APPENDIX 4

SECTION 15900 - AUTOMATIC TEMPERATURE CONTROL

PART 1 - GENERAL

1.0 STIPULATIONS

A. The specification sections "General Conditions", "Special Requirements", and "General Requirements" form a part of this section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.1 GENERAL PROVISIONS

A. Applicable General Conditions, Division 1, and any and all referenced in any other part of the overall documents for the project shall apply to the work in Division 15H, including all addenda and other supplemental instructions and modifications.

B. Coordination of HVAC interfacing with other trades is the responsibility of the HVAC Contractor.

1.2 SCOPE OF WORK

A. Provide a native BACnet Direct Digital Control (DDC) system for automatic temperature control, hereafter referred to as the Building Automation System (BAS), as specified herein and on the associated contract drawings. The system shall be a direct extension of the existing Automated Logic WebCTRL system. The control contractor shall furnish all engineering, material, labor, and supervision for a complete and functioning system.

B. All HVAC equipment shall be DDC control with electric actuation, unless otherwise noted.

C. The BAS shall be in full compliance with BACnet ANSI/ASHRAE Standard 135-1995. Non-BACnet compliant systems and devices (including gateways) shall not be acceptable. The Contractor shall provide a BACnet router supporting BACnet over Ethernet IP. The system will be monitored/adjusted by the existing WebCtrl system. Contractor shall be responsible for completely interfacing the BAS into WebCtrl, including thermographic floorplans, mechanical system graphics, BACnet schedules and BACnet trends.

D. All information regarding the general design and operation of the BAS is outlined on the contract drawings and in these specifications. The drawings do not contain manufacturer-specific information regarding point-to-point control wiring or auxiliary devices required (i.e. signal transmitters/transducers, relays, switches, etc.). The control contractor shall furnish all such wiring and material as approved.

E. The BAS architecture shall feature distributed control, permitting expansion through the addition of controllers without modification to the base system.

F. The BAS provider shall be a subcontractor to the HVAC contractor. All work, including supervision, management and coordination required for the complete installation and operation of the HVAC contract work shall be the responsibility of the HVAC contractor.

G. The HVAC contractor and the BAS provider shall satisfactorily complete the entire control system so that it is functional and operating to the satisfaction of the Professional and the University. Systems and their controls and their sequencing must be demonstrated and operated to the satisfaction of the Professional and the University. This specification requires that this entire system, with its complement of equipment and controls, operate properly in accordance with the design concept and functional occupancy program of the University.

1.3 WORK BY OTHERS

A. The sheet metal contractor shall install control dampers furnished under this section.

B. The HVAC contractor shall install all devices furnished under this section for mounting in piping systems (i.e. control valves, thermal wells, flow sensors, pressure taps, etc.).

C. The electrical contractor shall furnish and wire duct smoke detectors and fire alarm equipment. The sheet metal contractor shall install all duct mounted smoke detectors.

D. The electrical contractor shall furnish and install all power wiring unless noted otherwise. Power wiring shall be defined as follows:

1. 120VAC and higher wiring from disconnects, starters, and variable frequency drives to electric motors and coils
2. 120VAC (20A) wiring to controllers/panels (Note: It is the responsibility of the control contractor to provide 120VAC to controllers/panels, as required, if it is not shown on the contract drawings.)

E. The HVAC and electrical contractors shall provide the necessary manpower to assist the control contractor during checkout and startup of new controls.

1.4 ACCEPTABLE MANUFACTURERS

A. The system specified in this document shall be WebCTRL, manufactured by Automated Logic Corporation. Contact Tom Dunleavy, InterCon Automation @ 717-909-7000 x16.

B. All components of the BAS not produced by the system manufacturer shall be standard products from a vendor regularly engaged in the manufacture of such products, using similar materials, design, and workmanship. Standard products shall have been in commercial or industrial use for at least two years prior to the project bid. All components designed to operate on 120VAC and higher shall be UL listed and labeled.

1.5 WARRANTY AND GUARANTY

A. The control contractor shall guarantee all labor and material furnished for a period of one year from the date of acceptance, and shall keep the BAS in adjustment throughout the first heating and cooling seasons without expense to the Department or Using Agency. The following provisions apply:

1. Warranty service during normal working hours
2. Labor and material to replace defective parts or components
3. Labor to "tune" software if a change in season produces unacceptable control behavior
4. Monitoring and services via the system modem or internet, if a problem is reported by the University.

B. The control contractor shall maintain a current copy of all software and databases for the BAS, on a host computer at their office, for a period of one year from the date of acceptance. The contractor shall utilize the host computer for system debugging and troubleshooting if a problem with software is reported or suspected. Any modifications to software shall be saved on the host computer in addition to each controller affected, the customer operator interface, and any customer copies.

