HVAC CONTROLS

DOCUMENT NUMBER: 15200

APPLICATION: ELEMENTARY, MIDDLE AND HIGH SCHOOL

DATE OF ISSUE:

01-22-10 - Added an acceptable manufacturer in section 1.4A
03-23-09 - Deleted occupancy sensor from manual override
02-23-09 - Revised workstation requirements
05-16-07 - Revised 1.4A, clarifying controls manufacturer
05-12-03 - revised document no., misc format changes & clarifications, revised 2.1 F
07-05-02 - revised workstation requirements
05-25-00 - revised
06-22-98 - revised
06-20-97 - first issued

NOTES:
Provide HVAC controls in accordance with the attached specification.

The architect/engineer is expected to modify and supplement the attached information to reflect unique project requirements and to revise the format as necessary to match other specification sections.

Project Architect/Engineer is to forward one (1) set of pre-installation submittals to the project coordinator for advisory review.

ATTACHMENTS:
HVAC Controls Specification, dated 01-22-10.

HEATING, VENTILATING, & AIR CONDITIONING (HVAC) CONTROLS
01-22-10

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions of this specification, and Division 1 Specifications sections apply to work of this section.

B. Division 15 Basic Mechanical Materials and Methods sections apply to work of this section.

1.2 GENERAL REQUIREMENTS

A. Examine other Sections of the Specifications for requirements that affect work of this Division whether or not such work is specifically mentioned in this Division.

B. Coordinate work with that of other trades affecting, or affected by work of this Division. Cooperate with those trades to assure steady progress of work under contract. It is this controls contractor's responsibility to neatly "line item" work and responsibilities in their bid, of other subcontractors described in this section that are required for a complete HVAC controls system.

1.3 DESCRIPTION OF WORK

A. Provide a complete system of direct digital temperature controls as hereby specified and shown on the drawings.

B. Controls applicable to this section include, but are not limited to temperature and humidity sensors, automatic water valves with electric actuators, automatic dampers, pressure gauges and sensors, control relays, flow meters and related devices. Work of this contractor includes installation in conduit, wiring, wells, and enclosures necessary to provide a complete and operable system of controls.

C. The programmable controllers shall be programmed by the controls contractor to be compatible with the existing School District building automation systems software. Systems shall operate on the District's Wide Are Ethernet Network and communicate via IP/IXP protocol.

D. Extent of the direct digital control and energy management systems work required by this section is indicated on drawings and schedules, and by requirements of this section.

E. Control sequences and control point list are specified on the drawings as "Sequence of Operation".

F. Refer to other Division 15 sections for installation of instrument wells, valves, and dampers in mechanical systems; coordinate and communicate with the general contractor that this is not work of this section.

G. Refer to Division 16 sections for power supply wiring from power source to power connection of controls and/or unit control panels. Includes starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed by manufacturer.

1.4 CONTROLS CONTRACTOR QUALIFICATIONS

A. Acceptable manufacturers of control equipment are Johnson Metasys Control, Alerton Control, Krueter Controls, and Trane Tracer. The controls contractor is to be in the exclusive business of installing and factory-representing the above manufacturers. The controls contractor shall have a minimum of five (5) years experience in the programming, installation and service of commercial DDC control systems. Upon request, the controls contractor shall provide the names and qualifications of the following, who are assigned to the project:
   1. controls programmer
   2. controls equipment installer
   3. controls system analyst

B. The controls contractor shall retain the services of a Professional Engineer registered in Florida for performing the functions described below as they apply to the temperature control system.

C. Responsibilities regarding field equipment start-up and checkout
   1. Provide support to the contractor to insure all control devices are properly interfaced with HVAC equipment.
   2. Perform a point-to-point operational check of each analog and digital point.
   3. Power up the panels and verify correct power operation.
   4. Verify communications line integrity.
   5. Write all software programs and database.
   6. Install all software and database in the system.
   7. Verify operation of all operating software.
   8. Calibrate/adjust/setup field devices as necessary in the order to provide a complete and proper operating system.
   9. Notify Architect/Engineer of any problems related to the design within two (2) working days of find.
   10. Work with the Architect/Engineer to validate operation and final completion of the project.
   11. Work with the test and balance agency in balancing and adjusting the HVAC system.

D. Acceptance of the installation
   1. Once the job is installed and the controls contractor has thoroughly checked it, then it will be necessary to demonstrate to the Architect/Engineer that the project specifications have been met. The controls contractor shall prepare technical demonstrations to the Architect/Engineer requiring a random test of not less than 20% of the system points. A representative of SDHC must be invited to observe and given 48 hours notice prior to the demonstration. The demonstration will occur concurrent with the substantial completion inspection for the project.
   2. The controls contractor will provide the necessary data at the time of the demonstration, such that the architect/engineer can certify the system as complete.
   3. SDHC will accept the project as substantially complete only after the complete control system has been certified **in writing** complete by the engineer and the system has been successfully demonstrated in accordance with the above criteria.

