

**UNIVERSITY OF IDAHO
BUILDING MANAGEMENT CONTROL SYSTEM
DESIGN AND CONSTRUCTION DOCUMENT STANDARD
DIVISION 15 – SECTION 15950**

PART 1 – GENERAL

1.01 INTRODUCTION

- A. *To the designer: All italicized text shall be used as direction to the designer. All other text shall be considered for inclusion in project specification. Design work under this section shall include the complete plans and specifications, properly coordinated into project manual for the design of Building Automation Systems (BAS).*
- B. *These standards apply to the all U of I campus locations including branch campuses and remote building sites. The designer is advised to coordinate requirements specific to the branch campuses with the designated Architectural and Engineering Services (AES) Construction Manager (CM) and Facilities Maintenance and Operations (FMO) Representative.*
- C. *Design of work provided by this contract shall consist of intra (within a building) BAS and inter-building/site (between buildings/sites) Campus Automation System (CAS). Designer is responsible to complete the interconnection design of the BAS to the CAS and show the work to be performed in the contract documents.*
- D. *All system components shall be designed and must conform to local codes and U of I requirements.*
- E. *For the name of the University's FMO Representative contact the CM with AES.*
- F. *Any change to the control system scope of work shall be reviewed for approval by the U of I AES CM and the designated FMO Representative.*

1.02 SCOPE

Designer shall become familiar with the following general requirements and specific construction contract requirements and tailor project specifications around these. Project specifications shall reflect the content and the intent of the following technical specifications.

- A. *The intent of this document is to provide a standard specification that will be used for all U of I facilities requiring BAS infrastructure.*
- B. *This document provides the minimum performance criteria for the components and sub-systems comprising a complete Building Automation System that shall accommodate the Owner's requirements.*
- C. *Product specifications, general design considerations, and installation guidelines are provided in this document. Quantities of controllers, sensing equipment and sequencing of HVAC equipment for U of I facilities shall be coordinated and determined through design team meetings with U of I and Siemens Building Technologies. However, it is the responsibility of the designer to ensure all items required for a complete system are included and clearly defined within the contract documents.*

- D. *If the bid documents are in conflict, the CM for AES shall coordinate the correct interpretation with FMO and Designer to determine which document takes precedence. In general the more stringent shall apply.*
- E. *A scope of work statement shall occur at the beginning of the specification section describing to the contractor the work encompassed under this section. It shall read similar to:
Scope: Provide all labor, materials, and equipment necessary to install a complete and functional Building Automation System as described below. Work shall include coordination of work with project General Contractor for a complete Building Automation System. (Add project specific requirements in subsequent paragraphs.)*
- F. *The BAS Contractor is required to furnish all parts, labor, supervision, tools, miscellaneous mounting hardware and consumables to interconnect to existing CAS System.*
- G. *All system components shall be determined by the designer and completely incorporated into Building Automation System design.*
- H. *General Provisions, which shall apply to the work of this contract, include the General Conditions, Modifications, Supplementary General Conditions, Division 1, Division 15 and 16 and other portions of the contract documents as applicable.*

1.03 GENERAL

- A. *The University operates and maintains a state-of-the-art BAS. The University utilizes a Siemens Building Technologies Apogee system. This system is capable of, but not limited to, global campus controlling of electrical demand, heating demand and cooling demand using duty cycling, chiller optimization, peak demand limiting and start stop time optimization programs, lighting controls, irrigation, domestic water wells and reservoirs, metering condensate, metering chilled water, metering domestic water, metering electricity, and other applications as applicable. All global campus controlling shall be applied as defined in the project program. The control is provided via TCP/IP. The field panels report analog and digital value changes to the CAS server for alarm management and trending. The field panels are programmed to be fully-stand alone and power recoverable after electrical failures or loss of communication with the CAS server. Off campus remote field panels are programmed to connect to the CAS server after a power recovery to ensure complete operational integrity.*
- B. *Building Automation Systems Design criteria*
 - 1. *Control system downloads digital programs (DDC) to field panels to control building HVAC systems, pumps, converters, chillers, cooling towers, room VAV systems, VAV fume hood systems and other support systems on and off campus.*
 - a. *The Mechanical and Electrical consultants shall coordinate design to show on the drawings the line voltage requirements for the field panels necessary for the completion of the BAS.*
 - b. *Because state-of-the-art controls are changing very rapidly, the Mechanical Consultant must work with the FMO's Representative and Siemens Building Technologies representative to verify that latest materials and methods are being incorporated into the design.*
 - 2. *Individual room controls: Individual room controls are required in all office, classrooms, laboratories and other occupied areas.*
 - 3. *HOA shall be provided at Field Panel locations, not at control component end devices as coordinated with FMO Representative and Siemens.*

4. *System controls: All BAS are preferred to be electronic with electronic final control elements also preferred.*
 5. *The designer shall provide an Input/Output (I/O) summary, sequence of operation, and control schematic on the contract documents for a complete BAS.*
- C. *The Central Dispatch system utilizes single point, campus global controlling (this ability shall be maintained) to directly manage the following systems as a minimum:*
1. *Electrical Demand for peak load and power recovery after outages.*
 2. *Heating Demand for limiting purposes during emergency conditions.*
 3. *Cooling Demand for chilled water tank storage management.*
 4. *Campus chilled water loop pumping function at multiple locations.*
 5. *Central Chiller plant operation.*
 6. *Operation / integration of campus chillers into the chilled water loop.*
 7. *Building and exterior lighting control.*
 8. *Snowmelt system for outside stairways and walkways of campus.*
 9. *Ice-melt systems for gutters, downspouts and pipe protection.*
 10. *Domestic water wells and reservoirs.*
 11. *Outside air isolation for ventilation security.*
- D. *To ensure a fully functional system the Designer must specify end devices and equipment that is capable of interfacing to the Siemens BAS to provide the points listed below. An example of compatible end devices would be dry contacts for status and metering devices or 4-20mA signals for feed back and reset.*
- E. *The following is a listing of typical points to be controlled or monitored by BAS. This list is not intended to be all-inclusive, the Designer shall consider facility needs and add or subtract from this list as appropriate.*
1. *HVAC Systems. (Provide I/O summary, sequence of operation, and control schematic for all systems.)*
 - a. *AHU: fan; stop/start/proof; reclaim air; outside air; heating and cooling discharge air; mixed air; supply air; return air; heating and cooling coil valve modulation; duct and building static pressure monitoring; static pressure control; low temperature detection; supply duct humidity; and ventilation.*
 - b. *Converter: inlet and outlet temp; pump start/stop/proof and alternation or speed control.*
 - c. *Cooling tower: inlet and outlet temp; dampers or VFD control; pump start/stop/proof.*
 - d. *Chilled Water: each coil will require a dedicated Delta –P valve controlled to discharge temperature of coil. CAS override shall be accessible to FMO personnel.*
 - e. *Terminal reheat valve, terminal ventilation control.*
 - f. *Laboratories fume hoods and room pressurization.*
 - g. *Process Cooling systems.*
 2. *Alarm systems:*
 - a. *Filter banks via analog transmitters; clean room pressure, temperature and humidity; condensate pump operation & high levels; sump pump high level alarm; compressed air system low press; elevator trouble and bell;*
 - b. *Computer room AC units: filters; high and low temperature and humidity.*
 - c. *Research chambers*

