APPENDIX A

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BUILDING AUTOMATION SYSTEM

PART 1 GENERAL

1.01 SCOPE

A. Furnish and install a complete Direct Digital Control (DDC) Temperature Control System to automatically control the operation of the entire Heating, Ventilating and Air Conditioning System. Failure to mention any specific item or device does not relieve the Contractor of the responsibility for furnishing and installing such items or devices in order to comply with the intent of the Drawings and/or this Specification.

B. Proposed Equals shall be proposed as outlined in the Instructions to Bidders, Article 2.5, and as detailed below. To obtain approval to use unspecified products as 'approved equals', Bidders shall submit written requests to the Associate at least ten (10) working days before the bid date. Requests received after this time will not be considered. Requests shall clearly describe the system for which approval is asked, including all data necessary to demonstrate that it meets all performance requirements of the specifications. If the proposed equal is found to be acceptable, an addendum will be issued, as outlined in the Instructions to Bidders, Article 2.5, to all contractors on record. Submitted data shall be organized, tabulated, and annotated as follows:

1. Overall table of contents
2. Individual table of contents for each section
3. Tabulated list of included hardware and software (differentiated from available-but-not-included hardware and software)
4. Tabulated list of conformance to each paragraph of this specification, listing any exceptions thereto
5. Specific description of hardware, firmware, and software as proposed
6. Campus-wide Ethernet network diagram applicable to this project
7. Auto-dial/auto-answer communications network
8. Building-wide peer-to-peer DDC Controller network diagram
9. Supplementary Controller local area network diagram
10. Application Specific Controller local area network diagram
11. Detailed description of graphic and display software characteristics
12. Detailed description of DDC control software characteristics

C. Building Automation System (BAS) Contractor shall provide:

1. A fully integrated building automation system (BAS), UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, as manufactured by:

a. Landis & Staefa, Inc.

b. Johnson Controls, Inc.

c. Andover Controls Corp.

2. Necessary conduit, wiring, enclosures, and panels, for all DDC temperature control equipment and devices. Installation shall comply with applicable local and national codes.

3. All components and control devices necessary to provide a complete and operable DDC system as specified herein.

4. All final electrical connections to each stand-alone DDC Controller. Connect to 120VAC power as provided by the Division 26 contractor, to be terminated within 5 feet of the DDC Controller.

5. BAS Contractor shall be responsible for all electrical work associated with the BAS control system and as called for on the Drawings. This BAS control wiring shall be furnished and installed in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes.

6. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers, Application Specific Controllers and operator's workstations. Provide an external protection device listed under UL 1449 with minimum clamping voltage of 400 Volts and surge current capability of 26,000 Amps.

7. All 120V and low voltage electrical control wiring exposed throughout the building shall be run in conduit in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes.

8. All 24V power required for operation of the BAS shall be by the BAS Contractor.

9. BAS Contractor shall provide programming modifications necessary to fine tune sequences during commissioning and through warranty period of systems at no additional cost to the University.

D. HVAC Contractor provides:

1. All wells and openings for water and air monitoring devices, temperature sensors, flow switches and alarms furnished by BAS Contractor.

2. Installation of all control valves.

3. Installation of dampers and adjacent access doors for smoke; outdoor air, return air, exhaust air, and ventilation dampers.

4. All package unit control panels.

E. Electrical Contractor provides:

1. Electrical Contractor shall provide dedicated 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for each DDC Controller. Run power circuit within 5 feet of equipment installed and connected by BAS Contractor.

F. General Product Description:

1. The building automation system (BAS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.

2. The building automation system shall consist of the following:

   a. Stand-alone peer-to-peer DDC Controllers

   b. Stand-alone Supplementary Controllers

   c. Stand-alone Application Specific Controllers (ASC's)

   d. Portable operator's terminal(s)

   e. Provide seamless interconnection to existing central graphic workstation, and build customized graphics display system.

3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, Application Specific Controllers and operator devices.

4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

5. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central processing device. DDC Controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

1.02 RELATED WORK

A. Specified elsewhere:

1. _____- Sequence of Operation

2. _____- Variable Speed Control

3. _____- Basic Mechanical Requirements

4. _____- Motors

5. _____- HVAC Pumps

6. _____- Boilers

7. _____- Chillers

8. _____- Cooling Tower

9. _____- Terminal Heat Transfer Units

10. _____- Air Handling Units

11. _____- Testing, Adjusting and Balancing

12. _____- Basic Electrical Materials and Methods

13. _____- Equipment Wiring

B. Materials furnished by the BAS contractor, but installed by others:

1. BAS Contractor to furnish the following to the Heating, Ventilation and Air Conditioning Contractor for installation by the HVAC contractor:

a. Control valves and temperature sensor wells for wet systems,

b. Location of all wells and openings for temperature, pressure, and flow sensors for pipe systems

c. Control dampers for air systems

d. Location of all ducts and openings for temperature, pressure, flow, and humidity sensors for air systems.

1.03 QUALITY ASSURANCE

A. 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.

B. Install system using competent workmen who are fully trained in the installation of temperature control equipment.

C. Single source responsibility of supplier shall be the complete installation and proper operation of the BAS and control system and shall include debugging and proper calibration of each component in the entire system. The BAS must be supplied and installed by the same control contractor. Only Factory Authorized Distributors will be considered for installation. The letting of separate contracts by the prime HVAC Contractor for the Control System and a separate contract for its installation by a third party installer is strictly prohibited.

D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

E. All electronic equipment shall conform to the requirements of FCC Regulations, Part 15, Subpart B, Class A, governing radio frequency electromagnetic interference, and be so labeled.

F. BAS shall comply with, and be listed at time of bid for the following Underwriters Laboratories Standards:

1. UL 916 for Energy Management Equipment, per category PAZX for Energy Management Equipment.

2. UL 864 for Control Units for Fire-Protective Signaling Systems, per category UDTZ for Signal Appliance System Units.

3. UL 864 for Control Units for Fire-Protective Signaling Systems, per category UUKL for Smoke Control System Equipment.

G. Product shall be ISO 9002 Registered at the time of bid.

H. Design and build all system components to be fault-tolerant.

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3 Hertz variation in line frequency.

2. Static, transient and short-circuit protection on all inputs and outputs.

3. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.

4. Network-connected devices to be AC-coupled or equivalent so that any single device failure will not disrupt or halt network communication.

5. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and system low battery indication.

6. All programs shall retain their memory for a minimum of 7 days upon loss of power.

I. The BAS Installer shall have a competent Project Manager who is able to answer field questions, is aware of all schedules and schedule changes, and is responsible for the BAS Installer's work and the coordination of their work with all other trades. This Project Manager shall be available for on site and shall respond to design, programming, and equipment related questions. Failure to provide the above services shall be considered a substantial breech of Contract Documents.

1.04 SUBMITTALS

A. Submit 3 complete sets of drawings showing the kind of control equipment for each of the various systems and their functions, along with indications on the drawing of all original setpoints and calibration values, and setup parameters, and sequence of operation of the automation system. These drawings shall be submitted for approval to the Associate, and to The Ohio State University Facilities Operations and Development, Utilities Division, and to The Ohio State University Engineer's Office, together with a complete brochure describing the equipment and their functions and operation. Include all application software documentation (actual programs or their job-specific flow charts) with DDC system and schedule a review meeting with the University's Representative and the Associate at least two weeks before installation and start up.

1. Manufacturer's Product Data:

a. All equipment components

2. Shop Drawings:

a. System wiring diagrams with sequence of operation for each system as specified.

b. Submit manufacturer's product information on all hardware items along with descriptive literature for all software programs to show compliance with specifications.

c. System configuration diagram showing all panel types and locations as well as communications network and workstations.

B. Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Associate prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

PART 2 PRODUCTS

2.01 NETWORKING COMMUNICATIONS

A. The design of the BAS network shall integrate operator workstations and stand-alone DDC Controllers on a peer-to-peer communications network, and other devices on other networks. The network architecture shall consist of the following four levels:

1. A campus-wide Ethernet communications network based on TCP/IP protocol

2. An auto-dial/auto-answer telecommunications network

3. A building-wide peer-to-peer communications network between DDC Controllers

4. Many local area networks extended from appropriate DDC Controllers to associated Supplementary Controllers and associated Application Specific Controllers.