PART 2 - PRODUCTS

2.1 OPERATOR INTERFACE & SYSTEM OVERVIEW

A. The BAS contractor shall provide system software based on a server/thin-client architecture, designed around the open standards of web technology. The existing BAS server shall communicate using ASHRAE's BACnet/IP protocol. Server shall be accessed using a web browser over the Shippensburg University intranet and remotely over the Internet. The BAS Contractor shall integrate the thermographic floor-plans, graphics, scheduling, events, and trends into the existing WebCtrl and associated databases. Requirements for graphics, events, trends, and schedules are specified in the applicable sections of Paragraph 2.2 Web Browser Graphical User Interface. All of the system objects, schedules, and events shall be represented as BACnet objects by the BAS Contractor.

B. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft and Netscape Navigator browsers (6.0 or later versions), and Windows as well as non-Window operating systems. No special software, (active-x components or fat java clients) shall be required to be installed on the PC's / PDA's used to access the BAS via a web browser.

C. The web browser GUI shall provide a completely interactive user interface and must offer the following features as a minimum:

1. Trending
2. Scheduling
3. Downloading Memory to field devices
4. Real time 'live' Graphic Programs
5. Tree Navigation
6. Parameter change of properties
7. Setpoint Adjustments
8. Alarm / Event information
9. Configuration of operators
10. Execution of global commands

D. Software Components

1. All software components of the BAS system software shall be installed and completed in accordance with the specification. BAS system components shall include:

    a. Server Software, Database and Web Browser Graphical User Interface
    b. System Configuration Utilities for future modifications to the system
    c. Graphical Programming Tools
    d. Direct Digital Control software
    e. Application Software

E. BAS Server Database

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

F. Database Open Connectivity

1. The BAS server database shall be Java DataBase Connectivity (JDBC) compatible, allowing real time access of data via the following standard mechanisms:

a. Open protocol standard like CORBA or SOAP
b. OLE/OPC (for Microsoft Client's/Server platform only)
c. Import/Export of the database from or to XML (eXtensible Mark-up Language)

G. Communication Protocol(s)

1. The native protocol for the BAS server software shall be BACnet over Ethernet DataLink as defined by ASHRAE standard SPC135. The BAS Server shall support BACnet/IP Annex J to enable communication through common routers. Proprietary protocols over TCP/IP are NOT acceptable.

H. Thin Client – Web Browser Based

1. The GUI shall be thin client or browser based and shall meet the following criteria:

a. Web Browser's for PC's: Only a 6.0 or later browser (Explorer/Navigator) will be required as the GUI, and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet.
b. Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).
c. PDA's: BAS Server software must support other browsers used by Personal Digital Assistants like 3Com Palm Pilots and other Internet appliances specified herein.

2.2 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation

1. The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish 2.02 B thru 2.02 J of this specification. The Web Browser GUI shall (as a minimum) provide a Navigation Pane for navigation, and a Action Pane for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events.

B. Login

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

C. Navigation Pane

1. The Navigation Pane shall comprise a Navigation Tree which defines a geographic hierarchy of the Shippensburg University BAS system. Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic.

D. Action Pane

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

    a. Graphics: Using animated gifs or other graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content, and other valid HTML elements. The data on each graphic page shall automatically refresh at a rate defined by the operator.
    b. Properties: Shall include graphic controls and text for the following: Locking or overriding BACnet objects, demand strategies, and any

other valid data required for setup. Changes made to the properties pages shall require the operator to depress a 'accept/cancel' button.

c. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree) and in compliance with section 2.2.G

d. Events: Shall be used to view alarm event information geographically (using the navigation tree), acknowledge events, sort events by category, actions and verify reporting actions.

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

f. Logic - Live Graphic Programs: Shall be used to display a 'live' graphic programs of the control algorithm for the mechanical/electrical system selected in the navigation tree.

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

E. Color Graphics

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

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

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

   c. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints (see section 3.2 F below). The colors shall be updated dynamically as a zone's actual comfort condition changes.

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

   e. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:

      1) Each piece of equipment monitored or controlled including each terminal unit
      2) Each building

3) Each floor and zone controlled

F. Zone Setpoint Adjustments

1. Color floor plans displayed via a web browser shall utilize a contiguous band of colors, each corresponding to actual zone temperatures relative to the desired heating and cooling setpoints. The ideal temperature shall be shown as a green color band. Temperatures slightly warmer than ideal shall be shown in yellow, and even warmer temperature band shall be shown in orange. Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. All alarm colors shall be in red.
2. Active Zone Graphic Setpoint Controls: Utilizing a mouse, it shall be possible to select occupied or unoccupied setpoints (corresponding to the floor plan colors) and drag the color slide bar(s) to increase or decrease heating and cooling setpoints. In addition to the slide bars, an operator may type the numeric value of the heating and cooling setpoints. The floor plan graphic shall then change colors on a zone-by-zone basis to reflect the actual temperature in each zone relative to the changed heating or cooling setpoint.

G. Hierarchical Schedules

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

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

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

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

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

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

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

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

g. Schedule Distribution: For reliability and performance, instead of maintaining a single schedule in a field device that writes over the network to notify other devices when a scheduled event occurs, field devices will only keep their part of the schedule locally. The BAS server software shall determine which nodes a hierarchical schedule applies to and will create/modify the necessary schedule objects in each field device as necessary.