- d. *Power Plant Shadow Alarms*
 - e. *Fire and Trouble Shadow Alarms*
4. *Automation Systems Monitored and Controlled:*
- a. *Snow melt heat exchangers*
 - b. *De-icing cable*
 - c. *Indoor and outdoor lighting*
 - d. *Electrical Metering Demand*
 - e. *Steam Metering*
 - e. *Chilled water flow*
 - f. *Laboratory Ventilation and Pressurization*
 - g. *CO and CO2 building and parking monitors*
 - h. *Research chambers*
 - h. *Domestic wells and reservoirs*
5. *CAS shall be able to reset schedules for the following Operations:*
- a. *Campus Irrigation System*
 - b. *Facilities Scheduling*
- F. *Sequence of Operation (TYPICAL APPLICATION)*
1. *Air Handling units*
- a. *The BAS signals the starting sequence with a normally open maintained contact closure.*
 - b. *Upon a start signal, in a mixed air system, the outside air and exhaust air dampers shall remain closed and the return air dampers shall remain open for 2 minutes and then will slowly ramp into operation over a six (6) minute period allowing a controlled ease-in of operation. A reset schedule for the mixed air control loop will be based on the return or exhaust air temperature for its associated air handler unit. Keeping in mind the warmest space needs need to be satisfied. A typical reset schedule is RA 72 dg F MA 58 dg F and RA 68 dg F MA 66dg F.*
 - c. *The supply fan speed operates from duct static pressure control or a fan plenum static pressure high limit. The duct static pressure set point shall be established by the Total system Balancer and will be the lowest pressure required to do the job. The duct pressure transmitter will be located at a far duct location common to an area requiring the most to satisfy air delivery. An airflow monitoring station in the return air stream and the sum of the terminal units supply airflow shall signal the BAS to modulate return fan speed controller to maintain the correct return airflow.*
 - d. *A temperature sensor in the discharge of the air stream of each coil unit shall signal the BAS to modulate the preheat coil and chilled water coiled valves in order to maintain the correct discharge temperature set points. The preheat set point is set for the lowest temp required i.e. 55 dg F. The pre-heat coil (assumes Wing Type coil) face and bypass shall modulate open the steam valve and then the bypass damper in order to fully load the coil tubes and prevent stratification of the air stream. The mixed air set point varies on a return air table in heating mode and economizer to min OSA inlet when the OSA is above 76 dg F and the OSA-RA temp is greater than 2 dg F. The cooling set point is on a return air table i.e. typical RA 80 CL 60 – RA 74 CL 65 dg F. In Full or substantial OSA units the reclaim recovery will lead the mixed air set point by 2 dg F. Proper alarm values will be set in coordination with the owners approval.*
 - e. *Low limit manual reset protecting thermostats shall stop the fan, should preheat cold discharge temperature decrease below 37 degrees F. (or as set). A secondary contact shall show the status of the low limit thermostat and will alarm abnormal the condition.*

- f. *Duct mounted ionization type smoke detectors shall stop the fan should products of combustion be detected. The Division 16000 Electrical Contractor responsible for the fire alarms system shall provide and install the necessary duct smoke detectors with auxiliary contacts for connection within close proximity of fan motor.*
- 2. *Heating converter - steam to hot water*
 - a. *A temperature sensor in the HWS line shall signal the BAS to modulate (typically) the 1/3, 2/3 valve arrangements in order to maintain a reset schedule based on Outside Air Temperature.*
- 3. *VAV terminal boxes and fin tube heaters*
 - a. *Utilizing direct digital control, room sensors shall control VAV boxes and fin tube radiators in sequence. On a call for cooling, the box damper shall modulate open. Both the radiator and reheat coil valves shall be closed. On call for heating, the VAV box damper modulates closed to minimum position. The VAV reheat valve and fin tube shall then begin to modulate open. Occupied / unoccupied logic will be applied.*
- 4. *Toilet and other exhaust fans*
 - a. *Exhaust fans serving toilet areas shall be start/stop/proofed and scheduled by time of day scheduling through the BAS. Start/Stop time schedule shall be provided to Contractor by the University and will be adjustable from the Dispatch Center*
- 5. *Computer Room HVAC units*
 - a. *BAS shall monitor and enable control packaged Computer room units; alarm and report & record any alarm/failures to U OF I FMO Dispatch Center for response.*
- 6. *Elevator alarm bell and mechanical trouble*
 - a. *The BAS shall monitor elevator alarm bell and mechanical trouble conditions as specified in Section 16000.*
- 7. *100 percent outside air HVAC systems*
 - a. *Dampers shall be provided with an end switch on the damper blades to shut down the fan if the outside air dampers close for any reason. Adjustment of the end switch will allow the dampers to be open 50 percent before fan shall startup.*
- 8. *Steam Metering method*
 - a. *Steam metering shall be by condensate return method. The meter shall be in the return condensate line via condensate meter with mechanical reed switch type contacts.*
 - b. *The meter will report be a pulsed signal and the BAS will total the pulses for a totalized reading.*
- 9. *Domestic and Laboratory hot water heater*
 - a. *The instantaneous water heaters shall be controlled by packed controls provided with the unit.*
 - b. *The re-circulation pump(s) will be operated and scheduled from the BAS and will have the schedule provided to the BAS contractor by the University*
 - c. *The system shall have a water outlet temperature sensor. The system should provide an alarm at 130 deg F or as set and shut down the system to prevent scalding.*
- 10. *Interior building lighting*

- a. *Public room lighting shall be operated via BAS where possible. (i.e. hallways, Labs, conference rooms, etc.)*
 - b. *A scheduler shall be included and/or an occupancy sensor may be utilized.*
 - c. *Staggered restart shall occur after a power failure. The FMO Representative shall provide restart schedule during the submittal review session.*
11. *Exterior building lighting*
- a. *Accent and walkway lights shall be managed by the BAS and will be scheduled and photocell controlled. Staggered restart after a power outage will be installed into the scheduler operation.*
 - b. *Area street lighting included with the project shall be managed via the BAS and will include scheduler and photocell operation. Staggered restart after a power outage will be installed into the scheduler.*
12. *Electric snowmelt and gutter heaters*
- a. *Gutter heaters will be turned on by OSA temperature and will be managed for staggered restart after a power outage.*
 - b. *Snowmelt for exterior stairs and walkways shall be single point controlled through Dispatch Center. These units will duty cycle through out their operation for conservation and peak shedding. They will be stagger started on a power outage recovery.*
13. *Laboratory Fume Hoods*
- a. *Fume hood will incorporate VAV function and will be of DDC control type. Measuring the open area via sash position will control the fume hood volume and then setting the air volume to the value required to maintain 100 FPM, the action time will be less than 3 seconds.*
 - b. *The Fume hood controller will also incorporate an alarm that will indicate low / high velocity alarm and will display the actual airflow in feet per minute. The alarm will locally audible indicate alarm, with a local silence, and report alarm condition to the BAS dispatch center.*
 - c. *The make up air requirements will be controlled by the lab room controller to provide the correct Laboratory pressure and ventilation rates.*
14. *Electric Power Monitoring*
- a. *The building electric power shall be monitored by a power meter(s) that shall give instantaneous and demand kW and cumulative kWh (consumption) readings.*
 - b. *The meter shall be a CT type that can be installed without disconnecting the power conductors.*
 - c. *Option: if the division 16 contractor supplies an electric meter it shall be acceptable to use the provided outputs to supply the BAS requirements instead of providing a separate CT meter.*
15. *Chilled Water Metering*
- a. *Will be by a system that uses chilled water supply and return temperature differential plus a flow as calculated by a turbine flow meter.*
- G. *Implementation: To insure compatibility with the existing CAS, the Control Systems specification must be clear as to Contractor responsibilities. The following minimum specification guidelines are in three Parts (1, 2 & 3). Part 1 covers Scope of Work, Part 2 covers Products and Part 3 covers the Execution. A glossary of control systems and terms is included to insure uniformity in software and building systems.*