B. Access to system data shall not be restricted by the hardware configuration of the building automation system. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.

C. Campus-wide Ethernet Communications Network:

1. Local within this building, provide one Ethernet link between the campus-wide Ethernet and the building-wide peer-to-peer network (DDC Controller network). At least one of the peer-to-peer network devices (e.g., DDC Controller) shall provide the interface to the Ethernet for remote monitor, remote manual control, remote alarm, and remote programming of sequences of any and all building-wide points and sequences over the Ethernet.

2. Remote at the Central Utilities office, provide one Ethernet link for monitor, control, alarm, displaying graphics, and simultaneous programming of sequences. If programming of sequences cannot be accomplished simultaneously while performing monitor, control, alarm, and displaying graphics, then provide a second Ethernet link to allow for simultaneous programming.

3. All Ethernet communications shall include software management and control for both access and privilege. The remote Central Utilities office shall manage all rights for access and privilege per each remote location, for remote monitor, remote manual control, remote alarm, and remote programming of sequences of any and all building-wide points.

D. Auto-dial/Auto-answer Telecommunication Network:

1. Auto-dial/auto-answer communications shall be provided to allow DDC Controllers to communicate with remote operator stations and/or remote terminals on an intermittent basis via telephone lines, as indicated in the sequence of operations.

2. Auto-dial DDC Controllers shall automatically place calls to workstations to report alarms or other significant events.

a. DDC Controllers shall be able to store a minimum of 10 phone numbers of at least 20 digits. Retry a single primary number at a fixed interval until successful.

b. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers. Provide as a minimum 3 secondary numbers when communications cannot be established with the primary device.

3. Operators at dial-up workstations shall be able to perform all control functions, all report functions and all database generation and modification functions as described for workstations connected via the network. Routines shall be provided to automatically answer calls from remote DDC Controllers. The fact that communications are taking place with remote DDC Controllers over telephone lines shall be completely transparent to an operator.

a. An operator shall be able to access remote buildings by selection of any facility by its logical name. The workstation dial-up program shall store the phone numbers of each remote site, so the user shall not be required to remember or manually dial telephone numbers.

b. A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial DDC Controllers or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity, nor shall network activity keep the workstation from handling incoming calls.

4. Dial-up communications shall make use of Hayes compatible modems and voice-grade telephone lines. Provide modems rated at 28.8k baud with auto ranging. System access to be provided through phone lines to the existing campus Front End Computer. Cost of the phone line installation is the responsibility of this contractor and should be included in this contract. Contact, Manager - Utility Services- Automation Engineering for coordination.

E. Building-wide Peer-to-Peer Communications Network:

1. Operator workstations and DDC Controllers shall directly reside on a network such that communications may be executed directly between DDC Controllers and workstations on a peer-to-peer basis, without requirement for any device to operate or manage the network. A portion of the network management is built into each of the ‘peer-to-peer members. ‘Peer-to-peer’ refers to controllers that (when interconnected) will act independently as equals, without a network manager, and will communicate in a token passing protocol with each other to pass data packet information for the purpose of building-wide monitoring and control. A special data packet called the ‘token’ is constantly and continually ‘passed’ to every member of the peer-to-peer communications network. Any peer-to-peer device on the network can send a packet of data only when it has the ‘token’. Any peer-to-peer device on this network can request data from, or send data to, any other device on the network. With this procedure, token ensures that data collisions do not occur, and assures that all members of the network get equal opportunity for all data on the network.

2. Systems that operate via polled response or other types of protocols that rely on a network manager, file server, or similar device to manage panel-to-panel communications may be considered only if a similar device is provided as a standby. Upon a failure or malfunction of the primary network manager, the standby network manager shall automatically, without any operator intervention, assume all BAS network management activities.

3. All operator devices either resident on the peer-to-peer network, 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. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the peer-to-peer network data.

4. Network design shall include the following provisions:

   a. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any DDC Controller is displayed at workstations and/or alarm printers within 5 seconds.

   b. Support of any combination of DDC Controllers and operator workstations directly connected to the peer-to-peer network. A minimum of 32 devices shall be supported on a single network.

   c. Message and alarm buffering to prevent information from being lost.

   d. Error detection, correction and retransmission shall be included to guarantee data integrity.

   e. Synchronization of real-time clocks, to include automatic daylight savings time updating between all DDC Controllers shall be provided.

5. Acceptable protocols for intercommunications between building-wide peer-to-peer DDC Controllers:

   a. Landis & Staefa, Inc., – P2, Powers Protocol 2

   b. Johnson Controls, Inc., - N1 LAN

   c. Andover Controls Corp., - EnergyNet

F. Local Area (communications) Network (LAN):

1. This communications network shall be limited to Supplementary Controllers and Application Specific Controllers, and shall communicate bi-directionally with the peer-to-peer network through DDC Controllers for transmission of global data.

2. Supplementary Controllers and Application Specific Controllers shall be arranged on the LAN's in a functional relationship to the corresponding DDC Controllers. For example, a VAV Application Specific Controller serving a VAV terminal box shall be connected on a LAN from the DDC Controller that is controlling the corresponding air handling unit.

3. A maximum of 32 Supplementary Controllers and Application Specific Controllers may be configured on any individual LAN from any DDC Controller to insure adequate global data and alarm response times.

4. Acceptable protocols for intercommunications between Supplemental Controllers and DDC Controllers, and between Application Specific Controllers and DDC Controllers are as follows:

   a. Landis & Staefa, Inc., – Local Area Network LAN (LonWorks not permitted)

b. Johnson Controls, Inc., - N2 Bus (LonWorks N2E not permitted)

c. Andover Controls Corp., - Infinet Bus (LonWorks not permitted)

2.02 DDC CONTROLLER

A. DDC (stand-alone) Controllers shall be microprocessor-based with a minimum word size of 16 bits. They shall also be multi-tasking, multi-user, 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.

B. Each DDC Controller shall have sufficient memory, a minimum of 3 megabyte, 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:

1. Monitoring of the following types of inputs, without the addition of equipment outside of the DDC Controller cabinet:

a. Analog inputs

1) 4-20 mA

2) 0-10 Vdc

3) Thermistors

4) 1000 ohm RTD’s

b. Digital inputs

1) Dry contact closure

2) Pulse Accumulator

3) Voltage Sensing

2. Each DDC Controller shall be capable of providing the following control outputs without the addition of equipment outside the DDC Controller cabinet:

a. Digital outputs (contact closure)

1) Contact closure (motor starters, up to size 4)

b. Analog outputs

1) 4-20 mA

2) 0-10 Vdc

Note: The operation of pneumatic outputs shall require 4-20mA-to-3-15psig transducers. The 4-20 mA output of the DDC Controller shall power the transducer. The transducer shall not require the use of an additional power supply.

D. Each DDC Controller shall have a minimum of 10 per cent spare (panel real estate) capacity for future point connection. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two spares of each implemented I/O type. Provide all processors, power supplies, database memory, program sequence memory, and communication controllers complete so that the implementation of any added point (within the above 10% spare) only requires the addition of the appropriate point input/output termination module, point sensor, and wiring.

1. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

E. DDC Controllers shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, (VT-100 compatible) operator terminals, modems and laptop portable operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals. System-wide access must be provided at each mechanical equipment room through the local DDC Controller. Panel mounted terminals are not required.

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. These override switches shall be operable whether the panel processor is operational or not.

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 LED’s 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. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point termination's to suppress induced voltage transients consistent with current IEEE Standard C62.41.

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. Programs residing in memory shall be protected either by using EEPROM or by an uninterruptible power source (battery backup). The backup power source shall have sufficient capacity to maintain volatile memory in event of an AC power failure. Where un-interruptible power source is rechargeable (a rechargeable battery), provide sufficient capacity for a minimum of seventy-two hours backup. Charging circuitry, while the controller is operating under normal line power, shall constantly charge the rechargeable power source. A non-rechargeable power source shall not be permitted. Batteries shall be implemented to allow replacement without soldering.