1.5 DESCRIPTION OF RESPONSIBILITIES PROVIDED BY CONTROLS CONTRACTOR

A. Provided and installed by the controls contractor
   1. Room temperature sensors
   2. Duct temperature sensors
   3. Insertion temperature sensors
   4. Outside air temperature sensor
   5. Pressure sensors (air and water)
   6. Differential pressure switches (air and water)
   7. Control dampers (installed by sheet metal contractor)
   8. Control valves (installed by mechanical contractor)
   9. Damper actuators
   10. Damper linkages
   11. Valve actuators
   12. Outboard gear panels (auxiliary panels)
   13. Name plates (engraved type)
   14. Control relays
   15. Varistors
   16. Flow meters (installed by the mechanical contractor)
   17. Terminal strips
   18. Control fuse blocks
   19. Power supplies
   20. Humidity sensors
   21. Transducers
   22. Pressure switches
   23. End switches
   24. Submittal literature on all control devices provided
   25. 120/24VAC transformers
   26. Warranty
   27. Personal computer for Energy Management System (EMCS)
   28. Installation of DDC controllers
   29. Installation of all electric temperature control devices not in-line
   30. Power wiring from junction box at each control panel to power supplies
   31. Installation of all power supplies
   32. Install all system grounding

B. The programmable controllers shall be programmed by controls contractor to be compatible with existing software and point naming conventions in the School District's Energy Management Department. A software compliance statement shall be obtained by controls contractor from School District's Energy Management Department.

1.6 RESPONSIBILITIES OF THE MECHANICAL CONTRACTOR

A. Install air flow monitor.

B. Install all in-line control devices (such as valves, dampers, flow meters, water temperature sensors, air flow control devices, wells, flow switches, differential pressure switches across pumps).

C. Provide operation and maintenance manuals of HVAC equipment purchased.

D. Start-up and check-out of all HVAC equipment.

E. Install copper line connections to in-line devices.

1.7 QUALITY ASSURANCE

A. All control conduit and wiring shall meet the requirements of Division 16 for materials and installation. All electrical system components shall comply with NEMA and UL standards.

B. Electrical Standards: Provide electrical components of systems which comply with NEMA and UL standards.

C. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for control systems.

D. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

1.8 PRE-INSTALLATION SUBMITTALS

A. Submit product data in accordance with the requirements of Section 15010 - Basic Mechanical Requirements, and the requirements of Division 1.

B. Submit complete control diagrams and sequence of operation.

C. Submit the following product data:
   1. Manufacturer's detailed information for each piece of equipment used, identifying each item used.
   2. Catalog sheets for each item specified in the control diagrams. Identify specific model and accessories being used in the control diagram, when two or more devices or models are shown.

D. Provide the following information for each item and device: Proper system label, indication of coordination with submitted catalog information, proper settings and adjustments of instruments, physical dimensions of devices and accessories, and the normal condition of device, such as normally open or closed dampers, valves, and relays.

E. Submit automatic control damper information including amount of leakage, airflow characteristics, and construction of all components. Submit a damper and control valve schedule that shall include sizes, locations and pertinent information required for approval and coordination with the mechanical contractor and sheet metal subcontractor.

1.9 NETWORK AND APPLICATION SPECIFIC CONTROL PANEL SPECIFICATIONS

A. The control system shall be capable of integrating multiple building functions including equipment supervision and control alarm management energy management and historical data collection and archiving.

B. The control system shall consist of the following:
   1. Operator Workstation
   2. Stand-alone DDC panels
   3. Stand-alone application specific controllers (ASCs)
   4. Integration via Open protocol to 3rd Party equipment to include: Chiller Integration - McQuay, York, Carrier, Dunham-Bush, Trane
   5. Network Handheld Terminals

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

D. Stand-alone DDC panels shall be able to access any data from or send control commands and alarm report directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device. Stand-alone DDC panels shall also be able to sent alarm reports to multiple operator workstations without dependence upon a central processing device.

1.10 OPERATOR INTERFACE

Operator Workstation Description: Personal computer operator workstation 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 stand-alone DDC panels to facilitate greater fault tolerance and reliability. One workstation shall be provided, located as shown on the drawings, including all required software to view the control system as specified. Workstation shall be directly connected to the SDHC district system.

1.11 NETWORKING / COMMUNICATIONS

The control system shall network the operator workstations and the stand-alone DDC panels. Inherent in the system's' design shall be the ability to expand or modify the network either via the local area network or autodial telephone line modem connections or via a combination of the two networking schemes.

1.12 LOCAL AREA NETWORK

A. Workstation / DDC Panel Support: Operator workstation and DDC panels shall directly reside on a local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.

B. Dynamic Data Access: All operator devices and network resident panels 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 local area network. Access to data shall be based upon logical identification of building equipment.

C. Access to system data shall not be restricted by the hardware configuration of the facility management system. The hardware configuration of the FMS network shall be totally transparent to the user when accessing data or developing control programs.

D. General Network Design: Network design shall include the following provisions:
   1. High speed data transfer rates for alarm reporting quick report generator from multiple controllers and upload/download efficiency between network devices. The minimum baud rate shall be 1 Megabaud.
   2. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.

3. Detection and accommodation of single or multiple failures of either workstations, DDC panels or the network media. The network shall include provisions for automatically reconfiguring itself to allow all operation equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
    a. Message and alarm buffering to prevent information from being lost.
    b. Error detection, correction, and retransmission to guarantee data integrity.
    c. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
    d. Commonly available, multiple sourced, networking components and protocols shall be used to allow the BAS to coexist with other networking applications such as office automation. Ethernet is the acceptable technology.
    e. Use of an industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading.
    f. Synchronization of the real-time clocks in all DDC panels shall be provided.

1.13 MASTER DDC CONTROL PANEL

A. General: Stand-alone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each stand-alone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the point list.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases including:
    1. Control processes
    2. Energy Management applications
    3. Alarm Management
    4. Historical / Trend Data for all points
    5. Maintenance Support applications
    6. Custom processes
    7. Operator I/O
    8. Manual Override monitoring

C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:
    1. Digital inputs for status/alarm contacts
    2. Digital outputs for on/off equipment control
    3. Analog inputs for temperature, pressure, humidity, flow, and position measurements
    4. Analog outputs for valve and damper position control, and capacity control of primary equipment
    5. Pulse inputs for pulsed contact monitoring

D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators.