1.1 SCOPE OF WORK [Sample Specification]

- A. The Building Automation System (BAS) manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.
- B. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer.
- C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.
- D. BAS manufacturer shall be responsible for all BAS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes.
- E. BAS shall be an extension of the existing U of I Siemens Building Technologies Apogee BAS system. The new BAS shall utilize Apogee scalable system architecture to provide interoperability of the new facility through the existing Client/Server CAS network.
- F. Equipment VFDs, as specified under section 15970, will be supplied under this section 15950. BAS contractor will mount VFDs in the field to insure vibration free location. Division 16000 will provide all power wiring.

[The following underlined section applies only to Laboratory Controls Systems]

- G. Provide and install a laboratory airflow control system (LACS) to maintain laboratory airflow, pressurization, temperature and fume hood average face velocity. Room pressurization control shall utilize airflow tracking to vary the volume of supply air into the room and general exhaust air from the room to maintain both minimum ventilation and airflow balance. The room pressurization control system shall also maintain laboratory temperature.
- H. The exhaust air volume of laboratory fume hoods shall be controlled by a stand-alone fume hood controller that is, seamlessly, incorporated into the room pressurization control system. The system shall include room controllers, fume hood controllers, supply and exhaust air flow control devices and control valves, all associated low voltage wiring, all pneumatic air lines and equipment if needed, and all necessary accessories to implement an integrated system as specified herein. Fume hood alarm monitor shall be integral part of system and sound local user notification. System verification and documentation as specified under the commissioning section shall also be included.
- I. All laboratory airflow control system components shall be products of a single manufacturer and be the responsibility of that manufacturer. Siemens Building Technologies, Inc shall manufacture the laboratory airflow control system.

1.2 WORK BY OTHERS

- A. Mechanical contractor installs all wells, valves, taps, dampers, flow stations, etc. furnished by BAS manufacturer. Coordination of specific location for materials as described above will be provided by the controls contractor before field installation can be performed. Pipe transmitters shall be canted to fluid flow.

- B. All AHU factory mounted control dampers shall be provided and installed by AHU equipment manufacturer. The damper shall be specified under 15885 the Air Handling Equipment and be of specified manufacture. The HVAC controls contractor shall verify that the size, flow control and seal ability will provide the needed controllability for the system.
- C. All AHU factory mounted airflow measuring stations shall be provided and installed by AHU equipment manufacturer.
- D. Division 16000 Electrical Contractor provides:
 - 1. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by BAS manufacturer.
 - 2. Wiring of all power feeds through all disconnects and or starters to electrical motor(s).
- E. Products furnished but not installed under this section
 - 1. Hydronic Piping:
 - a. Control Valves
 - b. Flow Switches
 - c. Temperature Sensor Wells and Sockets
 - d. Turbine Flow Meters
 - e. Condensate Meter
 - 2. Duct-work Accessories:
 - a. Duct Mounted Automatic Dampers
 - b. Duct Mounted Airflow Monitoring Stations
 - c. Terminal Unit Controls
 - d. Duct Control Dampers

1.3 RELATED WORK

- A. Division 01000 General and Special Conditions
- B. Division 02810 Irrigation
- C. Division 14000 Elevators
- D. Division 15000 Mechanical
- E. Section 15970 Variable Frequency Drives
- F. Section 15850 Air Handling Units
- G. Section 15990 Balancing
- H. Division 16000 Electrical

1.4 QUALITY ASSURANCE

- A. The BAS system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Distributors or licensed installing contractors are not acceptable.
- B. The manufacturer shall provide an experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS.
- C. The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BAS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project.

- D. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- E. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL 864, categories UUKL, UDTZ, and QVAX and be so listed at the time of bid. All floor level controllers shall comply, at a minimum, with UL Standard UL 916 category PAZX; Standard UL 864, categories UDTZ, and QVAX and be so listed at the time of bid.
- F. Pre-installation Conference: Contractor shall conduct a pre-installation conference in accordance with Division One requirements.

[The following underlined section applies only to Laboratory Controls Systems]

- G. For Laboratory Air Control System all materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of LACS systems and shall be the manufacturer's latest standard design that complies with the specification requirements.
- H. Installation as well as the startup, checkout and commissioning of the LACS shall be by full time employees of the control system manufacturer and shall be fully trained by the system manufacturer.

1.5 SUBMITTALS

- A. Submit documentation in the following phased delivery schedule:
 - 1. Equipment Submittals:
 - a. Valve and damper schedules
 - b. Equipment data cut sheets
 - 2. Shop Drawings:
 - a. System schematics, including:
 - i. Sequence of operations
 - ii. Point names
 - iii. Point addresses
 - iv. Interface wiring diagrams
 - v. Panel layouts.
 - vi. System riser diagrams
 - b. Auto-CAD compatible system drawings
 - c. System Schematics, Schedule, Point Name, and Setpoint sign off sheet.
- B. Upon project completion, submit operation and maintenance manuals, consisting of the following (submit both had and electronic copies):
 - 1. Index sheet, listing contents in alphabetical order
 - 2. Description of sequence of operations
 - 3. As-Built interconnection wiring diagrams with manufacturer's equipment part list for all functional components of the system
 - 4. List of connected data points, including panels to which they are connected and input device (ionization detector, sensors, etc.)
 - 5. Current control programs

6. Valve schedule
7. Damper schedule
8. Manufacturer's equipment technical data

1.6 WARRANTY

- A. Provide all services, materials and equipment necessary for the successful operation of the new BAS system for a period of one year after beneficial use. Provide an extended warranty option on all products for an additional 12 months for a total warranty of 24 months. Extended warranty applies to material components only; installation labor (if required) will be charged on an hourly basis.
- B. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.
- C. If an emergency warranty call is placed, BAS contractor shall return call within 4 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.
- D. If the local office cannot resolve the problem, the national office of the building automation system manufacturer shall be contacted to resolve the issue. National office must be staffed and available 24hours a day, 7 days a week.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Siemens Building Technologies, Inc. BAU Division.
 - a. Shall be an extension of the existing Apogee CAS system

2.2 NETWORKING COMMUNICATIONS

- A. The design of the BAS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels, a campus-wide (Management Level Network) Ethernet network based on TCP/IP protocol, high performance peer-to-peer building level network(s) and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs.
- B. The design of BAS shall allow the co-existence of new DDC Controllers with existing DDC Controllers in the same network without the use of gateways or protocol converters.
- C. Peer-to-Peer Building Level Network:
 1. All operator devices either network resident or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.
 2. The peer-to-peer network shall support a minimum of 100 DDC controllers and PC workstations.
 3. Each PC workstation shall support a minimum of 4 peer-to-peer networks hardwired or dial up.

