SECTION 17200 - BUILDING MANAGEMENT SYSTEM

1.0 GENERAL:

1.1 Scope:

a. The Division 17 Contractor shall provide a complete and operating integrated Building Management System (BMS) designed to accomplish the integration of the Fire Alarm System, Security Access Control & CCTV System, Lighting Control System, and HVAC Control System, VFDs, chillers, and boilers. The Fire Alarm System, Security Access Control & CCTV System, Lighting Control System, and HVAC Control System will be furnished and installed by a single Division 17 Contractor.

b. Furnish all control wiring, conduit and electrical work required as integral part of Building Management System work or indicated on mechanical drawings.

c. Supplementary Conditions, applicable provisions of Division 17, General Requirements, and other provisions and requirements of the contract documents apply to work this section.

1.1.1 Acceptable Contractors:

a. Siemens Building Technologies, Inc.
b. Johnson Controls IFC

1.1.2 Alternates:

a. No other alternates for the supply and/or installation of these Systems will be accepted.

1.2 Quality Assurance:

a. The control system shall be installed by competent control personnel regularly employed by the manufacturers of the control equipment. All control equipment shall be the product of one manufacturer.

b. The Contractor shall have local maintenance capabilities available within a 50-mile radius of the job site.

c. Assurance provisions of this section are specified in section 17010.

1.3 System Description:

a. General. All computing devices, as defined in FCC Rules and Regulations, Part 15, shall be verified to comply with the requirements for Class A computing devices and labeled as set- forth in FCC Rules and

Regulations, Part 15. Every connected Analog Input (AI), Digital Output (DO), and Digital Input (DI) represents a "point" where referred to in this specification or referenced in the point list in Section 17250.

b. System Accuracy. The system shall maintain an end-to-end accuracy, as listed below, for one year from sensor to diagnostic display for the applications specified.

1. Space temperature applications with a range of 40ºF to 90ºF plus or minus ± 0.6ºF for conditioned space; of 20ºF to 120ºF plus or minus ± 1.0ºF for non-conditioned space.

2. Duct temperature with a range of 20ºF to 120ºF plus or minus ± 1.2ºF.

3. Duct averaging temperature with a range of 20ºF to 120ºF plus or minus ± 1.2ºF; the range of 70ºF to 220ºF plus or minus ± 1.2ºF.

4. Outside air (OA) temperature with a range of -58ºF to 120ºF plus or minus ± 1.3ºF.

5. Water temperature with a range of 20ºF to 70ºF plus or minus ± 0.6ºF; the range of 30ºF to 250ºF plus or minus ± 1.0ºF; and water temperatures for the purpose of performing BTU calculations using differential temperatures to plus or minus 0.6ºF.

6. Relative Humidity (RH) with a range of 20 to 95 percent plus or minus 2.0 percent.

7. Pressure with a range for the specific application plus or minus 2.0 percent of range.

8. Water flow with a range for the specific application plus or minus 1.0 percent of full scale.

9. Steam flow with a range for the specific application plus or minus 1.5 percent of reading on linear ranges.

10. Air flow with a range for the specific application plus or minus 2.0 percent.

11. Carbon Dioxide with a range of 0 to 2,000 ppm plus or minus 5.0 percent.

c. Field Enclosures: Enclosures shall conform to the requirements of NEMA Pub. No. 250 for the enclosure types specified. Finish color shall be manufacturers standard, unless otherwise specified. Damaged surfaces shall be repaired and refinished with the original type finish.

d. Abbreviations, Symbols and Definitions: All letter symbols and engineering unit abbreviations utilized in information displays and printouts shall be fully explained and documented in the documentation provided.

e. Environmental Conditions: All equipment shall operate under ambient environmental conditions of 35ºF to 122ºF dry bulb and 10 to 95%RH noncondensing. Sensors and control elements shall operate under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

1.4 Submittal Brochures:

a. The following shall be submitted for approval:

1. Control drawings with detailed ACAD piping and wiring diagrams, including bill of material and description of operation for all systems. Control drawings shall be a minimum of 11" X 17" in size. Installation/layout drawings shall be generated using AutoCAD 2002.

2. Panel locations, layouts and nameplate lists for all local and central panels.

3. Valve and damper schedules showing size, configuration, CV, system pressures, capacity and location of all equipment.

4. Data sheets for all control system components.

5. The flow and control diagrams for air, water, glycol and steam systems and the sequence of operation for all HVAC systems and sub-systems shall be shown on the drawings. The diagrams shall show complete operating description including starting, interlocks, part load operation, smoke control features, volumetric controls, alarms and emergency or power failure related operation.

1.5 Testing and Adjustment:

a. Upon completion of the project, the Contractor shall:

1. Completely adjust or calibrate, ready for use, all thermostats, sensors, transducers, valves, damper operators, relays, etc., provided under this section.