E. Serial Communication Ports: Stand-alone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel-mounted or portable DDC panel operator's terminals. Stand-alone DDC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

F. Hardware Override Switches: As indicated in the point schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, onboard hand/off/auto operator override switches for binary control points and gradual switches for analog control type points. These override switches shall be operable whether the panel is powered or not.

G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.

H. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.

I. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

J. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data. Battery back-up of the controller configuration shall not be permitted. Regardless of your approval as a manufacturer, in the event that the stand-alone controllers maintain their programs via batteries, this shall not be acceptable. This removes the need for emergency power to the controllers and reduces the generator requirements. Programs shall be maintained in non-volatile EEPROMS.

K. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

1.14 SYSTEM SOFTWARE FEATURES:

A. General: All necessary software to form a complete operating system as described in this specification shall be provided. The person machine interface software shall operate on a true Windows based operating system. OS/2, UNIX or any other operating systems shall not be acceptable.

B. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

1.15 CONTROL SOFTWARE DESCRIPTION

A. Pre-tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms:
   1. Two position control
   2. Proportional control
   3. Proportional plus integral control
   4. Proportional, integral, plus derivative control
   5. Automatic control loop tuning

B. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.

C. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commends to heavy electrical loads.

D. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

E. Energy Management Applications: DDC panels shall have the ability to perform any or all of the following energy management routines:
   1. Time of day scheduling
   2. Calendar based scheduling
   3. Holiday scheduling
   4. Temporary schedule overrides
   5. Optimal start
   6. Optimal stop
   7. Night setback control
   8. Enthalpy switchover (economizer)
   9. Peak demand limiting
   10. Temperature compensated load rolling
   11. Fans speed / cfm 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. 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 Execution portion of this specification.

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

G. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:
   1. Any system-measured point data or status
   2. Any calculated data
   3. Any results from other processes
   4. User-defined constants
   5. Arithmetic functions (+,-,*,/,square root, exp, etc.)
   6. Boolean logic operators (and, or, exclusive or, etc.)
   7. On-delay / Off-day / One-shot timers

H. Process Triggers: Custom processes may be triggered based on any combination of the following:
   1. Time interval
   2. Time of day
   3. Date
   4. Other processes
   5. Time programming
   6. Events (e.g., point alarms)

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

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

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

L. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms form being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC workstation or local I/O device, or communications with other panels on the network.

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

N. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Each DDC panel 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.

O. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

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

Q. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response. These alarm messages shall be utilized to perform the beeper interface alarm messaging.

R. Each stand-alone DDC panel shall be capable of storing a library of at least 250 alarm messages. Each message may be assignable to any number of points in the panel.

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

T. Historical Data and Trend Analysis: A variety of historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.
   1. Continuous Point Histories: Stand-alone DDC panels shall store point history files for all analog and binary inputs and outputs.
   2. The point history routine shall continuously and automatically sample the value of all analog inputs at half-hour intervals. Samples for all point shall be stored for the past 24 hours to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point history files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point. Continuous histories shall be provided on all points.
   3. Control Loop Performance Trends: Stand-alone DDC panels shall also provide high resolution sampling capability with an operator-adjustable resolution of 10-300 seconds in one-second increments for verification of control loop performance.

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

U. Data Storage and Archiving: Trend data shall be stored at the stand-alone DDC panels, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in 3rd party personal computer applications.

V. Runtime Totalization: Stand-alone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification
   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 Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

W. Analog / Pulse Totalization: Stand-alone DDC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
   1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. kWh, gallons, KBTU, 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.

X. Event Totalization: Stand-alone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event Totalization shall be performed on a daily, weekly, or monthly basis.
   1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 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.

1.16 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each stand-alone DDC controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases, including:
   1. Control Processes
   2. Energy Management Applications
   3. Operator I/O (Portable Service Terminal)

D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation, or any PC or portable operator's terminal connected to any DDC panel in the network. Provide a portable operator terminal connection to the network at every air handling unit mechanical room. This connection shall allow the operator the capability to access the system information as well as the entire facility. Refer to the specifications on the network terminal below. The network terminal shall operate off of the same passwords as on the workstation.

E. Application specific controllers shall directly support the temporary use of a portable service terminal. The capabilities of the portable service terminal shall include, but not be limited to, the following:
   1. Display temperatures
   2. Display status
   3. Display setpoints
   4. Display control parameters
   5. Override binary output control
   6. Override analog setpoints
   7. Modification of gain and offset constants
   8. Entire Network Information

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be store such that a power failure of any duration does not necessitate reprogramming the controller.

1.17 APPLICATION DESCRIPTIONS

A. VAV Box Unit Controllers: VAV box unit controllers shall support, but not be limited to, the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion:
   1. Single Duct Only
   2. Supply / Exhaust

B. VAV box unit controllers shall support the following types of point inputs and outputs:
   1. Proportional Cooling Outputs
   2. Box Heating Outputs
   3. Fan Control Output (On/Off Logic, or Proportional Series Fan Logic)

C. The modes of operation supported by the VAV box unit controllers shall minimally include, but not be limited to, the following:
   1. Day/Weekly schedules
   2. Comfort/Occupancy mode
   3. Economy mode (standby mode, unoccupied, etc.)
   4. Temporary Override mode

D. Occupant-Based Standby/Comfort Mode Control: Each VAV box unit controller shall have a provision for occupant override. Based upon the contact status of a manually operated override switch, the VAV box unit controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

E. Continuous Zone Temperature Histories: Each VV box unit controller shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

F. Alarm Management: Each VV box unit controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

G. The controller itself shall consist of 3 individual components; the controller, the actuator / velocity pressure transducer, and the temperature sensor.