4. The system shall support integration of third party systems (fire alarm, security, lighting, PCL, chiller, boiler) via panel mounted open protocol processor. This processor shall exchange data between the two systems for interprocess control. All exchange points shall have full system functionality as specified herein for hardwired points.

D. Management Level Network

1. All PCs shall simultaneously direct connect to the Ethernet and Building Level Network without the use of an interposing device.
2. Operator Workstation shall be capable of simultaneous direct connection and communication with BACnet, OPC, and Apogee networks without the use of interposing devices.
3. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
4. When appropriate, any controller residing on the peer-to-peer building level networks shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.
5. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet, as well as, directly connected building level networks. Any PC shall be able to interrogate any controller on the building level network.
6. Any break in Ethernet communication from the PC to the controllers on the building level networks shall result in an alarm notification at the PC.
7. The Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.
8. Access to the system database shall be available from any client workstation on the Management Level Network.
9. All controllers on the Ethernet Management Level Network shall be connected to a virtual local area network as directed by UI personnel.

2.3 DDC CONTROLLER FLOOR LEVEL NETWORK:

- A. This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data.

2.4 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLERS

- A. The DDC & HVAC Mechanical Equipment Controllers shall reside on the Building Level Network.
- B. DDC & HVAC Mechanical Equipment Controllers shall use the same programming language and tools. DDC & HVAC Mechanical Equipment Controllers, which require different programming language or tools on a network, are not acceptable.

- C. DDC & HVAC Mechanical Equipment Controllers, which do not meet the functions specified in Section 2.4.1 and Section 2.5 for DDC Controllers or Section 2.4.2 and Section 2.5 for HVAC Mechanical Equipment Controllers, are not acceptable.

2.4.1 DDC CONTROLLER

- A. DDC Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, and real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of three (3) Floor Level Application Specific Controller Device Networks.
- B. Each DDC Controller shall have a minimum of 72 Mb memory to support its own operating system and databases, including:
 - 1. Control processes
 - 2. Energy management applications
 - 3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - 4. Historical/trend data for points specified
 - 5. Maintenance support applications
 - 6. Custom processes
 - 7. Operator I/O
 - 8. Dial-up communications
 - 9. Manual override monitoring
- C. Each DDC Controller shall support firmware upgrades without the need to replace hardware.
- D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
- E. DDC Controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
- F. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.
 - 1. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
 - 2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.
- G. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O

device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.

- H. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components.
- I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
 - RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
 - Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
 - Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
 - Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)

Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:

- IEEE Standard 587-1980
 - UL 864 Supply Line Transients
 - Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)
- J. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.
 - 1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
 - 2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
 - 3. DDC controller program memory shall automatically reload from network CAS server upon power recovery if token check indicates memory loss.

2.4.2 HVAC MECHANICAL EQUIPMENT CONTROLLERS

- A. HVAC Mechanical Equipment Controllers shall be a 12-bit stand-alone, multi-tasking, multi-user; real-time digital control processors consisting of modular hardware with plug-in enclosed processors.
- B. Each HVAC Mechanical Controller shall have sufficient memory to support its own operating system and databases, including:
 - 1. Control processes
 - 2. Energy management applications
 - 3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - 4. Historical/trend data for points specified
 - 5. Maintenance support applications
 - 6. Custom processes
 - 7. Operator I/O
 - 8. Dial-up communications

- C. Each HVAC Mechanical Equipment Controller shall support firmware upgrades without the need to replace hardware.
- D. HVAC Mechanical Equipment Controllers shall provide a RS-232C serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.
- E. HVAC Mechanical Equipment Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
- F. Each HVAC Mechanical Equipment Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all components. The HVAC Mechanical Equipment Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
- G. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
 - RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
 - Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
 - Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
 - Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
 Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
 - IEEE Standard 587-1980
 - UL 864 Supply Line Transients
 - Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)
- H. In the event of the loss of normal power, there shall be an orderly shutdown of all HVAC Mechanical Equipment Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
 1. Upon restoration of normal power, the HVAC Mechanical Equipment Controller shall automatically resume full operation without manual intervention. Equipment shall return to normal operation based on a sequenced start-up restoration to allow sequential start-up of building systems and equipment. The *FMO* Representative will provide the timing sequence interval at submittal review based upon the Universities utilities loading and capability.
 2. Should HVAC Mechanical Equipment Controller memory be lost for any reason, the user shall have the capability of manually reloading the HVAC Mechanical Equipment Controller via the local RS-232C port or from a network workstation PC.
 3. The network workstation PC shall also be capable of automatically downloading the HVAC Mechanical Equipment Controller through the Building Level Network.

2.5 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLER RESIDENT SOFTWARE FEATURES

- A. General:

1. The software programs specified in this Section shall be provided as an integral part of DDC and HVAC Mechanical Equipment Controllers and shall not be dependent upon any higher-level computer for execution.
2. All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the PC workstation.
3. All digital points shall have user defined two-state status indication (descriptors with minimum of 8 characters allowed per state (i.e. summer/winter)).
4. The *U OF I* point naming scheme shall be supplied by the *FMO* Representative (F.O.R) in a joint meeting with the BAS Contractor, F.O. Dispatch Supervisor, and the F.O. Environmental Operations Supervisor where the plan for the BAS and CAS alarm response and monitor integration is decided.

B. Control Software Description:

1. The DDC and HVAC Mechanical Equipment Controllers shall have the ability to perform the following pre-tested control algorithms:
 - a. Two-position control
 - b. Proportional control
 - c. Proportional plus integral control
 - d. Proportional, integral, plus derivative control
 - e. Automatic tuning of control loops

C. DDC and HVAC Mechanical Equipment Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.

1. The system shall be capable of SSTO. Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.
 - a. The SSTO program shall operate in both the heating and cooling seasons.
 - b. It shall be possible to apply the SSTO program to individual fan systems.
 - c. The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.
 - d. The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.
2. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.
 - a. It shall be possible to individually command a point or group of points.

- b. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.
 - c. The operator shall be able to define the following information:
 - 1. Time, day
 - 2. Commands such as on, off, auto, and so forth.
 - 3. Time delays between successive commands.
 - 4. There shall be provisions for manual overriding of each schedule by an appropriate operator.
 - d. It shall be possible to schedule events up to one year in advance.
 - 1. Scheduling shall be calendar based.
 - 2. Holidays shall allow for different schedules.
3. Economizer Operation. The BAS will control the position of the air handler relief, return, and outside air dampers. If the outside air-dry bulb temperature falls below changeover set point the BAS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.
4. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.
5. Night setback control: The system shall provide the ability to automatically adjust setpoints for night control.
6. System shall be capable of Peak Demand Limiting. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
- a. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
 - b. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
 - c. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
 - d. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.
- D. DDC and HVAC Mechanical Equipment Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
- 1. A single process shall be able to incorporate measured or calculated data from any and all other DDC and HVAC Mechanical Equipment Controllers on the network. In

addition, a single process shall be able to issue commands to points in any and all other DDC and HVAC Mechanical Equipment Controllers on the network. Database shall support 30 characters, English language point names, structured for searching and logs.