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.

K. Application Specific Controllers are not acceptable for Air Handlers, Chiller/Boiler Plants.

L. DDC Controllers must comply with Section 2.02, A-I and 2.03. Panels that lose communication or control due to a single sensor failure are not permitted.

M. DDC Controllers will be used in each equipment room where major or more than two pieces of equipment are being controlled.

N. All points associated with a given mechanical system (i.e., an air handling unit) will be controlled from a single DDC Controller or point expansion panels from the respective master. (i.e., remote motor control centers). No points from a given mechanical system may be distributed among multiple panels - points must be run back to a single DDC Controller dedicated to that mechanical system. Closed-loop control must never depend upon network communications. All inputs, program sequences, and outputs for any single DDC control loop shall reside in the same DDC Controller.

O. Approved products for DDC Controllers for peer-to-peer networks are as follows:

1. Landis & Staefa, Inc., Modular Building Controllers (MBC's)

2. Johnson Controls, Inc., Network Control Units (NCU's)

3. Andover Controls Corp., AEclipse Central Processing Units (CX94##'s)

2.03 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

A. General:

1. All necessary software to form a complete operating system as described in this specification shall be provided.

2. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution

3. Point naming convention shall be as referenced in Appendix A.

B. Control Software Description:

1. The DDC Controllers shall have the ability to perform any or all of 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 control loop tuning

2. Control software shall include a provision for limiting the number of times that each piece of equipment may be cycled within any one-hour period.

3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

4. Upon the resumption of normal power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

C. All programs shall be executed automatically without the need for operator intervention and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operations. DDC Controllers shall have the ability to perform any or all of the following energy management routines:

1. Time-of-day scheduling

2 365 day Calendar-based scheduling

3. Holiday scheduling

4. Temporary schedule overrides

5. Start-Stop Time Optimization

6. Automatic Daylight Savings Time Switch over

7. Night setback control

8. Enthalpy switch over (economizer)

9. Peak demand limiting

10. Temperature-compensated duty cycling

11. Fan speed/ control

12. Heating/cooling interlock

13. Cold deck reset

14. Hot deck reset

15. Hot water reset

16. Chilled water reset

17. Condenser water reset

18. Chiller sequencing

19. Chiller load monitoring

D. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. It shall be possible to use any of the following in a custom process:

    a. Any system measured point data or status

    b. Any calculated data

    c. Any results from other processes

    d. User-defined constants

    e. Arithmetic functions (+, -, *, /, square root, exponential, etc.)

    f. Boolean logic operators (and/or, exclusive or, etc.)

    g. On-delay/off-delay/one-shot timers

2. Custom processes may be triggered based on any combination of the following:

    a. Time interval

    b. Time-of-day

    c. Date

    d. Other processes

    e. Time programming

    f. Events (e.g., point alarms)

3. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network.

4. 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.

5. The custom control programming feature shall be documented via English language descriptors. These descriptors (comment lines) shall be viewable from local operator I/O devices to facilitate troubleshooting.

E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator 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 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.

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.

   a. Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

   b. Alarms shall have ability to be acknowledged from the local operator I/O device, (once the problem is resolved).

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. DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

a. 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 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 l minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.

2. Trend data shall be stored at the DDC Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers are full. All trend data shall be available for use in 3rd party personal computer applications. File format type to be comma delineated.

3. DDC 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. Provide capability to view or print trend and tuning reports.

a. In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID values and input these values into the selected LOOP statement.

b. For troubleshooting in manual mode, the operator shall be able to select variables to override default values. Calculated PID value shall then be reviewed before they are inserted into the selected LOOP statement.

c. Loop tuning shall be capable of being initiated either locally at the DDC 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 Controllers shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary.

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

2. The user shall have the ability to define a warning limit for run-time totalization. Unique, user-specified messages shall be generated when the limit is reached.

H. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/O summary.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g., kWh, gallons, BTU, tons, etc.).

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

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

I. DDC Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for points as specified in the point I/O summary.

1. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.

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

J. Supplementary Controllers:

1. Each DDC Controller shall be able to extend its performance and capacity through the use of remote Supplementary Controllers. Each Supplementary Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Supplementary Controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. 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. Supplementary Controllers must comply with Section 2.03, items A through I with the exception of global type programs and on line programming. Supplementary Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden. As a minimum, 50% of the point inputs and outputs shall be of the Universal type, allowing for additional system flexibility. In lieu of Universal inputs and outputs, provide a minimum of 50% spare points of each type via additional point termination boards or controllers. A minimum of 12 global points (i.e. chilled water temperature, hot water temperature, etc.) must be able to be accessed through the Supplementary Controller. If global point access is unavailable with the Supplementary then a Master DDC Controller must be furnished.

3. The use of these Supplementary Controllers is limited to the monitor and control of building HVAC equipment that are outside of any mechanical equipment room, or outside of any electrical equipment room. All equipment located within, or controlled from within, any mechanical equipment room or electrical equipment room shall use the peer-to-peer DDC Controller.

4. Each Supplementary Controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event that communication with its DDC Controller is lost and to insure protection during power outages.

5. Provide each Supplementary Controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM or a minimum of 72-hour battery backup shall be provided. Supplementary Controllers must be fully programmable with a

minimum of 200 lines of code available for custom programming. All programs shall be field-customized to meet the user's exact control strategy requirements. Supplementary Controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide Master DDC Controllers for all central equipment in order to meet custom control strategy requirements.

6. Programming of Supplementary 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.

7. Local alarming and trending capabilities shall be provided for convenient troubleshooting and system diagnostics. Alarm limits and trend data information shall be user-definable for any point.

8. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs. All new values and programs may then be restored to EEPROM via the programming tool.

9. Supplementary Controllers that lose communication with master panels, and/or lose control due to a single sensor failure, are not acceptable.

10. At all Supplementary Controllers include a hardwired, concealed and secured, RJ-11 jack for use by the Portable Operators Workstation. The local operator, using the Portable Operators Workstation, shall plug into this jack, and shall perform all monitoring, control, and programming of sequences for any and all building-wide points and sequences while standing at any Supplementary Controller.

11. At all Supplementary Controllers, include the point database of the following minimum building-wide system data:

    a. Building Primary Hot Water Supply Temperature

    b. Building Primary Chilled Water Supply Temperature

    c. Building Common Outside Air Temperature

    d. Database for 10 other building-wide points, as field selected by the University.

2.04 APPLICATION SPECIFIC CONTROLLERS (ASC's)

A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASC's).

B. Each Application Specific Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Application Specific Controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide the following minimum types of Application Specific Controller:

1. Terminal Equipment Controllers

2. (Other ASC controllers as further specified)

C. The use of these Application Specific Controllers is limited to the monitor and control of building HVAC equipment that are outside of any mechanical equipment room, or outside of any electrical

equipment room. All equipment located within, or controlled from within, any mechanical equipment room or electrical equipment room shall use the peer-to-peer DDC Controller.

D. The electrical power source for these Application Specific Controllers shall be from local circuit breaker with appropriate fused, class 2, 100VA power-limited output. The breaker shall be dedicated to the Application Specific Controllers, labeled accordingly, and locked-out from inadvertent casual shutoff.

E. Terminal Equipment Controllers:

1. Provide for control of each piece of building HVAC equipment, including, but not limited to, the following:

   a. Variable Air Volume (VAV) terminal boxes

   b. Constant Air Volume (CAV) terminal boxes

   c. Dual Duct (DD) terminal boxes

   d. Unit Conditioners

   e. Heat Pumps

   f. Unit Ventilators

   g. Fan Coil Units

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs (except for unit ventilator controllers) shall be of the universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of universal outputs, provide a minimum of 50% spare outputs of each type via additional point termination boards or controllers. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators. Terminal equipment controllers utilizing proprietary control signals and actuators shall not be acceptable. As an alternative, provide DDC Controllers or other ASC's with industry standard outputs for control of all terminal equipment.

3. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:

   a. Accuracy: ± 1°F (±0.6°C)

   b. Operating Range: 35° to 115°F (2° to 46°)

   c. Set Point Adjustment Range: 55° to 95°F (2° to 30°C)

   d. Set Point Modes:

      1). Independent Heating

      2). Independent Cooling

      3). Night Setback Heating

4). Night Setback Cooling

e. Calibration Adjustments: None required

f. Installation: Up to 100 ft. from Controller

g. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. In lieu of an internal jack, provide a separate terminal jack mounted on a stainless steel wall plate adjacent to the sensor to facilitate direct access to the controller via the terminal.

h. Each room sensor shall also include the following auxiliary devices:

1). Setpoint Adjustment Dial

2). Temperature Indicator

3). Override Switch

i. The setpoint adjustment shall allow for modification of the temperature in a minimum of 1ºF increments by the occupant. Setpoint adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator at the central workstation, DDC Controller, or via the portable operator's terminal. In lieu of an integral adjustment dial, provide a separate dial mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.

j. The temperature indication shall be a digital display visible without removing the sensor cover. In lieu of integral indication, provide a separate thermometer or digital readout mounted on a stainless steel wall plate adjacent to the sensor for local temperature indication.

k. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, DDC Controller, or via the portable operator's terminal. In lieu of an integral switch, provide a separate momentary contact switch mounted on a stainless steel wall plate adjacent to the sensor to perform the specified functionality.

4. Each controller shall perform its primary control function independent of other DDC Controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the DDC Controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) values for all applications. All PID values and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings. Controllers that incorporate proportional and integral (PI) control algorithms only, without derivative (D) control algorithms, shall not be acceptable.

5. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of

72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide un-interruptible power supplies (UPS's) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of any applications are not acceptable.

6. Variable Air Volume (VAV) Box Controllers:

   a. As a minimum, shall support the following types of applications for pressure independent terminal control:

      1). VAV, cooling only

      2). VAV, with hot water reheat

      3). VAV, with electric reheat

      4). VAV, fan-powered

      5). VAV, fan-powered, with hot water reheat

      6). VAV, fan-powered, with electric reheat

   b. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

   c. The VAV box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 122°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

   d. The VAV controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm (0 to 20.4 m/s) and measurement accuracy of ±5% at 400 to 4000 fpm (2 to 20 m/s), insuring primary air flow conditions shall be controlled and maintained to within ±5% of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.

   e. The VAV box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and

insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.

f. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5°F (.9°C) of setpoint at the room sensor location.

g. The VAV box controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve, or cycling up to three (3) stages of electric reheat, as required to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.

7. Constant Air Volume (CAV) Box Controllers:

a. As a minimum, shall support the following types of applications for pressure independent terminal control:

1). CAV, cooling only

2). CAV, with hot water reheat

3). CAV, with electric reheat

b. All CAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

c. The CAV box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 122°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

d. The CAV controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm (0 to 20.4 m/s) and measurement accuracy of ±5% at 400 to 4000 fpm (2 to 20 m/s), insuring primary air flow conditions shall be controlled

and maintained to within ±5% of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.

e. The CAV box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.

f. The CAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5°F (.9°C) of setpoint at the room sensor location.

g. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve or cycling up to three (3) stages of electric reheat as required to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint. Control of the terminal unit damper to maintain cooling setpoint shall not be permitted. As an alternative, DDC Controllers or other ASC's controlling associated air handling equipment shall also directly control all CAV terminal units in order to provide the specified reset capability.

h. Each controller performing space pressurization control shall incorporate algorithms allowing for pressurization via the following methods as a minimum:

   1). Fixed air volume setpoints of supply and exhaust terminal units

   2). Updating of air volume setpoints of supply and exhaust terminal units

i. Each supply and associated exhaust terminal controller may be set at a fixed air volume setpoint which is within a percentage of each other or an actual CFM differential to meet space pressurization requirements. The controllers shall incorporate provisions for independent occupied and unoccupied mode setpoints and differentials, allowing for additional flexibility. Applications requiring updating of air volume setpoints depending on a variable volume of air leaving the space either through the exhaust terminal(s) or other exhaust ducts shall utilize supply terminal unit controllers incorporating algorithms to allow for "tracking" of space exhaust(s) to maintain the required air volume differential.

j. Terminal unit tracking shall be accomplished via actual measurement of terminal unit air volumes as previously specified. Controllers which track within a range of CFM's versus actual CFM setpoints shall not be acceptable. As an alternative, provide a DDC Controller or other ASC (one per room) for each space requiring pressurization control should terminal unit controllers be unable to perform the specified tracking functionality.

k. Zeroing of the differential pressure transducer shall be accomplished as previously specified for VAV box controllers. However, the method of stroking the terminal unit damper to a 0% position shall not be permitted should the controlled space(s) require constant pressurization or 24-hour per day operation. Controllers performing under 24-hour per day operation requirements shall incorporate an 'Auto-zero' auxiliary device(s) which functions to automatically zero the transducer without changing the damper position. This shall be accomplished by temporarily disengaging the transducer from the air velocity sensor so that a 0 cfm air volume reading is forced. The control damper position remains unchanged, as originally controlled before the start of the 'Auto-zero' recalibration. This shall automatically occur on a once per 24-hour basis, thus ensuring system accuracy as previously specified. Provide auxiliary devices and programming as required to perform this function.

l. Should a failure occur within the controller, the terminal unit damper shall automatically be positioned fully open or fully closed as previously defined by the operator. Controllers that revert to a pressure-dependent control mode during failure shall not be acceptable.

8. Dual-Duct (DD) Box Controllers:

a. As a minimum, shall support the following types of applications for pressure independent terminal control:

1). DD - Constant Volume - Cold Duct & Hot Duct Air Velocity Sensors with optional auxiliary heat.

2). DD - Constant Volume - Cold Duct & Outlet Air Velocity Sensors with optional auxiliary heat.

3). DD - Variable Air Volume - Cold Duct & Hot Duct Air Velocity Sensors with optional auxiliary heat.

4). DD - Variable Air Volume - Cold Duct & Outlet Air Velocity Sensors with optional auxiliary heat.

5). DD -Variable Air Volume - Cold Duct & Hot Duct Air Velocity Sensors with changeover.

b. All DD box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

c. The DD box controller shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 122°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

d. The DD controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm (0 to 20.4 m/s) and measurement accuracy of ±5% at 400 to 4000 fpm (2 to 20 m/s), insuring primary air flow conditions shall be controlled and maintained to within ±5% of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.

e. The DD box controller shall include provisions for manual and automatic reset of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Reset shall be accomplished by stroking the terminal unit damper actuator to 0%, full closed, position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa. Manual reset may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Reset of the transducer at the controller location shall not be necessary.

f. The DD box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5°F (.9°C) of setpoint at the room sensor location.

g. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve or cycling up to two (2) stages of electric reheat as required to satisfy space heating requirements.

h. Provide two air velocity sensors and transducers to match the application. For VAV applications, provide separate minimum and maximum air volume setting for heating and cooling ducts. For CAV applications, provide separate air volume set points for occupied and unoccupied modes.

i. Zeroing of the differential pressure transducer shall be accomplished as previously specified for VAV box controllers. However, the method of stroking the terminal unit damper to a 0% position shall not be permitted should the controlled space(s) require constant pressurization or 24-hour per day operation. Controllers performing under 24-hour per day operation requirements shall incorporate an ‘Auto-zero’ auxiliary device(s) which function to automatically zero the transducer without changing the damper position. This shall be accomplished by temporarily disengaging the transducer from the air velocity sensor so that a 0 cfm air volume reading is forced. The control damper position remains unchanged, as originally controlled before the start of the ‘Auto-zero’ recalibration. This shall automatically occur on a once per 24-hour basis, thus ensuring system accuracy as previously specified. Provide auxiliary devices and programming as required to perform this function.