H. Events (& Alarms)

1. Events and alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Events' view. Events, alarms, and reporting actions shall have the following capabilities:

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

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

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

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

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

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

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

h. Event Auto-Deletion: Events that are acknowledged and closed, shall be auto-deleted from the database and archived to a text file after an operator defined period.

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

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

j. Event Simulator: The web browser GUI user shall provide an Event Simulator to test assigned Reporting Actions. The operator shall have the option of using current time or scheduling a specific time to generate the Event. Utilizing the Navigation Tree and drop-down menus in the Graphic Pane, the operator shall be able to select the Event Type, Status, Notification, Priority, Message, and whether acknowledgement is required.

I. Trends

1. Trends shall conform to the BACnet Trend Log Object specification. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

a. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
b. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and

periodically uploaded to the BAS server if historical trending is enabled for the BACnet object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.

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

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

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

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

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

J. Security Access

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

a. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges.. Roles shall be defined in terms of View, Edit and Function Privileges.

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

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

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

b. Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with

similar competencies (and the same operator defined HVAC Role) to different areas of the system.

2.3 GRAPHICAL PROGRAMMING

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

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

1. Graphic Sequence

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

2. Simulation

   a. Full simulation capability shall be provided with the graphic programming. Operator shall be able to fully simulate the constructed control sequence prior to downloading into field control modules. Simulation capabilities shall include step-by-step, accelerated time, and operator defined simulation criteria like outside weather, demand, and communication status. Multiple graphic programs shall be simulated and displayed in split screens at the same time.

3. GPL Capabilities

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

1) Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
2) Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
3) BACnet Points: Shall be points that comply with the BACnet structure as defined in the BIBB's Addendum B1/B2, and the BACnet standard.
4) Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
5) Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O. Different wires types shall be used depending on whether the signal they conduct is analog or digital.
6) Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
7) Parameter: A parameter shall be a value that may be tied to the input of a microblock.
8) Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields and shall contain 'push buttons' for the purpose of selecting default parameter settings.
9) Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes it function.
10) Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
11) Live Graphical Programs: The Graphic Programming software must support a 'live' mode, where all input/output data, calculated data, and setpoints shall be displayed in a 'live' real-time mode. For each piece of HVAC equipment, the entire

graphic program shall be displayed through the Web Browser GUI. The operator must have the ability to scroll through the entire 'live' graphic program as necessary. Piecemeal graphic programs that only show one part of HVAC equipment program at any one time are NOT acceptable. For example, when viewing an AHU live graphic program, the operator shall see the entire AHU graphic program, not just the Heating Coil control. If Live Graphical Programs are not supported, the contractor shall generate a "flow control" graphic which depicts the actual program logic for the equipment. The mechanical system graphic will include a link to the flow control graphic and real-time inputs/outputs for each control block shall be mapped onto the flow control graphic.

2.4 BAS Service Tool - Laptop

A. Furnish and install a laptop PC for web service, operation, programming and engineering of the BAS. The laptop shall be provided with all hardware and software required to completely operate and service the system. The following minimum requirements apply:

1. Pentium M operating at 2.0 GHz
2. 512 MB RDRAM
3. 20 GB hard drive
4. 24X CD-ROM
5. 14.1-inch color monitor
6. 32 MB graphics card
7. Sound card and speakers
8. Integrated Ethernet card
9. TCPIP compatible
10. Microsoft Windows XP operating system

2.5 CONTROLLERS

A. The Global Controller shall be a stand-alone direct digital controller providing point control and/or interface to local controllers. User interface capabilities shall include display and modification of all system control points, variables, setpoints, schedules, and software. Local access shall be accomplished through the site operator interface.

B. Local Controllers shall be stand-alone direct digital controllers providing point control. Each local controller shall be able to have its program edited and/or modified. Pre-packaged software may not be used.

C. A Real-Time Operating System shall be resident in ROM or PROM, and shall initiate and commence operations without operator interaction. The system program shall incorporate the following features:

1. Operation and management of all external devices
2. Editing of software
3. System self-testing
4. Error detection and recovery

D. Memory shall be non-volatile EPROM, EEPROM, and/or RAM. All data stored in RAM shall be battery backed-up for a minimum of 72 hours. Each controller shall be supplied with sufficient memory to satisfy the associated software requirements.

E. Control Points shall be analog input (AI), digital input (DI), digital output (DO), or analog output (AO), as required for equipment and devices to be controlled and/or monitored. Each controller shall be supplied with sufficient input/output capacity to satisfy the associated control point requirements.

F. Control Loops shall reside on a single controller: the primary input associated with the operation of an output shall reside on the same controller as the output.

G. The Communication Network shall be a peer-to-peer high-speed local area network (LAN) capable of supporting a minimum of 20% system (control point) expansion. Each controller shall be capable of sharing point information over the LAN. If a controller fails, it shall not cause any other controller on the LAN to lose communication. If the network link for the global controller fails, the local controllers shall continue to function using the last values of shared information.

H. Real Time Clocks shall provide time of day, day of week, month, and year. The global controller shall have a real time clock accurate to within 10 seconds per day. Each local controller with a time clock shall be capable of receiving a signal from the associated global controller, over the LAN, for synchronizing clocks. Each local controller without a time clock shall receive schedule information from the associated global controller, over the LAN. Real time clocks shall allow for automatic changeover to daylight savings time.

