.

3. DDC terminal unit controllers may use AC power from motor power circuits.

C. BAS Conduits

1. All wiring shall be installed in conduit or raceway. Minimum control wiring conduit size 3/4”.

2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by LAWA in writing.

3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.

4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 6 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

D. Penetrations

BAS Contractor shall:

1. Provide fire stopping for all conduits and raceways penetrations through fire-rated walls and/floors

2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.

3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.

4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

E. BAS Identification Standards

1. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location. Cable types specified in Item A shall be color coded for easy identification and troubleshooting. BAS Contractor shall submit color coding legend to LAWA for approval prior to installation.

2. The conduits shall be painted in 50 feet intervals with Navy Blue paint. The junction box covers shall be painted with Navy Blue paint.

F. BAS Panel Installation

1. The BAS controls components such as communication modules, hubs, servers, controllers, network connections, etc. shall be mounted in cabinets. Cabinets shall have hinged doors. Cabinets in the indoor dry location shall confirm to NEMA 1 standards. Cabinets in the damp locations (pump rooms) shall be steel construction with baked enamel coating and shall confirm to NEMA 3R standards. Cabinets in the outdoor location shall be of a stainless steel construction and shall confirm to NEMA 3R standards.

2. The BAS contractor shall be responsible for coordinating panel locations with other trades and Electrical and Mechanical Contractors and LAWA.

3. The BAS panel shall be equipped with the minimum 500 VA UPS.

G. Input Devices

1. All Input devices shall be installed per the manufacturer recommendation

2. Locate components of the BAS in accessible local control panels wherever possible.

H. HVAC Input Devices – General

1. All Input devices shall be installed per the manufacturer recommendation

2. Locate components of the BAS in accessible local control panels unless otherwise approved in writing by LAWA.

3. The Mechanical Contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.

4. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.

5. Outside Air Sensors

a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions

accurately. If access to the North wall is limited, the sensor may be installed in the AHU outside intake air duct when approved in writing by LAWA.

b. Sensors shall be installed with a rain proof, perforated cover.

6. Water Differential Pressure Sensors

   a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.

   b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.

   c. The transmitters shall be installed in an accessible location unless otherwise approved in writing by LAWA.

7. Medium to High Differential Water Pressure Applications (Over 21" wc):

   a. Air bleed units, bypass valves and compression fittings shall be provided.

8. Building Differential Air Pressure Applications (-1" to +1" wc):

   a. Transmitter's exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.

   b. The interior tip shall be inconspicuous and located as shown on the drawings.

9. Air Flow Measuring Stations:

   a. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.

   b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

10. Duct Temperature Sensors:

    a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

    b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.

    c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.

    d. The sensor shall be mounted to suitable supports using factory approved element holders.

11. Space Sensors, Room Thermostats:

    a. Shall be mounted per ADA requirements.

    b. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

12. Low Temperature Limit Switches:

    a. Install on the discharge side of the first water or steam coil in the air stream.

    b. Mount element horizontally across duct in a serpentine pattern for large duct areas where the sensing element does not provide full coverage of the air stream,

provide additional switches as required to provide full protection of the air stream.

13. Air Differential Pressure Status Switches:

    a. Install with static pressure tips, tubing, fittings, and air filter.

14. Water Differential Pressure Status Switches:

    b. Install with shut off valves for isolation.

I. HVAC Output Devices

1. All output devices shall be installed per the manufacturer's recommendation. The Mechanical Contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.

2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

3. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.

4. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 psi. The maximum pressure drop for steam applications shall be 7 psi.

3.3 TRAINING

A. Provide training in accordance with Sections 01 79 00 of the Design and Construction Handbook.

B. In addition, the BAS contractor shall provide the following training services:

1. Operator Training (provide 40 hours): Operator training shall include the detailed review of the control installation drawings, points list, and equipment list. The instructor shall then walk through the building identifying the location of the control devices installed. For each type of systems, the instructor shall demonstrate how the system accomplishes the sequence of operation.

    a. From the workstation, the operator shall demonstrate the software features of the system. As a minimum, the operator demonstrate and explain logging on, setting passwords, setting up a schedule, trend, point history, alarm, and archiving the database.

    b. One day (8 hours) of the 40 hours will be devoted to on-site orientation by a field engineer who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the control system software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

2. Factory training for a minimum of six (6) LAWA representatives for 40 hours (minimum) in a factory training lab. This training shall be performed by a factory-certified professional trainer and, at a minimum, shall consist of:
    a. Two days (16 hours) basic system operation.
    b. One day (16 hours) system reporting and alarm management.
    c. One day (16 hours) scheduling and point trending
3. The LAWA shall be issued Continuing Education Credits (C.E.U.s) for the factory training.
4. Third Party Interface Training: BAS contractor shall provide a minimum of 24 hours detail training for systems such as lighting control, VFD, emergency generator, electrical switchgear and any other system or equipment that will interface with the BAS.