2. 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 or cause the execution of a dial-up connection to a remote device such as a printer or pager.
 3. DDC and HVAC Mechanical Equipment Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task-orientated information from the user manual.
 4. DDC and HVAC Mechanical Equipment Controller shall be capable of comment lines for sequence of operation explanation.
- E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC and HVAC Mechanical Equipment 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 and HVAC Mechanical Equipment Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 2. 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 six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC and HVAC Mechanical Equipment Controller 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.
 3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hours destinations) or based on priority.
 4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
 5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.
- F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.
1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC and HVAC Mechanical Equipment Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be

provided. Each DDC and HVAC Mechanical Equipment Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum predetermined number of data samples. All trend data shall be available for transfer to a Workstation without manual intervention.

2. DDC and HVAC Mechanical Equipment Controllers shall also provide high-resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.
 - a. Loop tuning shall be capable of being initiated either locally at the DDC and HVAC Mechanical Equipment Controller, from a network workstation or remotely using dial-in modems. For all loop-tuning functions, access shall be limited to authorized personnel through password protection.
- G. DDC and HVAC Mechanical Equipment Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.
- H. The peer-to-peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC Mechanical Equipment Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC Mechanical Equipment Controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer-to-peer network shall also allow any DDC and HVAC Mechanical Equipment Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.
- I. The peer-to-peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

2.6 FLOOR LEVEL NETWORK APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) through Floor Level LAN Device Networks.
- B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, and real-time digital control processor. Provide the following types of ASCs as a minimum:
 1. Central System Controllers
 2. Terminal Equipment Controllers
 - a. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.

C. Central System Controllers:

1. Provide for control of central HVAC systems and equipment including, but not limited to, the following:
 - a. Rooftop units
 - b. Packaged air handling units
 - c. Built-up air handling systems
 - d. Chilled and condenser water systems
 - e. Steam and hot water systems
2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences.
3. Each controller shall support a stand alone real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event communication with its DDC Controller is lost and to insure protection during power outages.
4. All programs shall be field-customized to meet the user's exact control strategy requirements. Central System controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide DDC Controllers for all central equipment in order to meet custom control strategy requirements.
5. Programming of central system controllers shall utilize the same language and code as used by DDC Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide a DDC Controller to meet the specified functionality.

D. Terminal Equipment Controllers: (TEC)

1. Provide for control of each piece of equipment, including, but not limited to, the following:
 - a. Variable Air Volume (VAV) boxes
 - b. Constant Air Volume (CAV) boxes
 - c. Dual Duct Terminal Boxes
 - d. Unit Conditioners
 - e. Heat Pumps
 - f. Unit Ventilators
 - g. Room and or Laboratory Pressurization
2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 3-15 psi pneumatic, 0-10VDC or 4-20 mA, allowing for interface to a variety of modulating actuators.

3. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the FLN, BLN or MLN is not acceptable.
4. The owner as a part of the submittal review process regarding which occupancy schedule(s) are applicable shall classify individual terminal equipment controllers. Siemens shall schedule the individual controllers accordingly.

2.7 PORTABLE OPERATOR'S TERMINAL (POT)

- A. BAS shall allow for use of industry standard, commercially available portable operator terminals with a LCD display and a full-featured keyboard or shall be a Personal Digital Assistant (PDA) compatible with the current Siemens customer tool set. The POT shall be handheld and plug directly into all DDC Controllers, HVAC & Mechanical Equipment Controllers, and Floor Level Network Controllers as described below. Provide a user-friendly, English language-prompted interface for quick access to system information, not codes requiring look-up charts.
- B. Functionality of the portable operator's terminal connected at any DDC Controller:
 1. Access all DDC Controllers and ASCs on the network.
 2. Backup and/or restore DDC Controller databases for all system panels, not just the DDC Controller connected to.
 3. Display all point, selected point and alarm point summaries.
 4. Display trending and totalization information.
 5. Add, modify and/or delete any existing or new system point.
 6. Command, change setpoint, enable/disable any system point.
 7. Program and load custom control sequences as well as standard energy management programs.
 8. Acknowledge alarms.
- C. Functionality of the portable operator's terminal connected to any application specific controller:
 1. Provide connection capability at either the Floor Level Network Controller or a related room sensor to access controller information.
 2. Provide status, setup and control reports.
 3. Modify, select and store controller database.
 4. Command, change setpoint, enable/disable any controller point.
- D. Connection of a POT to a DDC or HVAC & Mechanical Equipment Controller, or ASC Controller shall not interrupt nor interfere with normal network operation in any way, prevent

alarms from being transmitted or preclude centrally initiated commands and system modification.

- E. Portable operator terminal access to controller shall be password-controlled. Password protection shall be configurable for each operator based on function, points (designating areas of the facility), and edit/view capability.

2.8 BAS TO CAS CONNECTION

- A. Connect to the existing CAS/Client Server network to allow full access to all BAS controllers and equipment as described in the sequence of operation and Siemens Network Connectivity Standards.

2.9 WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30-character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level Networks and share data between any of the 4 networks. The software shall provide, as a minimum, the following functionality:
 - a. Real-time graphical viewing and control of environment
 - b. Scheduling and override of building operations
 - c. Collection and analysis of historical data
 - d. Point database editing, storage and downloading of controller databases.
 - e. Alarm reporting, routing, messaging, and acknowledgment
 - f. Display dynamic data trend plot.
 - g. Must be able to run multiple plots simultaneously
 - h. Each plot must be capable of supporting 10 pts/plot minimum
 - i. Must be able to command points directly off dynamic trend plot application.
 - j. Definition and construction of dynamic color graphic displays.
 - k. Program editing
 - l. Transfer trend data to 3rd party software
 - m. Scheduling reports
 - n. Operator Activity Log
 - o. Open communications via OPC Server
 - p. Open communications via BACnet Client & Server
2. Use existing graphical user interface, which shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.
3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run on a Windows NT based 32 bit operating system. These Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.
4. Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows. Operator shall be able to drag and drop information between applications, reducing the number of steps (i.e.

Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend).

- a. Dynamic color graphics and graphic control
 - b. Alarm management, routing to designated locations, and customized messages
 - c. Year in advance event and report scheduling
 - d. Dynamic trend data definition and presentation
 - e. Graphic definition and construction
 - f. Program and point database editing on-line.
5. Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.
6. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported).
7. Reports shall be generated on demand or via pre-defined schedule and directed to CRT displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
- a. A general listing of all or selected points in the network
 - b. List of all points currently in alarm
 - c. List of all points currently in override status
 - d. List of all disabled points
 - e. List of all points currently locked out
 - f. List of user accounts and access levels
 - g. List all weekly schedules
 - h. List of holiday programming
 - i. List of limits and dead bands
 - j. Custom reports from 3rd party software
 - k. System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
 - l. List of programs
8. Scheduling and override.
- Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line; PC is not required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spreadsheet graphic types as a minimum:
- a. Weekly schedules
 - b. Zone schedules, minimum of 200 unique zones
 - c. Scheduling for up to 365 days in advance
 - d. Schedule reports to print at PC.

g. Collection and Analysis of Historical Data

- a. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
- b. Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

B. Dynamic Color Graphic Displays

1. Create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, and room level terminal units, shall be provided by the BAS contractor as indicated in the point I/O schedule of this specification to optimize system performance, analysis and speed alarm recognition. Color selection to be coordinated with *FMO* Representative to minimize color deficiency conflicts.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of AutoCAD or scanned pictures for use in the system.
3. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
 - a. Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
 - b. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
 - c. Equipment state can be changed by clicking on the point block or graphic symbol and then selecting the new state (on/off) or setpoint.
 - d. State text for digital points can be defined up to eight characters.
4. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation

or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

C. System Configuration & Definition

1. Network wide control strategies shall not be restricted to a single DDC Controller or HVAC Mechanical Equipment controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
2. Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller or HVAC Mechanical Equipment Controller. Changes made at the DDC Controllers or HVAC Mechanical Equipment Controllers shall be automatically uploaded to the workstation, ensuring system continuity.
3. System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system back up must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.