H. Power Failure: In the event of the loss of normal power, there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data. Battery back-up of the controller configuration shall not be permitted. Regardless of your approval as a manufacturer, in the event that the stand-alone controllers maintain their programs via batteries, this shall not be acceptable. This removes the need for emergency power to the controllers and reduced the generator requirements. Programs shall be maintained in non-volatile EEPROMS only.

I. Unitary Controllers: Unitary controllers shall support, but not be limited to, the following types of systems to address specific applications described in the Execution portion of this specification, and for future expansion:
   1. Vents (ASHRAE Cycle I, II, III, or W)
   2. Pumps
   3. Fan Coils (four-pipe)
   4. Variable Air Volume Boxes

J. Unitary controllers shall support the following types of point inputs and outputs:
   1. Drybulb
   2. Outdoor Air Enthalpy
   3. Differential Temperature
   4. Binary Input from a separate controller
   5. Heating and Cooling Outputs
   6. Fan Output, On/Off Logic Control

K. Unitary controllers shall support the following library of control strategies to address the requirements of the sequences described in the Execution portion of this specification, and for future expansion:
   1. Daily/Weekly schedules
   2. Comfort/Occupancy mode
   3. Standby mode available
   4. Unoccupied not available
   5. Shutdown
   6. Lighting Logic Interlock to Economy Mode

L. Occupant-Based Standby / Comfort Mode Control: Each unitary controller shall have a provision for occupant override. Based upon the contact status of a manually operated override switch, the unitary controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

M. Continuous Zone Temperature Histories: Each unitary controller shall automatically and continuously, maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance of the past 24 hours. A minimum of two samples per hour shall be stored.

N. Alarm Management: Each unitary controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

O. Power Failure: In the event of the loss of normal power, there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data. Battery back-up of the controller configuration shall not be permitted. Regardless of your approval as a manufacturer, in the event that the stand-alone controllers maintain their programs via batteries, this shall not be acceptable. This removes the need for emergency power to the controllers and reduces the generator requirements. Programs shall be maintained in non-volatile EEPROMS only.

P. Air Handler Controllers: AH controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in the Execution portion of this specification, and for future expansion:
   1. Large air handlers
   2. Mixed air-single path
   3. Mixed air-dual path
   4. Single path
   5. Dual path

Q. AH controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally stand-alone fashion.

R. AH controllers shall have a library of control routines and program logic to perform the sequence of operation as specified in the Execution portion of this specification.

S. Occupant-Based Standby / Comfort Mode Control: Each AH controller shall have a provision for occupant override. Based upon the contact status of a manually operated override switch, the AH controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

T. Continuous Zone Temperature Histories: Each AH controller shall automatically and continuously, maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be store.

U. Alarm Management: Each AH controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

V. Power Failure: In the event of the loss of normal power there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data. Battery back-up of the controller configuration shall not be permitted. Regardless of your approval as a manufacturer, in the event that the stand-alone controllers maintain their programs via batteries, this shall not be acceptable. This removes the need for emergency power to the controllers and reduces the generator requirements. Programs shall be maintained in non-volatile EEPROMS only.

W. Open Protocol Application Controller: The BAS shall support open-protocol communications with other vendors equipment to minimize redundant automation networks with the facility and eliminate multiple user interfaces. Connectivity to third party controllers shall be through integrator panels that reside on the BAS network and have down-loadable drivers for accommodation of a specific equipment manufacturers protocol. Interfaces shall be required for the items described in the General Products description of this section. Hardwired interfaces or non-factory supported software gateways shall not be acceptable.

1.18 POINTS LIST SUMMARY AND AS SHOWN ON THE DRAWINGS

Chillers:

1. Water setpoint
2. Water control point
3. Entering chill water
4. Leaving chill water
5. Entering condenser water
6. Leaving condenser water
7. Evaporator refrigerant temperature
8. Evaporator pressure
9. Condenser refrigerant temperature
10. Condenser pressure
11. Discharge temperature
12. Bearing temperature

13. motor winding temperature
14. Oil sump temperature
15. Oil pressure transducer
16. Oil differential pressure
17. Base demand limit
18. Active demand limit
19. Line voltage percent
20. Line voltage actual
21. Compressor motor load
22. Compressor motor current
23. Compressor motor amps
24. Target Vane position
25. Actual van position
26. Total compressor starts
27. Starts in 12 hours
28. Compressor ontime
29. Service ontime
30. Compressor motor kW
31. Demand limit 4-20 mA
32. Temperature Reset 4-20 mA
33. Common CHWS sensor
34. Common CHWR sensor
35. Occupied 0-no, 1-yes
36. Alarm state 0-ok, 1-alarm
37. Chiller start/stop 0-stop, 1-start
38. Hot gas bypass relay 0-no, 1-yes
39. Chilled water pump 0-no, 1-yes
40. Chilled water flow 0-no, 1-yes
41. Condenser water pump 0-no, 1-yes
42. Condenser water flow 0-no, 1-yes
43. Compressor start relay 0-no, 1-yes
44. Compressor start contact 0-no, 1-yes
45. Compressor run contact 0-no, 1-yes
46. Starter Fault contract 0-no, 1-yes
47. Pressure trip contact 0-no, 1-yes
48. Single cycle dropout 0-no, 1-yes
49. Oil pump relay 0-no, 1-yes
50. Oil heater relay 0-no, 1-yes
51. Motor cooling relay 0-no, 1-yes
52. Tower fan relay 0-no, 1-yes
53. Compressor shunt trip relay 0-no, 1-yes
54. Alarm relay 0-no, 1-yes
55. Remote contacts input 0-no, 1-yes

1.19 OPERATOR INTERFACE

A. Basic Interface Description: Command entry/menu selection process; 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.