I. System Access shall be through a password security system. A password shall be programmed for each user or group of users, as requested by the Using Agency, for defining the level of system access.

J. Surge Protection shall be provided for the global controller to protect the electronics from high voltage spikes and noise. Surge protection shall comply with transient suppression in accordance with IEEE standard 587 as a Category B device.

K. Automatic Restart After A Power Failure shall be initiated upon the restoration of power, including but not limited to the following:

1. Updating of all monitored functions
2. Resumption of operation based on current synchronized time and status
3. Implementation of special start-up strategies as programmed in software

L. An Uninterruptible Power Supply (UPS) shall be provided for the global controller to increase protection against power loss and to condition controller power.

2.6 INPUT CONTROL DEVICES

A. Current Switches shall have an internal transformer operating normally open and/or normally closed contacts through a trip point adjustment. As a minimum, current switches shall have a range of 1A to at least 120% of the full load current rating of the equipment to be monitored. Where the equipment current rating exceeds the range of the current switch, a current transformer shall be provided to "step down" the current within the range of the switch. The current transformer shall have a current ratio with an upper limit that is at least 120% of the full load current rating of the equipment to be monitored with accuracy equal to ±5% of the range. Switch contacts shall be rated for the loads to be switched.

B. Current Transducers/Sensors shall have a built-in power supply and shall provide a signal compatible with controller inputs. As a minimum, current transducers/sensors shall have a range of 0 to at least 120% of the full load current rating of the equipment to be monitored with accuracy equal to ±3% of the range. Where the equipment current rating exceeds the range of the current transducer/sensor, a current transformer shall be provided to "step down" the current within the range of the transducer/sensor. The current transformer shall have a current ratio with an upper limit that is at least 120% of the full load current rating of the equipment to be monitored with accuracy equal to ±5% of the range. Current transducers/sensors for variable frequency drives shall have a polymer core and shall provide current sensing with accuracy equal to ±0.5% of the range.

C. Differential Pressure Switches shall have an internal diaphragm operating a snap-acting switch with normally open and/or normally closed contacts through a sensitivity (setpoint) adjustment screw. As a minimum, differential pressure switches shall have a range covering the upper and lower limits of the media to be sensed. Switch contacts shall be rated for the loads to be switched.

D. End Switches shall provide true mechanical operation of normally open and/or normally closed contacts. Switch contacts shall be rated for the loads to be switched.

E. Flow Switches shall have paddle segments, accommodating 1-inch diameter and larger pipes, operating a snap-acting switch with normally open and/or normally closed contacts through a sensitivity (setpoint) adjustment screw. Switch contacts shall be rated for the loads to be switched.

F. Flow Meters shall be insertion type with dual turbine rotors, a non-magnetic sensing mechanism, and shall provide a signal compatible with controller inputs. As a minimum, flow meters shall have a range of 0.4 to 30 feet/second with accuracy equal to ±2% of the range. Flow meters shall include a full port ball valve for installation and removal, and a local display.

G. Humidity Sensors shall have a capacitive sensing element and shall provide a signal compatible with controller inputs. As a minimum, humidity sensors shall have a range of 0 to 95% relative humidity (RH) between the upper and lower temperature limits of air to be sensed, accuracy equal to ±2% over the range of 20 to 90% RH, and stability as measured by no more than 1% drift per year. The following criteria shall be used for selecting humidity sensors:

1. Duct Sensors shall be used in all ductwork or for sensing outdoor air at intakes before any dampers when mounting of an outdoor sensor is not feasible, as approved by the Professional.
2. Outdoor Sensors shall be used when the North outdoor building exposure is available and accessible. Outdoor sensors shall be manufactured with a weatherproof enclosure.
3. Space Sensors shall be used in all open areas.

H. Pressure Sensors shall have a capacitive sensing element and shall provide a signal compatible with controller inputs. As a minimum, pressure sensors shall have a range of 0 to the upper limit of the media to be sensed with accuracy equal to ±1% of the range. Sensors for monitoring space static pressure shall be furnished with a range of -0.1 to +0.1-inches WC and shall include a minimum NEMA type 4 enclosure when mounted exposed. Sensors for monitoring water differential pressure shall be furnished with snubbers for protection against shocks and pulsations. Sensors for monitoring steam pressure shall be furnished with snubbers for protection against shocks and pulsations, and steam pigtail siphons for protection against high temperatures. Atmospheric pressure shall be sensed as required using an outdoor air static pressure sensor (reference).

I. Pressure-Electric Switches shall have an internal diaphragm operating a snap-acting switch with normally open and/or normally closed contacts through a sensitivity (setpoint) adjustment screw. As a minimum, pressure-electric switches shall have a range covering the upper and lower limits of the media to be sensed. Switch contacts shall be rated for the loads to be switched.