D. Alarm Management

1. Alarm Routing shall allow the user to send alarm notification to selected printers or PC location based on time of day, alarm severity, or point type.
2. Alarm Notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. These alarm icons shall be displayed when user is working in other Windows programs. The BAS alarm display screen shall be displayed when the user clicks on the alarm icon.
3. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
4. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

2.10 FIELD DEVICES

A. Provide instrumentation as required for monitoring, control or optimization functions.

B. Temperature Sensors

- 1) Digital room sensors shall have LCD display, day / night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment.

Temperature monitoring range	55° to 95° F (13° to 35°C)
Output signal	Changing resistance
Accuracy at Calibration point	±0.5°F (+/- 0.3°C)

- 2) Liquid immersion temperature:

Temperature monitoring range	-40/240°F
Output signal	Changing resistance
Accuracy at Calibration point	±0.5°F (+/-0.3°C)

- | | | |
|----|--|--|
| 3) | Duct (single point) temperature:
Temperature monitoring range
Output signal
Accuracy at Calibration point | -40/240°F
Changing resistance
±0.5°F (+/-0.3°C) |
| 4) | Duct Average temperature:
Temperature monitoring range
Output signal
Accuracy at Calibration point
Sensor Probe Length | -40/240°F
4 – 20 mA DC
±0.5°F (±0.3°C)
25' L (7.3m) |
| 5) | Outside air temperature:
Temperature monitoring range
Output signal
Accuracy at Calibration point | -40/240°F
Changing resistance
±0.5°F (+/-0.3°C) |

C. Liquid Differential Pressure Transmitter

Ranges	As Needed
Output	4 – 20 mA DC
Calibration Adjustments	Zero and span
Accuracy	±-0.2% of span
Linearity	±-0.1% of span
Hysteresis	±-0.05% of span

D. Differential pressure:

- | | | |
|----|--|---|
| 1) | Unit for fluid flow proof shall be Penn P74.
Range
Differential
Maximum differential pressure
Maximum pressure | 8 to 70 psi
3 psi
200 psi
325 psi |
| 2) | Unit for airflow shall be Siemens Building Technologies SW141.
Set point ranges: | 0.5" WG to 1.0" WG (124.4 to 248.8 Pa)
1.0" WG to 12.0" WG (248.8 to 497.6 Pa) |

E. Static pressure sensor:

Range	0 to .5" WG (0 to 124.4 Pa) 0 to 1" WG (0 to 248.8 Pa) 0 to 2" WG (0 to 497.7 Pa) 0 to 5" WG (0 to 1.2 kPa) 0 to 10" WG (0 to 2.5 kPa)
Output Signal	4 – 20 mA VDC
Combined static error	0.5% full range
Operating Temperature	-40° to 175° F (-40C to 79.5°C)

F. Air Pressure Sensor:

Range:	0 to 0.1 in. water (0 to 24.9 Pa) 0 to 0.25 in. water (0 to 63.2 Pa) 0 to 0.5 in. water (0 to 124.5 Pa) 0 to 1.0 in. water (0 to 249 Pa) 0 to 2.0 in water 90 to 498 Pa) 0 to 5.0 in. water (0 to 1.25 kPa)
--------	--

- | | | |
|--|---------------|-------------------------------------|
| | | 0 to 10.0 in. water (0 to 2.49 kPa) |
| | Output signal | 4 to 20 mA |
| | Accuracy | $\pm 1.0\%$ of full scale |
- G. Humidity Sensors:
- | | | |
|------|-----------------|----------------------------|
| i. | Range | 0 to 100% RH |
| ii. | Sensing Element | Bulk Polymer |
| iii. | Output Signal | 4 – 20 mA DC |
| iv. | Accuracy | At 77°F(25°C) $\pm 2\%$ RH |
- H. Insertion Flow Meters (Equal to Onicon Series F-1210)
- | | | |
|--|----------------------------|-----------------------------|
| | Sensing Method | Impedance Sensing |
| | Accuracy | $\pm 2\%$ of Actual Reading |
| | Maximum Operating Pressure | 400 PSI |
| | Output Signal | 4 – 20 mA |
- I. Pressure to Current Transducer
- | | | |
|--|---------------|---|
| | Range | 3 to 15 psig (21 to 103 kPa) or
3 to 30 psig (21 to 207 kPa) |
| | Output signal | 4 – 20 mA |
| | Accuracy | $\pm 1\%$ of full scale (± 0.3 psig) |
- J. Control Valves (all control valves shall have electric actuators).
1. Electric Control

Rangeability	40:1
Flow Characteristics	Modified. Equal percentage. Linear
Control Action	Normal open or closed as selected
Medium	Steam, heating water, glycol
Body Type	Screwed ends 2" and smaller, flanged Valves 2½" and larger
Body Material	Bronze
Body Trim	Bronze
Stem	Stainless Steel
Actuator	0-10 VDC, 4-20 MA or 2 position 24 VAC/120VAC
 2. All automatic temperature control valves in water lines shall be provided with characterized throttling plugs and shall be sized for minimum 25% of the system pressure drop or 5 psi, whichever is less.
 - a. Positive positioning relays shall be provided on pneumatic control when required to provide sufficient power for sequencing.
 - b. Two position valves shall be line size, and incorporate soft close technique to prevent hammer in system.
 - c. Chilled water valves shall be Delta- P valves, no exception.
- K. Damper Actuators
1. Electric control shall be Siemens Building Technologies OpenAir™ direct-coupled actuators direct-coupled actuators.

2. Damper actuators shall be brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.
 - a. The actuator assembly shall include the necessary hardware and proper mounting and connection to a standard ½" diameter shaft or damper blade.
3. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.
4. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed "v" shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft. Utilize friction-enhancing tape on shafts that do not provide flats for contact lock.
5. All actuators having more than a 100 in-lb torque output shall accept a 1" diameter shaft directly, without the need for auxiliary adapters.
6. All actuators shall be designed and manufactured using ISO900 registered procedures, and shall be listed under Standards UL873 and CSA22.2 No. 24-93 I.

2.12 MISCELLANEOUS DEVICES

- A. Thermostats
 1. Room thermostats shall be of the gradual acting type with adjustable sensitivity.
 2. They shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree. (Provide all thermostats with limit stops to limit adjustments as required.)
 3. Thermostats shall be arranged for either horizontal or vertical mounting.
 4. In the vertical position thermostat shall fit on a mullion of movable partitions without overlap.
 5. Mount the thermostat covers with tamper-proof socket head screws.
- B. Low Temperature Safeties: (Freezestats)
 1. Install freezestats as indicated on the plans.
 - a. Upon detection of low temperature, the freezestats shall stop the associated supply fans and return the automatic dampers to their normal position. Provide manual reset.
 - i. Primary contact on freezestat will control will control 120V power supplied to the AHU fan starters. Both the supply and return fans shall be disabled when the freezestat contact switch opens.
 - ii. The same 120V power shall energize a 24V transformer that provides low-voltage power to the OA, RA and EA, economizer dampers for that AHU. A separate 24V transformer must be provided for each AHU, which provides power only for these dampers. The OA, and EA economizer dampers shall be spring loaded Normally Closed, and RA damper shall be spring loaded Normally Open.