B. The operator interface 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.

C. Graphical and Text-Based Displays: At the option of the user, operator workstations shall provide consistent graphical or text-base displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

D. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

E. Passwords shall be exactly the same for all operator devices, including portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.
A minimum of five levels of access shall be supported.
1. Level 1 - Data access and display
2. Level 2 = Level 1 + Operator Overrides
3. Level 3 = Level 2 + Database Modification
4. Level 4 = Level 3 + Database Generation
5. Level 5 = Level 4 + Password Add/Modification
6. A minimum of 20 passwords shall be supported at each DDC panel.

F. Operators will be able to perform only those commands available for their respective passwords. Menu selections display at any operator device, including portable or panel- mounted devices, shall be limited to only those items defined for the access level of the password used to log on.

G. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

H. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
1. Start-up or shutdown selected equipment
2. Adjust setpoints
3. Add/Modify/Delete time programming
4. Enable/Disable process execution
5. Lock/Unlock alarm reporting for each point
6. Enable/Disable Totalization for each point
7. Enable/Diable Trending for each point
8. Override PID Loop setpoints
9. Enter temporary override schedules
10. Define Holiday schedules
11. Change time/date
12. Enter/Modify analog alarm limits
13. Enter/Modify analog warning limits
14. View limits
15. Enable/Disable Demand Limiting for each meter
16. Enable/Disable Duty Cycle for each load

I. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:
   1. A general listing of all points in the network
   2. List all points currently in alarm
   3. List of all off-line points
   4. List all points currently in override status
   5. List of all disable points
   6. List all points currently locked out
   7. List of all items defined in a "follow-up" file
   8. List all weekly schedules
   9. List all holiday programming
   10. List of limits and deadbands
   11. Operator transaction file to include person and action performed.

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

K. System Configuration and Definition: 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.

L. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
   1. Add / Delete / Modify Stand-alone DDC Panels
   2. Add / Delete / Modify Operator Workstations
   3. Add / Delete / Modify Application Specific Controllers
   4. Add / Delete / Modify points of any type, and all associated point parameters, and tuning constants
   5. Add / Delete / Modify alarm reporting definition for each point
   6. Add / Delete / Modify control loops
   7. Add / Delete / Modify energy management applications
   8. Add / Delete / Modify time and calendar based programming
   9. Add / Delete / Modify Totalization for every point
   10. Add / Delete / Modify Historical Data Trending for every point
   11. Add / Delete / Modify custom control processes
   12. Add / Delete / Modify dial-up telecommunication definition
   13. Add / Delete / Modify all operator passwords
   14. Add / Delete / Modify alarm messages

M. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications, and control sequences shall be performed through fill-in-the- blank templates and graphical programming approach.

N. Graphical programming shall allow the user to define the software configuration of DDC control logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.

O. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting lines between symbols depicting inputs, operators, (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used represent:
   1. Process inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.
   2. Mathematical process operators, such as addition, subtraction, multiplication, or greater than, equal to, less than, etc.
   3. Logical process operators such as and, or, exclusive or, not, etc. time delays.
   4. Process control outputs such as start/stop control point, analog adjust points, etc.
   5. Process calculation outputs
   6. Text file outputs and advisories

P. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single DDC panel, but shall be able to include data from any and all other DDC 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).

Q. Sequence Testing and Simulation: A software tools shall be provided, which allows a user to simulate control sequence execution to test strategies before they are actually applied to mechanical systems. Users shall be able to enter hypothetical input data, and verify desire control response and calculation results via graphical displays and hard copy printouts.

R. System Definition / Control Sequence Documentation: All portions of system definition shall be self-documenting to proved hard copy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

S. Database Save / Restore / Back-up: Back-up copies of all stand-alone DDC panel databases shall be stored in at least one personal computer workstation.

T. Continuous supervision of the integrity of all DDC panel data bases shall be provided. In the even that any DDC panel on the network experiences a loss of its data base for any reason, the system shall automatically download a new copy of the respective data base to restore proper operation. Data base back-up / download shall occur over the local are network without operator intervention. User shall also have the ability to manually execute downloads of any or all portions of a DDC panel's data base.

U. Personal Computer Operator Workstation Description: 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 stand-alone DDC panels to facilitate greater fault tolerance and reliability. Workstations shall be provided, as shown on the drawings, including all required software to view the control system as specified.

V. Workstations shall be general purpose, commercially available, personal computers with sufficient memory and processor capacity to perform all functions described in this specification.

W. Sufficient Winchester technology bulk storage shall be provided to accommodate al fully configured point data bases, all application databases, all graphics data bases, all user-defined reports, and all historical data archival as described in this specification.

X. The display provided for system operation shall have a diagonal screen measurement of no less than 13", and a minimum display resolution of no less than 640 x 320 pixels. Separate controls shall be provided for color, contrast, and brightness. The screen shall be non-reflective.

Y. Stand-alone DDC Panel Local or Portable Operator's Terminals: Operator terminal shall be either a laptop computer with necessary software or hand-held device. Each DDC panel shall be capable of supporting an operator's terminal for local command entry, instantaneous and historical data display, and program additions and modifications. Provide terminal access location in each mechanical equipment room with an air-handling unit. Provide two operator terminals for this project.