3.4 COMMISSIONING AND TESTING.

A. Provide commissioning in accordance with Sections 01 19 00 of the Design and Construction Handbook.
    1. General
        a. Commissioning the Building Automation System is a mandatory documented performance requirement of the selected BAS Contractor for all control systems detailed in this Specification and sequence of operations. Commissioning shall include verification of proper installation practices by the BAS Contractor and subcontractors under the BAS Contractor, point verification and calibration, system/sequence of operation verification with respect to specified operation, and network/workstation verification. Documentation shall be presented upon completion of each commissioning step and final completion to ensure proper operation of the Building Automation System.
        b. BAS commissioning and testing documentation is to be provided separately to LAWA.
    2. Testing Requirements
        a. Intent: Demonstrate to satisfaction of authorized representative that BAS is performing in accordance with requirements of this Section.
        b. Logs of Tests: Complete logs of tests retained by Contractor for inspection and review of authorized representative at any time after testing started. Upon final completion of system tests log records submitted.
        c. Witness of Tests: At time directed by authorized representative complete functional, operational test shall be performed by contractor. Test witnessed by personnel directed by authorized representative. Tests continue until functions of points, of alarms and command functions are proven to satisfaction of authorized representative.
        d. Performance of Field Tests: Complete tests required at different and distinct times for various phases of construction as designated by authorized representative.

3. Testing Procedure

    a. Upon completion of the installation, the BAS Contractor shall start-up the system and performs all necessary testing and run diagnostic tests to ensure proper operation. The BAS Contractor shall be responsible for generating all software and entering all database information necessary to perform existing control sequences.

4. Testing Documentation

    a. Prior to acceptance testing, BAS Contractor shall create, on an individual system basis, trend logs of input and output points, or have an automatic Point History feature for documentation purposes.

5. Field Points Testing

    a. This step shall verify that all of the installed points receive or transmit the correct information prior to loading/activating the system software.

    b. ON/OFF commands from the workstation shall be performed in order to verify each binary output point.

    c. All binary input points are to be tested by observing a change of state upon command at PC workstation or locally in the field.

    d. All analog output points shall be tested using a command from the PC workstation to modulate the output device from minimum calibrated signal to maximum calibrated output.

    e. All analog input points are to be tested by comparing the reading obtained through the workstations to the value of an independent testing meter

    f. All two-way communication interfaces (Modbus, Bacnet, etc.) tested and monitored values and commanded verified at the BAS workstation and in the field.

6. Verify that activation of site related alarms specifically identifies and notifies LAWA remote monitoring sites and selected personnel.

7. VAV box performance verification and documentation: (Perform testing if required).

    a. As part of the commissioning of the terminal unit control (UC) and air distribution system, the Contractor shall initiate an automated test where the dampers in one half of a group of boxes are stepped towards full open while the other half are stepped towards full closed. At each step, after a settling time, box airflow and damper positions will be sampled. Following the cycle, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation, or Maximum flow not achieved. The report shall be submitted as documentation of the installation.

    b. The controls contractor shall issue a report based on a sampling of the UC calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance. The sampling shall take place after

completion of Test and Balance, when design cooling and heating media have been available and occupied conditions approximated for five consecutive days.

c. Verify that new graphics are complete and contain dynamic (real-time) information that can be viewed at both workstation locations.

8. Non-compliant Items

a. The Contractor shall remove and replace, at its expense, all items that are not in compliance with the requirements of this section or other portions of LAWA's Design and Construction Handbook.

3.5 SEQUENCES OF OPERATION AND CONTROL DIAGRAMS

A. Control points and sequences

1. All equipment shall be user-definable as to which piece of equipment is the lead unit, the lag unit or the spare (standby) unit. The unit arrangements called out for initial start-up conditions only.

2. All set points shall be user-definable; set points called out are for initial start-up conditions only.

3. See plans for control details and Sequences of Operation.

3.6 POINT LISTS

The BAS Contractor shall provide the system's point list. The sample is show below:

Sample Point List

Systems	**AHU 1,2,3,4**

Point	**Description**	**Type**	**Units**	**Trend**	**Alarm**	**Totalize**
DA-P	Discharge Static Pressure	AI	in WC	X		
DA-T	Discharge Air Temperature	AI	Deg F	X		
PH-T	Preheat Temperature	AI	Deg F	X		
SF-S	Supply Fan Status	BI	Off On	X	X	X
PH-O	Preheat Output	AO	%	X		
RH-O	Reheat Output	AO	%	X		
CLG-O	Cooling Output	AO	%	X		
SF-O	Supply Fan Output	AO	%	X		
SF-C	Supply Fan Command	BO	Off On	X		
PH-LCKO	Preheat Lockout Command	BO	Off On	X		
CLG-LCKO	Cooling Lockout Command	BO	Off On	X		

RH-LCKO	Reheat Lockout Command	BO	Off On	X
DAT-SP	Discharge Temperature Set point	AO	Deg. F	X
PHT-SP	Preheat Temperature Set point	AO	Deg. F	X
DAP-SP	Discharge Static Pressure Set point	AO	in WC	X

END OF SECTION 25 20 00