9. Unit Conditioner Controllers:

a. As a minimum, shall support the following types of applications for terminal control:

1). Fan coil units

2). Induction units

3). Pressure dependent terminal boxes

b. As a minimum, shall support the following types of fan coil units:

1). Fan Coil, 2-pipe, heating or cooling

2). Fan Coil, 4-pipe, heating or cooling

3). Fan Coil, cooling, and electric heating

4). Fan Coil, 2-stage cooling, and electric heating

5). Fan Coil, 2-stage cooling, and hot water heating

c. As a minimum, shall support the following types of Induction units:

1). Induction Unit, 2-pipe

2). Induction Unit, 4-pipe

d. As a minimum, shall support the following types of pressure dependent terminal control:

1). Heating, or cooling

2). Hot water reheat

e. All Unit Conditioner control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

f. The Unit Conditioner controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 122°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

g. The Unit Conditioner controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5°F (.9°C) of setpoint at the room sensor location.

h. The Unit Conditioner controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve, or cycling up to three (3) stages of electric reheat, as required to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to

signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.

10. Heat Pump Controllers:

    a. As a minimum, shall support the following types of applications for heat pump terminal control:

        1). Heat Pump, water source

        2). Heat Pump, air-to-air source

        3). Heat Pumps, with ventilation air

        4). Heat Pump, with auxiliary heat

    b. All Heat Pump control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

    c. The Heat Pump controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32° to 122°F (0° to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

    d. The Heat Pump controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5°F (.9°C) of setpoint at the room sensor location.

    e. The Heat Pump controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve, or cycling up to three (3) stages of electric reheat, as required to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective DDC Controller to perform the required discharge temperature reset in order to maintain space temperature cooling setpoint.

11. Unit Ventilator Controllers:

    a. As a minimum, shall support the following types of applications for heating only unit ventilator applications:

        1). Unit Ventilator, ASHRAE Cycle 1, 2 or 3

        2). Unit Ventilator, ASHRAE Cycle 1, 2 or 3 with auxiliary reheat

        3). Unit Ventilator, Nesbitt Cycle W

4). Unit Ventilator, Nesbitt Cycle W with auxiliary reheat

b. All Unit Ventilator controller applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

c. The Unit Ventilator controllers shall be powered from either a 115 or 230 VAC power source common to the unit ventilator. The controllers shall function normally under ambient conditions of 32° to 122°F (0° to 50°C) and 10% to 95% (non-condensed). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

d. The Unit Ventilator controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within ±1.5°F (.9°C) of setpoint at the room sensor location.

e. The Unit Ventilator controller shall also interface to averaging temperature sensor(s) located in the discharge or mixed air stream(s) as required by application. The sensor(s) may be either RTD or thermistor type, providing the following minimum performance requirements are met:

1). Probe: Averaging type

2). Accuracy: ± 1°F (± 0.6°C)

3). Temperature Monitoring 0° to 180°F (-18° to 82°C)

2.05 PORTABLE OPERATOR'S TERMINAL (POT) (Optional, depending on project scope)

A. Provide One (1) portable operator terminal (POT) with a minimum LCD display of 80 characters by 25 lines and a full-featured keyboard. The POT shall be hand-held and plug directly into individual distributed control panels 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 on the network.

2. Backup and/or restore DDC Controller databases for all system panels, not just the DDC Controller connected thereto.

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.

C. Functionality of the portable operator's terminal connected to any application specific controller:

1. Provide connection capability at either the ASC 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. If the same portable operator's terminal cannot be used for both DDC Controllers and Application Specific Controllers provide separate POT's to accomplish the above functional requirements.

1. Provide 2 of each type portable operator's terminals as specified in A above.

2. Provide as a minimum, a POT connection in each mechanical room capable of accessing entire system information.

E. Connection of a POT to a distributed control processor 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.

F. Portable operator terminal access to controller shall be password-controlled.

G. Portable operator terminal minimum hardware and performance criteria shall be as referenced in Appendix B.

2.06 PERSONAL COMPUTER OPERATOR WORKSTATION (Optional, depending on project scope)

A. Personal computer operator workstations shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability. Personal computer operator workstation minimum hardware and performance criteria shall be as referenced in Appendix B.

2.07 WORKSTATION OPERATOR INTERFACE SOFTWARE (Optional, depending on 2.06)

A. Basic Interface Description

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification and industry standard PC application software. The software shall provide, as a minimum, the following functionality:

a. Graphical viewing and control of environment

b. Scheduling and override of building operations

c. Collection and analysis of historical data

d. Definition and construction of dynamic color graphic displays

e. Editing, programming, storage and downloading of controller databases

2. Provide a graphical user interface, which shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

    a. Provide functionality such that all operations can also be performed using the keyboard as a backup interface device.

    b. Provide additional capability that allows at least 10 special function keys to perform often-used operations.

3. The software shall provide multi-tasking operating system such that alarm notification occurs while user is running other applications such as Word or Excel; trend data uploads occur in the background while other applications are running. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows[a] or similar industry standard software that supports concurrent viewing and controlling of systems operations.

    a. Provide functionality such that any of the following may be performed simultaneously, and in any combination, via user-sized windows:

        1). Dynamic color graphics and graphic control

        2). Alarm management coordinated with section 2.04.E.

        3). Time-of-day scheduling

        4). Trend data definition and presentation

        5). Graphic definition

        6). Graphic construction

    b. If the software is unable to display several different types of displays at the same time, the BAS contractor shall provide at least two operator workstations.

4. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities. Privileges shall be customizable for each operator; the main menu shall reflect the privileges upon log on showing only the applications appropriate for the operator.

    a. Customizable such that operators can monitor, command, or edit an application or group of points. An operator can be defined with privileges for access to a building, group or buildings, or areas (labs--point names with the designation “lab”), by application: the operator has monitor, command, and edit capability for time of day schedules and calendars (only) for the entire campus: or by function: the operator (i.e. security guard) has ability to view/monitor all areas of the campus and receive alarms, etc.

    b. A minimum of 50 unique passwords, including user initials, shall be supported.

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

d. The system shall automatically generate a report of log-on/log-off time and system activity for each user.

e. User-definable, automatic log-off timers of from 5 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line as well as have the capability to generate a report of log-on, log-off time, parameters modified, and system activity for each user.

5. Software shall allow the operator to perform commands including, but not limited to, the following:

a. Start-up or shutdown selected equipment

b. Adjust setpoints

c. Add/modify/delete time programming

d. Enable/disable process execution

e. Lock/unlock alarm reporting for points

f. Enable/disable totalization for points

g. Enable/disable trending for points

h. Override PID loop setpoints

i. Enter temporary override schedules

j. Define holiday schedules

k. Change time/date

l. Automatic daylight savings time adjustments

m. Enter/modify analog alarm limits

n. Enter/modify analog warning limits

o. View limits

p. Enable/disable demand limiting for each meter

q. Enable/disable duty cycle for each load

6. Operator shall have ability to schedule reports to print at a pre-specified time and frequency and direct to either 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 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. DDC Controller trend overflow warning

g. List all weekly schedules

h. List of holiday programming

i. List of limits and dead bands

1) Summaries shall be provided for specific points, for a logical point group, for a user-selected group or groups or for the entire facility without restriction due to the hardware configuration of the building automation system. Under no conditions shall the operator need to specify the address of the hardware controller to obtain system information.

B. Scheduling

1. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:

a. Weekly schedules

b. Zone schedules

c. Monthly calendars

2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.

3. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.

4. Monthly calendars for a 24-month period shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

C. Collection and Analysis of Historical Data

1. 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 changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting.

2. Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred easily to Microsoft Office, Excel ®. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.

3. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A minimum of 4 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.

    a. Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.

    b. Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

D. Dynamic Color Graphic Displays

1. 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, room level terminal unit equipment shall be provided by the BAS contractor as indicated in the point I/O summary of this specification to optimize system performance analysis and speed alarm recognition.

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.

3. Dynamic temperature values, humidity values, flow values, percent load, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

4. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several graphics 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.

5. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays.

    a. The BAS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling

coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.

b. The graphic package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:

1) Define symbols

2) Position and size symbols

3) Define background screens

4) Define connecting lines and curves

5) Locate, orient and size descriptive text

6) Define and display colors for all elements

7) Establish correlation between symbols or text and associated system points or other displays

8) Ability to import scanned images and CAD drawings in Autodesk ®, DWG format.

c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points, which aids the operator in the analysis of the facility.

1) To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC Controllers including Application Specific Controllers used for DDC equipment or VAV terminal unit control.

6. Dynamic system status graphic of the site-specific architecture showing status of system hardware, including quantity and address of networks, field panels, terminal equipment controllers, and printers.

E. System Configuration and Definition

1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

a. Add/delete/modify stand-alone DDC Controller panels

b. Add/delete/modify operator workstations

c. Add/delete/modify application specific controllers

d. Add/delete/modify points of any type and all associated point parameters and tuning constants

e. Add/delete/modify alarm reporting definition for points

f. Add/delete/modify control loops

g. Add/delete/modify energy management applications

h. Add/delete/modify time and calendar-based programming

i. Add/delete/modify totalization for points

j. Add/delete/modify historical data trending for points

k. Add/delete/modify custom control processes

l. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data

m. Add/delete/modify dial-up telecommunication definition

n. Add/delete/modify all operator passwords

o. Add/delete/modify alarm messages

3. Definition of operator device characteristics, DDC Controllers individual points, applications and control sequences shall be performed using instructive prompting software.

   a. Libraries of standard application modules such as temperature, humidity and static pressure control may be used as "building blocks" in defining or creating new control sequences. In addition, the user shall have the capability to easily create and archive new modules and control sequences as desired via a word processing type format. Provide a library of standard forms to facilitate definition of point characteristics. Forms shall be self-prompting and incorporate a fill-in-the-blank approach for definition of all parameters. The system shall immediately detect an improper entry and automatically display an error message explaining the nature of the mistake.

   b. If programming must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.

   c. Inputs and outputs for any process shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

   d. Provide the capability to backup and store all system 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. Similarly, changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.

   e. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

F. Additional Workstation Software

1. Provide automatic dial-up communications for buildings as specified. Automatic dial-up communications shall include the following features as a minimum:

a. Dial-Out

1) Manual dial-out from the workstation to remote networks shall be accomplishable using only a mouse to select and request the desire remote connection.

b. Dial-In

1) Alarms shall automatically dial into the workstation for display at the terminal and for hard copy printout at the associated event printer.

2) Alarms shall, at the operator's option, dial into a stand-alone modem-printer to provide for real-time alarm printouts even when the workstation is off-line (such as when it is being used to run operator-selected 3rd party software) alarms can interrupt 3rd party applications to alert the operator that an alarm has occurred.

3) Trend data shall be scheduled for automatic updating to the workstation at operator-selected times. The operator shall also have the option of manually collecting trend data at any time.

2.08 FIELD DEVICES

A. All devices and equipment shall be approved for installation. All pneumatic devices shall be manufactured by Landis & Staefa, Barber-Colman, Honeywell, or Johnson Controls.

B. Temperature Sensors: Each temperature sensor shall match the requirements of the associated temperature controller. Each sensor shall be designed for the appropriate application (i.e., duct, immersion, etc.) and be provided with all necessary installation accessories. Ranges shall be selected to the middle of the control range. Temperature sensors must have a minimum accuracy of +/- 2 deg F or .5 % of scale; whichever will provide the least error in measurement.

1. Electronic: A modulating solid state controller with built-in detector, P, PI, or PID controller, as required, with continuous voltage or current output. Each controller shall have individual setpoint, proportional band, start point, and span adjustments. Input voltage shall be 24 VAC or less. Each controller to be provided with night setback, summer/winter switchover or remote reset capabilities as required. Controllers shall be of matching type to the input detectors and output drives or sequencers. Thermostats to be key operated.

2. Thermostat guards shall be provided where specified, indicated on control diagrams, or indicated on floor plans. Guards shall be firmly attached to wall and thermostat cover shall be visible through the guard. All room sensors in public areas will have concealed setpoint adjustments.

3. All room sensors in classroom, office, or laboratory spaces will have exposed set point adjustments locked to provide adjustment between 68 degrees and 72 degrees only.

4. Install thermostats and sensors at 4'-6" AFF to bottom unless otherwise noted on Architectural Drawings. Coordinate installation with the work of other trades before any rough-ins are made.

5. Duct Sensors: DDC duct sensors shall match the requirements of the associated controller incorporating an electrical signal to insure exact and proportional relationship between the measured variable and the transmitted signal. Static pressure sensors shall be mounted in temperature control panels with connecting sensor lines in hard copper. Where a device is used for sensing of Mixed Air Temperature or Preheat applications and the duct area is in excess of 24 square feet the instrument shall incorporate a capillary averaging element with a minimum length of 96 inches or a suitable array of duct sensors wired as a single input. Averaging sensors shall be used on any duct application where duct area exceeds 24 square feet.

6. Provide temperature sensors as required to meet the sequence of operation; in addition, provide temperature sensors in the following locations: return air, mixed air and discharge air sections if not required by the sequence of operation.

C. Humidity Sensors: The relative humidity transmitter monitors and transmits changes in humidity, accurate to +/- 2 % RH. Operating range shall be 0 to 99% RH.

D. Pressure Sensors: Duct static pressure analog sensors shall be high accuracy +/-1% of range suitable for the low pressures and selected for at least 50% over range Sensors shall have industry standard 4-20 mA output and zero end span adjustments.

E. Control Dampers (Multiple Blade Dampers): Automatic dampers furnished by the BAS Contractor shall be single blade or multiple blades as applicable. All dampers are to be sized to the application by the manufacturer using methods similar to control valve sizing. Dampers are to be installed by the HVAC Contractor under the supervision of the Temperature Control Contractor. All dampers furnished by air handling unit manufacturers must meet the requirements listed in this section. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the HVAC Contractor. All damper frames are to be constructed of No. 13 gauge galvanized sheet metal and shall have flanges for duct mounting. Damper blades shall not exceed 6 inches width. All blades are to be airfoil type construction in ducts with air velocities above 1500 FPM and will be equal to Ruskin RCD 50 control dampers with blade and jamb seals. In applications with velocities less than 1500 FPM control dampers will be equal to Ruskin RCD46 control dampers. Blades are to be suitable for high velocity performance. All damper bearings are to be made of nylon. Bushings that turn in the bearings are to be oil impregnated sintered metal. Dampers hung with blades mounted vertically shall be provided with thrust bearings. Butyl rubber seals are to be installed along the top and bottom of the frame and along each blade edge. Independent, self-compensating, stainless steel end seals shall be installed to insure minimum leakage between blade ends and damper frame. Seals shall provide a tight closing low leakage damper. Damper sections shall not exceed 48" in length or 16 sq. ft. and shall have minimum of one operator per damper section. All dampers in modulating applications shall have opposed blades. Dampers in two position services shall have parallel blades. Where sequence requires, submittals shall include damper sizes and leakage characteristics. Leakage shall not exceed 1 % at 4" W.C. when tested per AMCA Standard 500.

1. Control dampers will be sized by the temperature control contractor to the inside of the duct or duct liner whichever is smaller. Sizing of dampers to duct size and the subsequent cutting back of insulation to make dampers fit is unacceptable.

2. Control dampers used for outside air or exhaust air applications will be installed a minimum of 6" away from wall penetrations to allow for external mounting of their respective damper motors. Jackshafting in these applications will only be allowed to prevent having to mount motors in the outside airstream. When internal damper motor

mounting is required the sheetmetal contractor shall provide access panels at each motor location to allow for ease of service.

F. Damper Operators: Positioning relays will be provided for each damper section; one each for the outside air, return air, and relief air damper sections. A 1 1/2" pressure gauge will be provided for each damper section.

1. Electronic damper motors for terminal boxes will be provided by the temperature control contractor and shipped to the terminal box manufacturer for mounting. Mounting charges shall be the responsibility of the terminal box manufacturer.