Z. There shall be a provision for both permanently mounting the stand-alone DDC panel operator terminal, and using it as a portable hand-held unit.

AA. The DDC panel operator terminal shall simultaneously display a minimum of 6 points with full English identification to allow an operator to view single screen dynamic displays depicting entire mechanical systems.

BB. The operator functions provided by the DDC panel operator terminal shall include, but not be limited to, the following: As the system is distributed, the information shall be available form any single location of the entire network.
1. Start and stop points
2. Modify setpoints
3. Modify PID loop setpoints
4. Override PID control
5. Change time/date
6. Add / Modify Start / Stop weekly scheduling
7. Add / Modify setpoint weekly scheduling
8. Enter temporary override schedules
9. Define holiday schedules
10. View analog limits
11. Enter / Modify analog warning limits
12. Enter / Modify analog alarm limits
13. Enter / Modify analog differentials
14. View point history files

CC. The DDC panel operator terminal shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a subset of predefined "global points", but shall provide totally open exchange of date between the operator terminal and any DDC panel in the network.

DD. Operator access at all DDC panel operator terminals shall be identical to each other, as well as identical to the PC or laptop operator workstations. Any password changes shall automatically be downloaded to all controllers on the network.

EE. The DDC panel operator terminal shall provide English language prompting to eliminate the need for the user to remember command format or point names. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error.

FF. A multi-function touchpad shall be provided for point and command selection, as well as parameter entry. To minimize the possibility of operator error, the DDC panel operator terminal shall change and limit touchpad functions based upon an operator's password clearance, the function being performed, and types of points being displayed. Screen displays shall clearly indicate only valid touchpad functions.

GG. Context-Sensitive Help: On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "help" function shall provide general system operating instructions, and specific descriptions of commands available in the currently displayed menus.

HH. Identification for all real or calculated points shall be consistent for all network devices. The same English language names used at PC workstations shall be used to access points at the DDC panel operator's terminal to eliminate cross-reference or look-up tables.

II. In addition to instantaneous summaries, the DDC panel operator's terminal shall allow a user to view a point history file for system points. Point history files shall provide a record of of value of analog points over the last 24 hours, at 30-minute intervals, or a record of the last ten status changes for binary type points.

1.20 DELIVERY, STORAGE AND HANDLING

Provide factory shipping cartons for each piece of equipment and control device. Maintain cartons while shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

1.21 RECORD DOCUMENTS

A. Provide operation and maintenance manuals.

B. Provide and install plastic encased charts and flow diagrams in each equipment room.

C. One copy of the control system record drawings, submitted as part of the project close-out package. Submission shall be in AutoCAD format on disk (no paper copies), to include the following information:
   1. point-to-point wiring diagrams and sequences of operation based on the SDHC standard
   2. Location on the drawings of critical control devices such as control panels, auxiliary control panels, static pressure sensors, room temperature sensors, water temperature sensors/wells.
   3. Location of all 120/1/60 power sources for the control devices.
   4. Control valve sizing (valve CV and pressure drops). Valve schedules.
   5. Complete bill of material.
   6. Room schedule.
   7. Phone line or internet location for remote system access.

8. Homerun connections between panels.
9. Communication trunk line layout.
10. Lightning protection devices (quantity and location).
11. Surge protection devices (quantity and location).

1.22 TRAINING

A. Provide 40 hours of training for owner's personnel which shall include the following:
   1. Layman's description of the HVAC/control system.
   2. Location of all key control devices (such as panels, override switches, etc.).
   3. Operational training.

B. The initial training shall be given when the system is operational and has been verified completed by the engineer. Follow-up sessions will be scheduled as needed by the School Principal during the 1-year warranty period.

C. Training hours are to be recorded on a log sheet to be prepared by the trainer and given to the School Principal at the initial training session. Each subsequent training event is to be entered onto the log and initialed by both the trainer and trainee with a brief description of the instruction given.

1.23 WARRANTY

Provide full parts and labor warranty on all control devices installed during this project for one (1) year from the date of substantial acceptance of the project. Warranty is to include:

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS:

A. Low Temperature Detector: Provide manually reset freezestats on outside air AH's with a minimum of 20 foot vapor tension element. Interlock to AH starter to shut unit off in either hand or auto position. Acceptable manufacturers are Johnson Controls A70, Alerton, and Krueter.

B. Static Pressure Transmitters: Provide electronic supply duct static pressure transmitter as required. Transmitter shall sense the differential between the supply duct and the space pressure. Sensing point shall be located 2/3 downstream in the longest ductwork run. Output shall be 4-20 mA proportional to pressure increase. Accuracy to be ±2% of full range. Acceptable manufacturers are Johnson Controls DPT-2641-6, Robinson-Halpern, Alerton, and Krueter.

C. Water Differential Pressure Transmitter: Provide industrial grade differential pressure transmitter to monitor and control the differential pressure across the supply and return piping chilled water. The transmitter shall have a 4-20 mA signal proportional to the pressure increase. Output variations shall not exceed .1% of full scale with a 10:1 turndown ration. Transmitter shall have integral accessible zero/span adjustment, RFI/EMI protection, 316ss diaphragm and pipe mounting bracket. Operating range 32 to 100°F with 10 to 90% RH non-condensing. Acceptable manufactures are Barton Model 6001, Robinson-Halpern, Alerton, and Krueter.