- iii. The auxiliary contact from the freeze-stat shall be connected to the EMS DI point.
 - b. Provide input point to BAS for monitoring.
 - c. Installation to incorporate a serviceable testing loop that allows for insertion of element loop into a 4-inch throat vessel for calibration.
- C. Smoke Detectors:
 - 1. Provided and installed by others.
- D. Electronic Airflow Measurement Stations and Transmitters (At Duct Locations).
 - 1. Stations – each insertion station shall contain an array of velocity sensing elements and straightening vanes. The velocity sensing elements shall be of the RTD or thermistor type. The sensing elements shall be distributed across the duct cross section in a quantity to provide accurate readings. The resistance to airflow through the airflow measurement station shall not exceed 0.08 inches water gage at airflow of 2,000 fpm. Station construction shall be suitable for operation at airflow of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus 3 percent over a range of 125 to 2,500 fpm scaled to air volume. Each transmitter shall produce a linear, temperature compensated 4 to 20 mA DC, output corresponding to the required velocity pressure measurement.
- E. Current Sensing Relay:
 - 1. Provide solid-state, adjustable, current operated relay. Provide a relay, which changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
 - 2. Adjust the relay switch point so that the relay responds to motor operation under load as an “on” state and so that the relay responds to an unloaded running motor as an “off” state. A motor with a broken belt is considered an unloaded motor.
 - 3. Provide for status device for all fans and pumps.

[The following underlined section applies only to Laboratory Controls Systems]

2.13 LABORATORY SUPPLY AND EXHAUST AIR TERMINALS

- A. Laboratory terminal units shall provide turndown ratios of 5 to 1 for fume hood exhaust terminals and adequate turndown for room supply and general exhaust terminals. Adequate turndown to assure that the airflows specified can be maintained. All terminals shall be controlled to be pressure independent and include actual airflow measurement feedback as an integral part of their control process. Minimum airflow measurement accuracy shall be +/- 5% of actual reading over the entire rated airflow range of each device. Minimum to maximum terminal airflow (or visa versa) shall be attained in less than 1 second.
- B. Exhaust airflow measurement shall be provided by airflow sensing techniques that are not likely to obstruct the exhaust duct or become inoperative due to the accumulation of chemical deposits. For example, pitot tube arrays are NOT acceptable for exhaust airflow measurement since they may collect tissues and other debris and their minute pressure sensing holes become plugged with deposits.
- C. All supply air terminals shall be constructed of minimum 20 gauge-galvanized steel. Damper shafts shall be solid stainless steel with Teflon or Teflon infused aluminum bearings. Supply terminals must be capable of 100% shut-off to accommodate smoke

control requirements. Supply terminal air leakage shall not exceed 2% of design airflow at 4 inches w.g. positive static pressure.

- D. All general exhaust terminals shall be constructed of 316 L stainless steel or coated with corrosion resistant Teflon (can also be 20 gage galvanized steel if required). Damper shafts shall be solid stainless steel with Teflon bearings.
- E. All FHET (Fume Hood Exhaust Terminals) shall be constructed of 316L stainless steel or coated with corrosion resistant Teflon. Damper shafts shall be solid stainless steel with Teflon bearings.
- F. All terminals shall have a pressure drop of 0.3" or less at the maximum rated airflow.
- G. A loss, increase and/or decrease of airflow shall be transmitted to the fume hood or room controller as appropriate.
- H. Discharge and Radiated sound power level data for all terminals shall be available and provided at the owner or engineer's request. The data shall be in accordance with the test procedure in ARI 880-89 Standard for Air Terminals and all data shall be obtained in a qualified, accredited and ARI approved testing laboratory.

2.14 LABORATORY ROOM CONTROLLER

- A. Each supply and associated exhaust terminal shall be controlled to maintain an actual CFM airflow differential between total room exhaust and supply air that is equal to 10% of the maximum laboratory room design airflow or 200 CFM, whichever is greater, to meet space pressurization requirements. For negatively pressurized rooms, supply airflow shall be controlled to equal the total room exhaust airflow less the required airflow differential. For positively pressurized rooms, total exhaust airflow shall track supply airflow less the required airflow differential
- B. Room airflow tracking shall be accomplished via actual measurement of terminal unit airflow. Controllers, which track within a range of airflow's versus actual airflow setpoints, shall not be acceptable.
- C. Each laboratory room controller shall be specifically designed for control of laboratory temperature, (humidity and differential pressure monitoring where applicable) and room ventilation. Each controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. Control sequences shall be included as part of the factory supplied software. These sequences shall be field customized by adjusting parameters such as control loop algorithm gains, temperature setpoint, alarm limits, airflow differential setpoint, and pressurization mode. Closed loop Proportional Integral Derivative (PID) control algorithms shall be used to maintain temperature and airflow offset set points.
- D. Should a power failure or operational failure occur within the controller, the terminal unit damper shall automatically be positioned to the fully open or fully closed (failsafe) position as defined by the owner.
- E. Controller shall include all inputs and outputs necessary to perform all specified control sequences.
- F. Each controller shall operate stand alone, performing its specified control responsibilities independently.

- G. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM memory, or a minimum of 72-hour battery backup shall be provided. All controllers shall return to full normal operation without any need for manual intervention after a power failure of unlimited duration.

2.15 VARIABLE AIR VOLUME FUME HOOD CONTROLLER

- A. Provide a UL 916 listed individual VAV fume hood controller for each fume hood, which shall maintain the face velocity setpoint (adjustable) in response to sash position.
- B. In operation, the VAV fume hood control process consists of calculating the fume hood exhaust flow necessary to provide the required average face velocity at any sash position based upon actual sash position and total fume hood open area. The controller shall then position the fume hood exhaust terminal damper to attain the required exhaust airflow in conjunction with constant feedback from an integral exhaust airflow sensor. The controller shall perform this exhaust airflow calculation ten times per second to ensure maximum speed of response to changes in sash position. Even when no change has occurred in sash position since the previous calculation, the controller shall continue to position the exhaust terminal damper in response to its airflow measurement feedback to ensure that the required fume hood exhaust is always maintained independently of variations in exhaust system static pressure or room conditions that could otherwise affect fume hood exhaust airflow.
1. The VAV fume hood controller shall initiate corrective action immediately upon sash movement and be completed when sash movement stops so as to restore the required average face velocity within 1 second after completion of sash movement. Control scenarios that are not based upon sash sensing are not acceptable. All such ASHRAE 110 testing shall be conducted by a qualified, accredited and independent testing source.
 2. A "Sash Alert" feature shall provide periodic beeps at the Operator Display Panel when the sash remains open above the recommended safe working height (adjustable) for an adjustable period of time. This feature shall enhance fume hood safety operation and energy efficiency. This feature shall include a beep interval and be capable of being implemented on individual fume hoods as desired by authorized owner personnel.
- C. The face velocity setpoint shall be adjustable by authorized owner personnel
- D. Controllers shall include the ability to accept and incorporate into the control sequence a dry contact closure from auxiliary sensors. Example: Occupancy override, Emergency button, etc.
- E. Controllers shall provide a general alarm output for use with auxiliary devices.
- F. Momentary or extended losses of power shall not change or affect any of the control system's setpoints, calibration settings, or emergency status. After power returns the system shall continue operation exactly as before without need for any manual intervention.