2. VAV Terminal Boxes using internal actuators (electronic or pneumatic) are unacceptable.

G. Automatic Control Valves (Throttling Plugs): General Design - All valves shall be equipped with throttling plugs and removable composition discs. All valves are to be sized by the Control Contractor and shall submit pressure drop calculations and guarantee sufficient size to meet the requirements of the equipment being served. Valve operators shall be of such design so as to provide adequate operating power for valve positioning. Positioning relays will be furnished for all converter valve and normally closed valve applications. Valve operators shall be of the rubber diaphragm type or of the piston type. All valves are to be equipped with U-cup silicone packing.

1. Reheat valves controlled by Application Specific Controllers shall utilize electronic actuation. All reheat valves shall fail normally closed. All reheat valves serving Laboratories and/or Vivariums (animal) rooms shall include spring return, to fail normally closed.

2. Three-way Valves: Three-way valves are to be of the three port mixing arrangement, designed expressly for mixing of two inlets and providing a common outlet. The use of reverse piped diverting valves shall not be acceptable. The Temperature Control Contractor will be responsible to the HVAC Contractor to notify and provide guidance as to correct method of piping of all three-way valves.

3. All control valves for HVAC equipment within mechanical equipment rooms shall utilize pneumatic actuation. Butterfly valves for air handling unit coil control are unacceptable. If high GPM requirements dictate the valve size to be greater than 6", then Temperature Control contractor shall provide two control valves for the application, and the HVAC Contractor shall install the two control valves, for parallel and/or sequenced operation.

4. A 1/3, 2/3 valve configuration will be utilized on all hot water converter applications. The 1/3 valve will be normally open and the 2/3 valve will be normally closed. A separate AO pneumatic output will be used for each valve. The use of a single AO and a reversing relay is not permitted.

5. For all fan systems with separate pre-heat and separate 2nd heating coil. The pre-heat coil shall fail normally open, shall include separate analog output AO point for control, and separate analog input AI point for low-limit pre-heat discharge control. The separate 2nd heating coil shall fail normally closed, shall include separate analog output AO point, and separate analog input AI point for low-limit heating control.

6. For all fan systems with re-heat coil within the mechanical equipment room, the reheat coil valve shall fail normally closed.

7. Pressure drop through modulating control valves shall not exceed 7 feet. Control valves for 2-position applications shall be line sized.

H. Air Volume Measurement

I. Smoke Detectors

J. Air Static and Velocity Pressure Transmitter: The pressure transmitter shall be used for measuring duct static or velocity pressure in variable air volume fan systems.

K. Low Limit Detection Thermostat: Low limit detection thermostats equal to Landis & Staefa ET 134-1504 shall be of the vapor tension capillary type having a sensing element a minimum of 20 feet in length. These thermostats shall be of the manual reset type. The elements shall be complete with necessary fittings to permit installation in the duct so as to sense the correct discharge temperatures. One low limit detection thermostat will be installed for every 24 square feet of protected area and arranged so as to stop their respective units and close the outside air dampers in the event discharge temperatures fall below 38 degrees F. The normally closed contact shall be wired to the fan circuit and the normally open contact (close on alarm) shall be wired to a DDC input. One common circuit is suitable for multiple thermostats on a single AHU coil area.

L. Electric Thermostats: Heavy-duty snap action type with key operators rated at 10 FLA at 120 RIAC contacts suitable for the intended service. Provide manual selector switches as required in the sequence of operation.

M. Pneumatic Outputs: Analog output points shall be 4-20 mA, driving Electronic-to-Pneumatic Transducers. Transducers shall be Barber Coleman, CP-8551, with 4-20 mA input and 3-15 psig output. Pulse Width Modulation is not permitted.

1. Pressure output of pneumatic devices will be displayed in terms of PSI on the operator's display. If this capability is not available then a separate analog input connected to the pneumatic output will be included with override capability at the BAS panel.

2. A pneumatic gauge must be provided at the output as well as at the end device to display pressure.

N. Fan and Pump Proof: Proof points for air handling unit fans, exhaust fans and pumps will be accomplished through the use of current sensing relays at the motor control center or motor starters. Current sensing relays shall be split-core design, for installation over any single power lead. Current sensing relays shall include field adjustable set screw for amperage setpoint adjustment, and shall include integral LED status light to locally indicate the 'on' and 'off' condition.

O. Solenoid Air Valves (EP)

P. Pressure Electric Switch (PE)

Q. Instrument Air Distribution: Polyethylene tubing shall meet the following specifications: 0.92 grams per CC density, 1.30 decigrams per minute melt index, 2,000 hours minimum per ASTM D1693-60T stress rack resistance, 1,725 psi tensile strength, 500 psi at 75 degrees F, and 157 psi at 175 degrees F, maximum pressure-temperature. Fitting connections for low-pressure polyethylene tubing (20 psig or less) may be made with barbed push-on fittings. For high pressure polyethylene tubing (more than 25 psi) the connections shall be made with the specification for seamless copper tube ASTM-B75. Tubing with an outside diameter 3/8 inch and larger shall have a minimum wall thickness equal to type M valves; tubing with an outside diameter smaller than 3/8 inch shall have a minimum wall thickness of 0.025 inch. Either hard drawn or soft annealed tubing may be used subject to the conditions of the installation specification. Fitting connections for both high and low pressure copper tubing shall be either solder or crimp on, except at connections to equipment where compression fittings shall be used.

All polyethylene tubing in return air plenums shall be in conduit. All installed pneumatic tubing shall be marked at both ends for individual identification.

1. Exposed Installation: Single polyethylene tubing or soft copper tubing may be run exposed for 18" or less. For lengths which exceed 18", the line shall be run within enclosed trough or conduit, and this tube carrier system shall be installed in a workmanlike manner, parallel to the building line, adequately supported, etc. All connections except for terminal connections to valves, damper actuators, etc., shall be made inside rough, junction boxes, or control cabinets. Factory manufactured bundles of polyethylene tubing with protective outer sheath or hard copper tubing, may be installed without an additional trough or conduit envelope, provided that the tube system is installed in the same manner specified above for trough and conduit systems. All tubing in mechanical rooms will be either hard drawn copper or poly tubing run in conduit or trough.

2. Concealed-Accessible Installations: Soft copper tubing or hard drawn copper tubing, either individual or bundles, shall be installed in a workmanlike manner, securely fastened to fixed members of the building structure at sufficient points to avoid excessive freedom of movement.

3. Concealed-Inaccessible Installations: Non-accessible tubing such as in pipe chases, above drywall or plastered ceilings shall be either hard or soft copper tubing. Tubing shall be installed in the same manner specified above.

R. Compressed Air System: A duplex compressed air system shall be provided, installed and guaranteed by the Temperature Control Contractor. Each compressor shall be of 3/4 HP minimum and of enough capacity under normal conditions to run not more than 33-1/3% of the time. Air compressors should be sized to include air requirements for steam pressure reducing stations and steam de-superheater, when compressed air is required. The compressor shall be of the type, which is proven to be satisfactory for temperature control system air supply. The crankcase must be vented to the atmosphere, not to the compressor suction. The air compressor suction filter shall have a 10 micron filtering ability. It shall be of the replaceable impingement type. Each compressor shall be driven by an electric motor with nameplate voltage of that available at the installation. Each motor shall be controlled by a pressure operated, enclosed pilot switch connected to the combination motor starter/alternator. Pressure switches for start-up controls shall be set to operate between 70 and 100 psi and shall be adjustable. Air storage tanks shall be constructed, tested and stamped in accordance with ASME Code of Unfired Pressure Vessels. Tank shall be constructed of steel plate, welded and designed for a working pressure of not less than 125 psi. Tanks mounted with compressors may be horizontal or vertical. The safety valve, placed between the compressor and the discharge hand valve, shall be set for a pressure 10% above the control switch off pressure. The air storage vessel shall have sufficient capacity to allow no more than 12 starts of the compressor per hour. Include compressor sizing calculations with submittals.