J. Temperature Sensors shall have either a thermistor or an RTD sensing element and shall provide a signal compatible with controller inputs. As a minimum, temperature sensors shall have a range covering the upper and lower limits of the media to be sensed, accuracy equal to ±0.36°F, and stability as measured by no more than 0.24°F drift over five years. The following criteria shall be used for selecting temperature sensors:

1. Duct Averaging Sensors shall be used where air stratification may be a problem, such as in mixed air.
2. Duct Probe Sensors shall be used where air temperature is consistent across ductwork, such as in supply or return air. Duct probe sensors may also be used for sensing outdoor air at intakes before any dampers when mounting of an outdoor sensor is not feasible, as approved by the Engineer. Duct probe sensors used for sensing outdoor air shall have an RTD sensing element only.
3. Immersion Sensors shall be used for sensing liquid temperature in pipes. Brass thermal wells shall be furnished for installation of immersion sensors in piping. Stainless steel thermal wells shall be furnished for installation of immersion sensors in piping.
4. Outdoor Sensors shall be used when the North outdoor building exposure is available and accessible. Outdoor sensors shall have an RTD sensing element only and shall be manufactured with a weatherproof enclosure.
5. Space Sensors shall be used in all open areas. Space sensors shall be furnished with setpoint adjustment, push-button occupancy override, and digital display where required by the sequence of operation.
6. Flush Mounted, Tamper Resistant Space Sensors shall be used in public areas such as corridors lobbies, and restrooms
7. Strap-On Sensors shall be used for sensing liquid temperature in pipes where the installation of thermal wells is not practical, as approved by the Professional.

2.7 OUTPUT CONTROL DEVICES

A. Relays shall be plug-in style with one or more sets of normally open and/or normally closed contacts and a snap-mount socket for panel mounting. Relays for field mounting may be a one-piece assembly. Relay contacts shall be rated for the loads to be switched.

B. Electric-pneumatic transducers shall be panel-mounted pneumatic transducers, +/- 1% accuracy selected for the applications. Transducers shall be provided with integral pneumatic gauge and manual override.

2.8 SAFETY CONTROL DEVICES

A. Freezestats shall have an extended sensing element, manual reset, and a temperature range down to at least 15°F. Freezestat contacts shall be rated for the loads to be switched.

2.9 LOCAL CONTROL DEVICES

A. Electric Thermostats shall provide switching of electrical contacts in response to changes in temperature. Thermostats shall be heating and/or cooling as required, and shall be furnished with a setpoint adjustment over a range including all setpoints indicated. Thermostat contacts shall be rated for the loads to be switched. The following criteria shall be used for selecting thermostats:

1. Aquastats (Bulb Thermostats) shall be used for sensing liquid temperature in pipes where the installation of thermal wells is not practical.
2. Space Thermostats shall be used in all open areas and shall include a locking cover. Space thermostats shall be programmable or non-programmable as required.

2.10 CONTROL DAMPERS

A. Control dampers shall be of the multi-louver type with adjacent blades rotating in opposite directions for proportional control and in parallel directions for 2-position control unless noted otherwise. Frames shall be constructed from hat-shaped channel and blades shall be a maximum of 6-inches wide. Axles shall be 1/2-inch diameter plated steel and bearings shall be either synthetic or oil-impregnated sintered bronze. A removable 6-inch x 1/2-inch diameter control shaft shall be provided for external mounting of actuator(s). Dampers shall have a mill finish and shall be furnished in the size required for installation. Linkage may be either exposed or concealed in the frame. Where damper size exceeds the maximum available for a single section, linkage shall be provided to allow multiple sections to operate as a single damper. All dampers shall be fabricated of extruded aluminum with airfoil blades, flexible metal or extruded silicone jamb seals, and rubber blade seals. Discharge air dampers shall be fabricated of galvanized steel with U- or hat-shaped channel frame, airfoil blades a maximum of 8-inches wide, stainless steel bearings pressed into the frame, and no seals.

2.11 CONTROL VALVES

A. Control valves shall be 2-way or 3-way and sized for the required flow rates, as indicated on the contract drawings. All valves shall be globe style and 3-way valves shall be mixing type, unless noted otherwise. Flow type for 2-way valves shall be equal percentage or modified equal percentage for water applications, and modified equal percentage for steam applications. Flow type for 3-way valves

shall be linear. Valves up to 2-inches in size shall have brass or bronze bodies, brass or stainless steel trim, screwed ends, and ANSI Class 250 pressure rating. Valves 2-1/2-inches in size and larger shall have cast iron or cast carbon steel bodies, brass or stainless steel trim, flanged ends, and ANSI Class 125 pressure rating. All valves shall be rated for operation from 40°F to 250°F. The following criteria shall be used for sizing control valves:

1. Proportional valves in water lines shall be sized for a 3 to 5 psi pressure drop across the valve.
2. 2-position valves in water lines shall be line size or sized for a pressure drop across the valve equal to 10% of system water pressure.
3. Differential pressure valves across water lines shall be sized for a pressure drop equal to system water pressure at total system water flow.
4. Proportional valves in steam lines shall be sized for a pressure drop across the valve equal to 50 to 80% of the steam supply pressure.
5. 2-position valves in steam lines shall be sized for a pressure drop across the valve equal to 10% of the steam supply pressure.