D. Air Differential Pressure Switches: Provide differential pressure switches for fan status to the DC system which are diaphragm operated to actuate a single poke double throw snap switch. Motion of the diaphragm shall be restrained by a calibrated spring that can be adjusted to se the exact pressure differential at which the electrical switch can be actuated. Acceptable manufacturers are Johnson Controls P32 Air Flow Switch, Dwyer, Alerton, and Krueter.

E. Water Differential Pressure Switch: Provide differential pressure switch for pump status to the DDC system. Switch to be in a NEMA 4 enclosure. Pressure range form 3-150 psig. Acceptable manufacturers are Johnson Controls P74 Water Flow Switch, Penn, Alerton, and Krueter.

F. Electronic Air Flow Measurement: Linear temperature compensated analog electronic velocity signal. Microprocessor based electronic control signal capable of low flow sensitivity. True average velocity measurement across entire width of ductwork. 4-20 mA or 0-10 VDC output signals. Manufacturer: Ebron model #3000 series or Air Monitor Inc.

G. Water Flow Measurement: The sensor shall be a 4-20 mA output type, with the repeatability of ±.1% of value. Shall incorporate back-lit display and keypad on the meter. Flowmeter shall utilize Vortex shedding technology with a turndown of 20:1. Temperature limits: -40.0ø to 80.0øC. Material is dependent upon that of the size and type of pipe material. Manufacturer: Johnson Yokogawa Yewflow Vortex Flowmeter.

H. Air Quality Transmitter (CO_2 Sensors): The sensor shall be a 4-20 mA / 1-5 VDC output type and designed to monitor IAQ/CO_2 levels in accordance with ASHRAE standard 62-1989. Acceptable manufacturers are Johnson Controls CDS-2000, Gaztec, Alerton, and Krueter.

I. Control Valves Normally Open Two-Way Control Valves: Provide fully proportioning two-way control valves with equal percentage modulating plugs for normally open applications. Valves shall be sized for 3 to 5 psi pressure flow at maximum flow rate. Valves shall have stainless steel stems and spring-loaded Teflon packing. Leakage shall not exceed 0.05 percent of valve CV. Utilize existing pneumatic valves where possible otherwise. Use electric with manual override capability similar to Johnson Controls actuator type M9100 series or Belimo; other acceptable manufacturers are Alerton and Krueter.
   1. Up to 2 Inch: Valves shall be cast brass, screwed ends, ANSI Class 125.
   2. 2½ to 6 Inch: Valves to be cast iron, flanged ends, ANSI Class 125.
   3. Manufacturers: Johnson Controls, Alerton and Krueter.

J. Butterfly Valves: Provide two-way butterfly valves rated per ANSI 150 with fully tapped and threaded lugs and carbon steel body. Valves shall have field replaceable elastomer resilient seats. Disc shall be fabricated from aluminum or manganese bronze and shaft shall be 416, 316 or 17-4PH stainless steel. Manufacturer: Bray Valves or Keystone.

K. Control Dampers: Provide automatic control dampers. Installation by Division 15 contractor per specification section "Ductwork Specialties". Provide damper for low leakage, parallel blade type. Blades to be a minimum 16 gauge galvanized steel of single unit design or 22 gauge galvanized sheet steel of double unit construction. Damper blades shall be 6 inches wide and a maximum length of 60 inches with square block pins of zinc-plated steel. Frames shall be 13 gauge galvanized sheet metal with non-ferrous sleeve type bearings. Dampers shall have solid stops with edge seals so that the blade edges shall interlock with neoprene seals. Leakage shall not exceed 6.3 cfm per square foot with the damper closed against 4 inches w.g. static pressure.

L. Operator Workstation: The system shall utilize an IBM-compatible, personal computer which will allow for multiple site interface. The addition of a new workstation will allow for access to the entire local and remote networks. The operator workstation shall be compatible with Windows XP Operating system. All operating system software, control software, and graphics generation software shall be provided, along with required usage licenses. All software shall be provided for the Owner to make changes to the system without Control Contractor support (i.e. if the Owner needs to change a graphic, provide the graphic software that generated the original). Minimum Requirements:
   1. 2.4 GHz Processor
   2. 2 GB RAM
   3. 160 GB Hard Drive
   4. CD-RW/DVD-ROM
   5. 17” LCD Flat Panel Monitor, 1280 x 1024 / 75Hz
   6. 256 MB Graphics Card, 1280 x 1024
   7. Inkjet printer
   8. 10/100 MBPS Ethernet capability (onboard or PCI)
   9. 600 KVA UPS

M. Network Terminal: Provide access of the entire network. Access will include access and control of the features similar to the operator workstation. Adjustments, overrides, scheduling, trends, histories must all be available for every system no matter the location of the network terminal. Provide NT access at each of the AH's and mechanical rooms.

N. Temperature Sensors: Temperature sensors shall be either thermister type (+/- 0.7 F accuracy) or nickel wire temperature elements (RTD) with a precision of ±.1% of full scale, not to exceed 2°F. Room sensors to include digital readout and manual setpoint adjustment, with range of adjustability to be software definable.

O. Duct-Mounted Insertion Elements: Use averaging elements of 17' length.

P. Pipe Insertion Elements: Use separable brass thermowell with minimum insertion length of 2½ inches.

Q. Humidity Sensors: Provide a monolithic IC humidity sensor with ±3% accuracy, washable sensor, one point calibration, 4-20 mA linear output. Acceptable manufacturers are Johnson Controls HE-6300, Hycal, Alerton, or Krueter.

2.2 CURRENT TRANSFORMERS

Current transformers shall be Independent Transformer model 500 or 600 or approved equal.

2.3 CURRENT TRANSDUCER

Current transducer shall be Kele model 4CTV or approved equal.