S. Refrigerated Air Dryer: After coolers of the mechanical refrigeration type shall be provided. They are to be of sufficient capacity to assure a dew point of a maximum of 10 degrees F in the 20 psi supply (-5 degrees F at atmosphere). The compressed air treatment unit will run continuously whenever any part of the control system is in operation. A water rejection system will be provided to discharge all water and oil condensed in the after cooler and the pressure reducing valve. Pressure reducing valve shall have a 150 psi inlet pressure rating or higher. They shall be of the relieving type with an operating temperature of 200 degrees F or better. The pressure reducing valves shall have a capacity equal to or greater than the system they serve. Provide filtration system capable of removing oil vapors and 5 micron particles from the air stream. Provide one 30 psig pressure control and relief valve per pressure regulator.

T. Compressor Sequencer: Furnish and install an electric sequencer for the dual air compressors to automatically alternate the compressor motors after each running cycle. Sequencer shall be further connected to energize the lag compressor at the setting of the lower pressure switch if the lead compressor fails.

U. Air Gauges: Air pressure indicating gauges of at least 1 inch in diameter shall be provided for the indication of supply and control pressures at the output of EP switches, PE switches, duct controllers, valves actuators, damper operators, and other points throughout the system where visual indication of air pressure is required including all temperature control cabinets or will prove beneficial to operating personnel in the operation of their control systems. Air gauges will not be required on room type thermostats.

2.09 LABELING

A. Provide labels for all field devices including sensors, transducers, thermostats, and relays. Exception: Room temperature and/or humidity sensors shall not be labeled.

B. Labels shall be black laminated plastic with white letters and adhesive backing or screw fasteners. Labels shall be located adjacent to device and permanently affixed to device mounting surface. Do not install the label on the device. Labels for sensors in pipes may be secured using chain around the sensor well.

C. Labels shall include system virtual/pseudo point name as well as English language name of device being controlled or specific condition being sensed.

D. Identify all control wiring and pneumatic tubing at each end with a number.

PART 3 EXECUTION

3.01 SEQUENCE OF OPERATION

3.02 ON-SITE TESTING

A. Provide the University's Representative and the Associate with approved operation and acceptance testing of the complete system. The University's Representative and the Associate will witness all tests.

B. Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The installer shall complete all testing, calibrating, adjusting and final field tests. Provide a detailed cross-check of each sensor within the system by making a comparison between the reading at the sensor and a standard traceable to the National Bureau of Standards. Provide a cross-check of each control point within the system by making a comparison between the control command and the field-controlled device. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. Submit the results of functional and diagnostic tests and calibrations to the University's Representative and the Associate for final system acceptance.

C. Compliance Inspection Checklist: Submit in the form requested, the following items of information to the University's Representative and the Associate for verification of compliance to the project specifications. Failure to comply with the specified information shall constitute non-performance of the contract. The contractor shall submit written justification for each item in the checklist that he is unable to comply with. The University's Representative and the Associate will initial and date the checklist to signify contractor's compliance before acceptance of system.

1. Verify to the University's Representative and the Associate in letter form that supplier has in-place support facility. Letter shall show location of support facility, name and titles of technical staff, engineers, supervisors, fitters, electricians, managers and all other personnel responsible for the completion of the work on this project.

   User_____Date_____A/E_____Date_____

2. Submit in data sheet form or official government approval form compliance to F.C.C. Regulation, Part 15, Section 15.

   User_____Date_____A/E_____Date_____

3. Manually generate an alarm at a remote DDC Controller as selected by the University's Representative and the Associate to demonstrate the capability of the workstation and alarm printer to receive alarms within 5 seconds.

   User_____Date_____A/E_____Date_____

4. Disconnect an operator workstation in the central control room and manually generate an alarm at a remote DDC Controller to demonstrate the capability of the system printer to receive alarms when the workstation is disconnected from the system.

   User_____Date_____A/E_____Date_____

5. Disconnect one DDC Controller from the network to demonstrate that a single device failure shall not disrupt or halt peer-to-peer communication. Panel to be disconnected shall be selected by the University's Representative and the Associate.

   User_____Date_____A/E_____Date_____

6. At a DDC Controller of the University's Representative and the Associate's choice, display on the portable operator's terminal:

   a. At least one temperature setpoint and at least one status condition, i.e., on or off for a system or piece of equipment attached to that panel as well as for points at another DDC Controller on the network.

   b. The diagnostic results as specified for a system or piece of equipment attached to that panel as well as for a system or piece of equipment attached to another DDC Controller.

   c. The ability to add a new point to the DDC Controller with the POT and have it automatically uploaded to the workstation to modify that panel's stored database without having to power down or take the DDC panel off-line.

   User_____Date_____A/E_____Date_____

7. At an ASC of the University's Representative and the Associate's choice, disconnect the LAN connection to demonstrate its lack of reliance on a DDC Controller to maintain full control functionality.

   User_____Date_____A/E_____Date_____

3.03 SERVICE AND GUARANTEE

A. General Requirements: Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year after completion of successful performance test. Provide necessary material required for the work. Minimize impacts on facility operations when performing scheduled adjustments and non-scheduled work.

B. Description of Work: The adjustment and repair of the system includes all computer equipment, software updates, transmission equipment and all sensors and control devices. Provide the manufacturer's required adjustments and all other work necessary.

C. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. University shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

D. Systems Modifications: Provide any recommendations for system modification in writing to University. Do not make any system modifications, including operating parameters and control settings, without prior approval of University. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

E. Software: Provide all software updates and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and shall be incorporated into the operations and maintenance manuals, and software documentation.

3.04 TRAINING

A. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays as follows:

B. Provide 8 hours of training for University's operating personnel. Training shall include:

1. Explanation of drawings, operations and maintenance manuals
2. Walk-thru 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

C. Provide 8 hours of additional training quarterly for a period of one year from final completion of the project.

D. Since the University may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the University requires such training, it will be contracted at a later date. Provide description of available local and factory customer training.

PART 4 APPENDICES (See Attached Appendices)

Appendix A.1:

The physical and virtual (pseudo) point naming convention has been standardized and in most cases will follow the pattern of designators as listed below.

The first character shall include the building name first letter, i.e.,

A for Arps Hall
B for Bricker Hall
-
W for Wexner Center
Z for Zoology

The second character is the type of mechanical system

A = Air (Handler)
C = (Main) Cooling (Chiller System)
Z = Zone
H = (Main) Heating (System)
R = Reheat
D = Domestic
F = Fin Tube (Radiation)
P = Preheat
E = Exhaust

The third character is the system or equipment number (used even if only one in group). To identify groups containing more than 9 components, alphabetical characters will be used successively to represent these additional items.

1
-
9
(Please, do not use '0' (zero) for '10')
A
-
Z

The fourth through sixth characters are standardized University abbreviations, which describe the specific controlled process and/or condition being sensed.

SWT = Supply Water Temp.
RWT = Return Water Temp.
01S = Pump #01 Start/Stop
01P = Pump #01 Status or Proof
CDS = Cold Deck Setpoint
HDC = Hot Deck Control
S1S = First or only Supply Fan Start/Stop
R2P = Second Return Fan Status or Proof
S1V = First or only Supply Fan Velocity

Appendix A.2:

The minimum hardware requirements for the Portable Operator Terminal (POT) are as follows:

150 MHz Pentium Processor
16 Mb RAM
1 serial and 1 parallel port
2.0 GB IDE Hard Drive
12.1” Color VGA display
3.5” (1.44MB) internal Diskette Drive
8X internal CD-ROM Drive
Operating system compatible with current version of Workstation Interface Software
Integrated keyboard and pointing device
2 NiMH battery packs, 110 VAC adapter/charger
2 type II (or 1 Type III) PCMCIA slots
28.6Kbps internal Modem
Carrying Case
Three-year limited warranty

The minimum hardware requirements for the Personal Computer Operator Workstation are as follows:

200 Mhz Intel Pentium™ Processor
32 MB RAM
2 serial and 1 Parallel Port
2.0 GB IDE Hard Drive
3.5” (1.44MB) Diskette Drive
8X internal CD-ROM drive
15”, SVGA, 1280 x 1024 non-interlaced .28 dot pitch color monitor
Key board and mouse
Operating system compatible with current version of Workstation Interface Software
Surge Protector
Three-year limited warranty

END OF APPENDIX A