2.12 ACTUATORS

A. Actuators and linkage for control dampers shall meet the following criteria:

1. Actuators shall be proportional or 2-position type as required to achieve the sequence of operation.
2. Actuators shall be spring return or non-spring return type as required to achieve the sequence of operation. Normal positions for dampers with spring return actuators, determined by loss of power, are indicated on the contract drawings.
3. Actuators for single section dampers shall be sized using a minimum requirement of 5 in.-lb. torque (at the control shaft) per square foot of damper area. Actuators for multiple section dampers with a jackshaft linkage assembly shall be sized using a minimum requirement of 7 in.-lb. torque (at the control shaft) per square foot of damper area.
4. Electric Actuators shall be direct coupled type.

B. Actuators and linkage for control valves shall meet the following criteria:

1. Actuators shall be proportional or 2-position type as required to achieve the sequence of operation.
2. Actuators shall be spring return or non-spring return type as required to achieve the sequence of operation. Normal positions for valves with spring return actuators, determined by loss of power, are indicated on the contract drawings.
3. Actuator/linkage assemblies shall be capable of closing valves against a minimum unbalanced pressure equal to total system pressure.

4. Actuator/linkage assemblies for steam applications shall be designed for high temperature operation.

C. All actuators shall be rated for operation from -22°F to 122°F ambient. Actuators that are mounted outdoors shall be provided with a weatherproof cover/enclosure.

D. Actuation shall be electric, unless otherwise noted.

2.13 CONTROL PANELS

A. Enclosures for indoor mounting shall be NEMA Type 1, constructed of 16 or 14 gauge steel with hinged door, and painted both inside and outside. Enclosures for outdoor mounting shall be NEMA Type 3R, constructed of 16 or 14 gauge galvanized steel with drip shield top, seamfree front, back, and sides, hinged door, and painted both inside and outside. Sub-panels (backplates) shall be 14 or 12 gauge steel painted both sides, or perforated 16 gauge galvaneal steel. All enclosures/sub-panels shall be sized for 20% spare space and shall be furnished with door lock kits.

B. Transformers shall provide the AC voltage required, sized for the load to be served, and fused on the secondary for not more than 125% of transformer rating.

C. Power Supplies shall provide the DC voltage required, sized for the load to be served, and fused on the secondary.

2.14 CONTROL WIRING AND CABLE

A. Individual low voltage (24VAC/24VDC and lower) control wiring shall be stranded copper and a minimum of No. 18 AWG. Individual high voltage (120VAC and higher) control wiring shall be stranded copper and a minimum of No. 14 AWG. All wiring shall comply with local and national electric codes.

B. In general, multi-conductor cable for control wiring shall be furnished as specified and/or approved by the controller and device manufacturers. Plenum cable shall be provided for wiring installed in plenum ceilings. Shielded cable shall be provided when required for proper system operation. All cable shall comply with local and national electric codes.

C. All wiring for the BAS shall be dedicated to control. The use of power line carriers will not be accepted.

PART 3 - EXECUTION

3.1 SUBMITTAL

A. The control contractor shall provide a submittal, for review and approval by the Professional, containing the following information:

1. Sequence Of Operation
2. Controller Point Lists
3. Material Information Sheets
4. Damper/Valve Schedules
5. Control Drawings

B. Material information sheets shall include manufacturer's description and technical data for all controls with the exception of wire, tubing, conduit, and miscellaneous hardware. Specific information is required for the following components:

1. Operator Interface
2. Controllers
3. Input Control Devices
4. Output Control Devices
5. Safety Control Devices
6. Local Control Devices
7. Control Dampers
8. Control Valves
9. Actuators
10. Automatic Block Valves/Actuators
11. Enclosures
12. Transformers
13. Power Supplies

C. As a minimum, control drawings shall include point-to-point wiring and control diagrams showing system configuration and device locations for equipment to be controlled. In addition, provide a riser diagram showing controllers/panels, the operator interface, and associated communication/interlock wiring.

D. If a complete submittal cannot be provided within two weeks of the contractor being awarded the project, a separate submittal containing information on all long-lead items (i.e. control dampers, etc.) shall be provided in advance.

3.2 DELIVERY, STORAGE, AND HANDLING

A. No material may be ordered until submittals are approved.

B. All material shall be delivered to the job site unless noted otherwise. The control contractor shall be responsible for receiving all material for controls unless arranged otherwise.

C. All material shall be stored per the manufacturer's instructions and shall be protected from weather, dirt, dust, and other contaminants.

3.3 FACTORY MOUNTING AND WIRING

A. All local controllers and air valve actuators (electronic) for VAV boxes shall be furnished by the BAS contractor, and shall be shipped for factory mounting and wiring by the VAV box manufacturer. Space temperature sensors shall be field installed and wired. Provide all applicable material, control drawings, and coordination/assistance to the factory contact, as supplied by the HVAC contractor.

B. Refer to the HVAC Equipment Section of these specifications for additional information regarding controls to be factory supplied and/or mounted and wired.