2.4 CONTROL CONDUCTORS AND CONDUIT

A. Provide control conductors that meet the BAS manufacturer's requirements and by control diagrams, not less than number 18 AWG stranded copper for all digital signal / control and not less than 18 AWG stranded and shielded copper conductors between controllers. Provide MTW controls conductors within enclosures and number 12 AWG stranded copper (minimum) THHN or THWN power conductors.

B. In unburied indoor concealed locations, provide EMT conduit with compression type fittings in normally cooled / conditioned spaces. Provide galvanized steel IMC with cast type galvanized screwed fittings in non-cooled / conditioned spaces, including mechanical rooms. Plenum rated cable may be used in plenums only.

C. In unburied outdoor locations, provide weather-tight galvanized steel IMC with cast type galvanized screwed fittings. Provide liquid-tight flexible metallic conduit (18 inches minimum length, 6 feet maximum) for connections to all vibrating equipment. Provide insulated grounding bushings at conduit connections to all boxes and panels. Seal water-tight all conduit penetrations.

D. Conduit buried outdoors and below slabs shall be PVC, in accordance with Division 16 of the specifications.

E. Provide UL approved components and located for accessibility to NEC requirements. Plenum cable on separate supports mounted on vertical walls of the plenum shall be acceptable, provided it is tagged and bundled. Plenum cables where exposed or in walls shall be in Flex, EMT, or Wiremold per NEC. Plenum cable bundles shall not be supported from ductwork or pipes.

F. All control wiring, whether in conduit or bare, shall be home runs without splices.

G. Conduit Markings: In the mechanical rooms and any other location where the conduit is exposed, mark junction boxes to identify controls conduit.

PART 3 - EXECUTION

3.1 INSPECTION

Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the engineer.

3.2 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

B. The control equipment and connecting wiring shall be installed in a neat and workman-line manner by trained mechanics on staff and under direct supervision of the controls contractor, conforming to all applicable state and local codes.

C. Provide all communications accessories for an operable energy management/direct digital control system.

D. Provide all components, accessories, installation adjustment and testing necessary for an operational system.

E. Provide temperature and humidity sensors, automatic water valves with actuators, control wiring, panels, and other auxiliaries and appurtenances necessary to obtain satisfactory control of mechanical systems and as specified in the control diagrams. Coordinate with Air Distribution System installer for control air requirements. Provide electronic system components necessary to accomplish the automatic control requirements of the mechanical work.

F. Provide conductors and conduit for control systems. Installation shall meet requirements of Division 16.

G. Coordinate and work with Test and Balance Agency to insure proper system adjustments of all control components and control devices such as dampers, valves, etc. Provide the necessary assistance labor to the Test and Balance agency during start-up and check-out periods.

H. All panels shall be installed in accessible locations, free of obstructions from pipes, conduits, ductwork, etc. Unless otherwise shown on contract documents all panels shall be reached from the floor without the use of ladders.

3.3 LIGHTNING & ELECTROMAGNETIC SUPPRESSION:

A. All interbuilding (building to building) communications shall be over 62/125 X EE-6 meter wavelength fiber installed by Division 16. Fiber optic tranceivers shall be provided by the Controls Installer. Fiber patch panel at hub locations to be provided by Division 16.

B. For protection of the Hayes 1200 Baud Modem Telephone, incorporate a Surge Protector Model PDS-11-Electronic Specialists, Natick, Massachusetts 01760.

3.4 CONTROL WIRING:

A. Install control wiring, without splices between terminal points, color coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.

B. All wiring and piping shall be run straight, parallel to building lines and structure. All wires shall be bundled and independently supported when not in conduit. Flexible wireways shall be limited to six feet long. Reroute wires as directed by Architect when not in compliance with this paragraph.

C. All control points shall be homeruns with no splices and as shown on the control diagrams.

D. All control point wiring shall land at the controller end on a terminal strip, either a separate strip or the I/O strip.

E. Splices shall not be permitted in wireways or AUX cabinets.

F. Wiring shall conform to the manufacturers recommend installation practices including transient suppression on I/O circuit.

G. Wiring shall be labeled to match the control shop drawings.

H. Electrical contractor will provide a 120 VAC junction box at each DDC panel. Controls Contractor shall provide all other necessary power and control wiring to all control devices including valves, dampers, variable air volume terminals, and wiring to damper operators, valves, etc.

I. Provide communications accessories for an operable energy management/direct digital control system.

J. Coordinate input and output requirements between controller and remote devices/sensors.

K. Coordinate and work with the general contractor and Test and Balance Agency to insure proper system adjustments of all control components and control devices, such as dampers, valves, etc.

L. Secure controls conduit to building structure. Do not substitute attachments to work of other trades (such as pipes, ducts, other conduits). Provide accessory steel supports, as required. Refer to Division 16 specifications and details for methods of neat and secure support of cables and conduit.

M. Locate control instruments or accessories on insulated/covered casings/pipes/ducts on the finished surfaces of the covering. Seal penetrations to assure no leaks are present around stems that penetrate into the air or water systems.

N. Provide thermowells for all pipe mounted sensors.

O. Identification: Provide engraved laminated plates and valve disks for identification of each: control valve, controls damper, controls panel, flow sensor, display gauge, and sensor (not internal panel gauges). Label all nonpanel devices (as well as instruments mounted in face of panels) to indicate system function.

P. Provide a room temperature sensor for each occupied space and as indicated on the drawings.

Q. Provide CT's on all chiller power supplies and provide monitoring of current (power) use.

3.5 TESTS

Test piping during and after installation.

END OF SECTION 15200