2.16 FUME HOOD OPERATOR DISPLAY

- A. An operator display panel shall be provided for each fume hood to comply with laboratory safety standards. The operator display panel shall provide the following functionality:

- B. Indicator lights that verify normal operation (green), marginal operation (yellow), and alarm condition (red). An alarm condition shall automatically be initiated for both high and low face velocity conditions.
- C. An audible alarm device shall also be initiated in response to an alarm condition. The audible alarm device shall be capable of being silenced by a user silence button, however the alarm device shall automatically resound upon another alarm occurrence.
- D. A user initiated emergency purge functions shall initiate visual and audible alarm and increase the fume hood exhaust to maximum airflow. When the emergency purge button is depressed, a second time, the emergency sequence shall be terminated and fume hood control shall return to normal operation.

2.17 SASH SENSOR

- A. Provide, sash position sensors for each fume hood to indicate the actual position of each sash. The sash sensor shall be a precision, linear device with repeatable location accuracy within one half inch.
- B. Sash sensors material shall be corrosion resistant.
- C. Sash sensors shall allow complete and easy removal of the sashes for cleaning and maintenance.
- D. Operational life of each sash sensor shall be a minimum of 1,000,000 full cycles.
- E. Sash sensor failure shall be indicated as an alarm at the fume hood operator display panel.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

- A. Provide a designated project manager who will be responsible for the following:
 1. Provide Input to the GC's project schedule.
 2. Construct and maintain project schedule.
 3. On-site coordination with all applicable trades, subcontractors, and other integration vendors as pertaining to the BAS installation.
 4. Authorized to accept and execute orders or instructions from owner/architect.
 5. Attend project meetings as necessary to avoid conflicts and delays.
 6. Make necessary field decisions relating to this scope of work.
 7. Coordination/Single point of contact.
 8. Make changes to submittal documents for the BAS system that representative of the building As-Built final documents.

3.2 SEQUENCE OF OPERATION

3.3 START-UP OF BAS

- A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The manufacturer shall complete all testing, calibrating, adjusting and final field tests. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.

- B. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.
- C. BAS contractor shall follow the manufacturer's recommended startup and commissioning guidelines and provide a commissioning report initialed by the startup technician that the equipment was installed and operational. This checklist will be included in the O&M manuals.
- D. Siemens shall provide a "96 hour Guaranteed Run" of BAS. The "Guarantee Run" shall commence after all field equipment is installed, calibrated, commissioned and running under normal operating conditions – temporary installation(s) are not allowed to be considered as part of the "Guarantee Run". The "Guarantee Run" shall precede the testing, adjusting and balancing of the mechanical systems.
- E. The "Guarantee Run" shall include performance of all the associated software and hardware operations called for in these specifications. The "Guarantee Run" shall be for 96 continuous hour's duration, which no Contractor maintenance shall be required. All major setpoints, measured variables and equipment status will be trended during the "Guarantee Run". A list of the trended points shall be submitted to the Universities designated FMO Representative for approval in advance of the "Guarantee Run".

[The following underlined section applies only to Laboratory Controls Systems]

- F. System startup shall be provided by factory certified and trained employees of the laboratory ventilation control system manufacturer. Start up shall include the following:
 1. Determine when the HVAC equipment and physical space is ready for operational testing.
 2. Set up fume hood face velocity controls and verify face velocity and air flow measurement accuracy
 3. Verify VAV room supply system performance
 4. Verify VAV room exhaust system performance
 5. Verify room airflow tracking performance
 6. All steps of system startup shall be formally recorded when performed and provided to the owner as part of the as built documentation.
- G. BUILDING AUTOMATION SYSTEM INTERFACE
The following laboratory environment information shall be provided to the building automation system.
 1. Fume hood exhaust airflow (cfm)
 2. Laboratory room supply airflow (cfm)
 3. Laboratory room general exhaust airflow (cfm)
 4. Fume hood sash position
 5. Fume hood flow alarm
 6. Laboratory room airflow alarm
 7. Laboratory room temperature
 8. Laboratory room airflow offset setpoint adjustment
 9. Laboratory room temperature setpoint adjustment
 10. Occupied state of Laboratory room controls
- H. Information may be transmitted electronically through protocol translators, seamless LAN connection.

3.4. BALANCING COORDINATION

- A. BAS contractor shall be available to assist the testing, adjusting and balancing contractor up a total of 12 hours.
- B. At the pre-balance conference the BAS contractor shall provide the TAB contractor software necessary to interface to and operate the control system. The BAS contractor shall provide a complete point list of controlled elements and list of Terminal Equipment Controllers. (TEC)
- C. The BAS contractor shall instruct the TAB contractor how to update daily balancing settings. Weekly the BAS contractor shall verify these updates, during the TAB process.

3.5 ELECTRICAL INSTALLATION WIRING AND MATERIALS

- A. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. All wiring shall be installed in a minimum of ¾" conduit. Room Temperature Sensor wiring may be interconnected to respective ASC in a ½" conduit.
- B. Provide wiring between thermostats, aquastats and unit heater motors, all control and alarm wiring for all control and alarm devices for all Sections of Specifications.
- C. Provide status function conduit and wiring for equipment covered under this Section.
- D. Provide conduit and wiring between the BAS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit.
- E. Provide conduit and control wiring for devices specified in this Section.
- F. All wiring to be compliant to local building code and the NEC.
- G. Provide conduit and wiring between metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contactors, and BAS panels, as shown on the drawings or as specified.
- H. All electrical installation wiring and methods must comply with Division 16000 specifications.

[The following underlined section applies only to Laboratory Controls Systems]

- I. The laboratory ventilation system contractor shall install the sash sensors, control equipment, and operator display panels on fume hoods. This contractor shall install and terminate all low voltage control wiring between each controller and all control and sensing devices, and provide 24 VAC power where required by the controllers and control devices. This contractor shall be a representative of Siemens Building Technologies or approved subcontractor under the direction of Siemens Building Technologies.

3.6 PERFORMANCE

- A. Unless stated otherwise, control temperatures within plus or minus 2°F of set point, humidity within plus or minus 3% of the set point and static pressure within 5% of set point.

3.7 TRAINING

- A. The manufacturer shall provide training by a qualified Siemens technician who is familiar with the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The manufacturer shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 am to 4:30 P.M. weekdays.

- B. Provide (8) hours of training for Owner's designated operating personnel. Training deliverables shall be coordinated with the FMO Representative and will include a combination of the following:
 - 1. Explanation of drawings, operations and maintenance manuals
 - 2. Walk-through of the job to locate control components
 - 3. Operator workstation and peripherals
 - 4. DDC controller and ASC operation/function
 - 5. Operator control functions including graphic generation and field panel programming
 - 6. Operation of portable operator's terminal
 - 7. Explanation of adjustment, calibration and replacement procedures
 - 8. Student binder with training modules

- C. Since the Owner requires personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Manufacturer. Each Major Capitol Project will include training for one University technician at a factory-training center. The training will be for one week typically, at the level needed to successfully operate the BAS controls supplied. The Owner will bear the cost of transportation and lodging for this class.