3.4 INSTALLATION

A. No construction may begin until submittals are approved.

B. The University shall provide an Ethernet IP drop and an IP address for the BAS router and server.

C. All work shall be performed in accordance with local and national electric codes in effect and amended as of the bid date.

D. Provide the necessary scheduling, supervision, and coordination with other trades to insure a smooth installation. Provide representation at job meetings as requested.

E. All control wiring/tubing and terminations/connections required for the BAS shall be the responsibility of the control contractor unless noted otherwise. If installation labor is subcontracted, the control contractor shall be responsible for insuring that the subcontractor provides a first class installation in accordance with this specification and the contract drawings.

F. In general, low voltage (24VAC/24VDC and lower) control wiring installed in open areas and all high voltage (120VAC and higher) control wiring shall be run in conduit. Low voltage control wiring installed above drop ceilings and inside walls may be exposed provided it is plenum cable. All conduit/wiring and cable shall be installed in conformance with the applicable provisions of the Electrical Section. No conduit or cable shall be supported from any potentially moveable item unless it is directly associated with that item.

G. In general, pneumatic tubing installed in open areas shall be hard drawn copper, or fire resistant polyethylene run in conduit or Wiremold. Pneumatic tubing installed within control panels, enclosures, or troughing shall be soft drawn copper or fire resistant polyethylene. Pneumatic tubing installed above drop ceilings and inside walls may be fire resistant polyethylene. All tubing shall be installed in a manner consistent with that required for conduit/wiring and cable, to be installed in conformance with the applicable provisions of the Electrical Section. No tubing shall be supported from any potentially moveable item unless it is directly associated with that item.

H. All controls shall be installed in accordance with the manufacturer's recommendations unless noted otherwise.

I. In general, space temperature and humidity sensors shall be mounted at a height of 60-inches AFF. Space temperature sensors with setpoint adjustment and/or push-button occupancy override, and space switches shall be mounted at a height of 48-inches AFF. Space static pressure sensors/references for open areas shall be mounted at 10-feet AFF or ceiling height, whichever is lower. Space static pressure sensors for areas with a drop ceiling shall be mounted above the drop ceiling with a reference through the ceiling. Outdoor air temperature and humidity sensors, and static tubes for referencing atmosphere shall be mounted at a minimum height of 12-feet above ground level, for protection against vandalism.

J. One freezestat, with a sensing element of approximately 20-feet, shall be installed for every 20 square feet of water or steam coil.

K. Verify sizes for all control dampers with the sheet metal contractor before ordering this equipment.

L. All controls mounted on equipment or ductwork shall be installed outside insulation, to prevent sweating and to facilitate removal without damaging insulation. The control contractor shall utilize standoff boxes or brackets for mounting controls at all locations where insulation is to be applied, as coordinated with the HVAC contractor.

M. Provide the HVAC contractor with a sketch or installation diagram showing specific port designations for all 3-way control valves.

N. Each device installed under this section that is not mounted in a panel shall be identified by a plastic laminated tag or approved equal containing the device designation.

O. Refer to the HVAC Equipment Section of these specifications for information regarding controls to be factory supplied and/or mounted and wired.

P. All controllers, transformers, power supplies, transmitters, and output control devices shall be installed on a sub-panel (backplate) for mounting in an enclosure, as specified for control panels, unless approved otherwise. Controllers may be mounted external to panels if furnished with a suitable enclosure. A disconnect switch and at least one power outlet shall be installed in each panel with 120VAC power; the disconnect switch shall remove power from all panel components except the power outlet(s). Terminal blocks shall be installed in all panels larger than 12-inches by 12-inches. Controllers/panels shall be located as indicated on the contract drawings or, where there is a conflict, as approved by the Using Agency and the Professional.

Q. Pressure Transducers shall be provided with gauges for monitoring the main air supply and the branch air signals; a common gauge may be provided for the main air supply to multiple transducers in one panel/location. The main air supply to all pressure transducers shall be filtered.

R. Each item inside a control panel shall be designated in a neat and professional manner, and all designations shall correspond to documentation referencing the panel. The panel, 120VAC power for the panel (if required), and each item on the panel door (where applicable) shall be identified using black phenolic nameplates with white lettering. The nameplate for panel power shall list voltage (120VAC), power panel designation, and breaker number.

S. Provide all interlock wiring between separate components of equipment as required unless noted otherwise.

T. Provide all communication/interlock wiring between controllers/panels, as furnished or supplied by others. It shall be the responsibility of the control contractor to provide any hardware required that is not already specified for interface and connection to another manufacturer's controls.

U. The operator interface shall be set-up and located as indicated on the contract drawings or, where there is a conflict, as approved by the Using Agency and the Professional.

3.5 SOFTWARE

A. All software shall be user-programmable including control strategies, algorithms, parameters, and setpoints. Software shall be created from the approved sequence of operation and shall be line-by-line or utilizing "block" programming techniques connecting tested control blocks to form control sequencing. All software shall reside in controller memory and shall not be dependent upon the operator interface for direct operation. The use of "burnt-in" or "canned" programs is not acceptable unless approved by the Professional.

B. All initial software shall be programmed by the control contractor. The customer shall be provided with copies of the software and all associated documentation necessary to interpret and edit control programming as requested.

C. Analog outputs shall be programmed using proportional plus integral (PI) control. The integral time constant shall be adjusted as required for proper "tuning" of control loops.

D. Setpoints, schedules, and holidays shall be entered as indicated on the contract drawings and/or as directed by the Using Agency.

E. Provide visual and/or printed reports and histories (trends) for all control points. Reports and histories shall group points by system, controller, or point type (i.e. space temperature, fan status, etc.).

F. Provide visual and/or printed alarm messages, when conditions apply, for all alarms described in the sequence of operation. Alarm messages shall be in plain English and shall include alarm setpoint, actual condition, date, and time. Provide remote (dial-out) alarms as requested by the Owner.

3.6 GRAPHICS

A. Graphic screens shall allow the display and manipulation of BAS information through the workstation mouse. The following graphic screens shall be provided:

1. The Campus/Complex Plan shall be a representation of the campus or complex where the building to be controlled is located. The plan shall include an icon for selecting the building to be controlled.

2. The Building Screen shall be a picture or photograph of the facility.

3. The Riser Diagram shall be a representation of the BAS riser diagram. Each floor/section of the riser shall include icons for selecting the associated floor plan and equipment on that floor.

4. Floor Plans shall be representations of the plans provided on the contract drawings. Each floor plan shall include point information in text format for all space sensors and switches, and icons for selecting all equipment to be controlled on that floor.

5. Equipment shall be diagrams or representations of the equipment to be controlled. Each diagram/representation shall include all point information, in text format, for the equipment to be controlled. A separate diagram/representation shall be provided for each piece of equipment to be controlled. If the system does not supply "live logic graphics", flow

control graphics with real-time data updates and links to the systems graphics shall be provided as specified in Paragraph 2.

B. Graphics shall be divided into logical partitions if the required information cannot be shown on a single screen. As applicable, graphics shall allow alteration of schedules and setpoints, display of report and history (trend) information, and selection of other screens. All point information shall be dynamic with updating at least every 5 seconds.

C. Contract drawings shall be made available, at the contractor's request, for generating graphic screens.

3.7 CHECKOUT AND STARTUP

A. Each point of control shall be checked for proper operation. Any controllers or devices that are found to be defective shall be repaired or replaced and rechecked until proper operation is established. Once all associated control points for a particular piece of equipment have been checked-out, that piece of equipment shall be started-up under control of the BAS. This procedure shall continue until all equipment specified to be controlled has been checked-out and started-up.

3.8 BALANCING

A. Provide the necessary positioning of control dampers and valves for air-side and water-side balancing, as applicable. Assistance shall be provided either remotely or on-site, as required by the balancing contractor.

3.9 FUNCTIONAL TESTING

A. The contractor shall provide a functional test of all controls. This shall include all control devices, dampers, valves, actuators, sequence of operations and equipment. Contractor shall submit testing procedures and sample test sheets for review and approval.

3.10 DEMONSTRATION

A. Upon completion of functional testing, the contractor shall provide complete written documentation of testing. Contractor shall then schedule demonstration of system testing to Commissioning Authority. The contractor, using their own labor and equipment, shall demonstrate the testing of the system. The demonstration will involve the retesting of approximately 20% of the initial testing performed. The Commissioning Authority shall select the devices to test.

B. If less than 5% of the retesting fails to verify the original test, the test will be considered as successful. If the error rate exceeds 5%, then the demonstration shall have failed. Upon failure of the test, the contractor shall make corrective action to systems and the system shall be re-demonstrated to the Commissioning Authority. The retest shall be similar to the first demonstration, except different devices may be selected. Demonstration shall continue until the error rate is reduced to below 5%.

3.11 FINAL ACCEPTANCE

A. Final acceptance shall be determined when controls have been demonstrated to Commissioning Authority's satisfaction as provided above and training has been provided as below.

3.12 FINAL DOCUMENTATION

A. Provide the requested number of Operator & Maintenance Manuals, containing as-built copies of all information in the approved submittal along with general user information regarding system access and manipulation.

3.13 TRAINING

A. Provide up to 24 hours of on-site training on the BAS. Training shall utilize the Operator & Maintenance Manuals for the system. Training shall be conducted following final acceptance, both before and after the Using Agency has had working experience with the system.

B. As a minimum, training shall include the following topics:

1. System Overview

    a. Architecture
    b. Hardware
    c. Operator Interface

2. System Operation

    a. Access
    b. Monitoring
    c. Scheduling/Setpoint Adjustment
    d. Trending
    e. Control Override

f. Software Reload and Backup

3. System Troubleshooting

a. Hardware
b. Software

C. In addition to the on-site training, ATC contractor shall provide classroom training at an approved training facility. Classroom training shall include tuition for one individual for the WebCTRL Operators Training Class (3-day course). Travel expenses, accommodations and per-diem costs shall be furnished by the University.

D. Videotape all training and provide the tapes to the Using Agency, or provide a multi-media Training CD that is fully interactive and includes training for all operator functions.

PART 4 - SEQUENCE OF OPERATION

END OF SECTION 15900