2. Provide testing and adjustment of the complete Control System. Validate every control system point to the Standalone DDC panel,

to the Standalone application specific controllers, to the Personal Computer Operator Workstation.

3. Test all connected devices so that the displayed controlled variable is within plus or minus one percent of the actual sampled variable.

b. The control system Contractor shall provide training and the operator terminals required to operate the entire control system to insure the completion of the testing and balancing.

1.6 Final Documentation:

a. The Contractor shall provide three copies of the following for operation and maintenance manuals, covering the function and operation of the control systems on the project, for the use of the Owner's Operating Personnel. Provide 8-1/2" X 11" loose-leaf 3-ring binders with identification inserts in clear vinyl on the front cover and the back spine. Separate sections with an appropriate tabbed divider with title and specification section number.

b. Detailed documentation of the control system, including as built AutoCAD 2002 drawings, three (3) hard-copies and one (1) set of electronic media with all cables and terminations identified, riser/backbone riser diagrams, a bill of materials of all installed equipment and wiring, equipment layouts showing placement of equipment and model numbers of all installed equipment.

c. System verification and acceptance documentation signed and dated by the installer and designer shall also be provided. This documentation shall include test measurements and system calibrations specified under Section 3.6 performed, for the entire system. A certification report shall be provided listing the tests.

1.7 Guarantee:

The control system designated on drawings and plans and herein specified, shall be guaranteed to be free from original defects in both material and workmanship for a period of one (1) year of normal use and service, excepting damages from other causes. This guarantee shall become effective starting the date of final project acceptance unless otherwise noted.

1.8 Certification:

Furnish a letter from the control system manufacturer stating that the system is properly installed and operating as designed.

1.9 Training and Instruction:

a. Instructions to Owner's Representative Personnel: Provide the services of competent instructors who will give full instruction to designated personnel in the operation and maintenance of the Control System. Orient the training specifically to the system installed. Instructors shall be thoroughly familiar with the subject matter they are to teach. The Owner's Personnel designated to attend will have a high school education or equivalent. The number of training days of instruction shall be as specified. Provide a training manual for each student at each training phase that describes in detail the data included in each training program. Provide one additional copy for archiving.

b. Training Program: Accomplish the training program as specified. Conduct training at the site at a time mutually agreeable between the Owner's Representative and the Contractor prior to final acceptance. Train 3 operating personnel in the functional operations of system and the procedures that personnel will follow in systems operation.

1.10 Work by Others: Division 15 Contractor shall be responsible for setting in place of valves, starters, VFDs, flow meters, water pressure and differential taps, flow switches, thermal wells, fire/smoke dampers and control air dampers. Division 16 Contractor shall be responsible for interlock wiring of all fire, smoke, combination fire/smoke dampers. Division 16 Contractor shall be responsible for high voltage wiring for VFDs.

2.0 PRODUCTS:

2.1 General:

a. Provide temperature control products in the size and capacities indicated; conforming to manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by the manufacturer and as required for the application indicated.

b. Where two units of the same type of equipment are required, these units shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address and the model and serial number in a conspicuous place.

2.2 General Product Description:

a. The Building Management 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 Building Management System shall consist of the following:

1. Standalone DDC panels
2. Standalone application specific controllers (ASCs)
3. Portable Operator's Terminals
4. Personal Computer Operator Workstations.

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

c. System architectural design shall eliminate dependence upon any single 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. Standalone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device. Standalone DDC panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

2.3 NETWORKING COMMUNICATIONS

A The design of the BMS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels, a management level network via TCP/IP communications(MLN), a high performance building level network (BLN) and DDC Controller specific floor level networks(FLN).

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

C Management Level Network (MLN):

1) The MLN provides for communications between operator workstations and the system host(server) and can also provide for control panels residing on the BLN to communicate directly with the workstation or host(server) via TCP/IP over a variety of different Ethernet protocol configurations including LAN, WAN and Internet services.

D Building Level Network (BLN):

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.

2) Systems that operate via polled response or other types of protocols that rely on a central processor, 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 central processor, the standby shall automatically, without any operator intervention, assume all BMS network management activities.

3) All operator devices either network resident or connected via dial-up modems shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. 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 network data.

4) Network design shall include the following provisions:

   a) System shall be able to communicate peer to peer at baud rates of up to 115K 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 99 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 to guarantee data integrity.

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

E DDC Controller Floor Level Network (FLN):

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

2) Application specific controllers shall be arranged on the FLNs in a functional relationship manner with DDC Controllers. For example, a VAV terminal unit controller shall be on a FLN from the DDC Controller that is controlling its corresponding AHU.

3) A maximum of 32 application specific controllers may be configured on individual DDC Controller FLNs to insure adequate global data and alarm response times.

4) The DDC controller shall support a minimum of three independent FLN.

E Telecommunication Capability:

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 33,600 baud or higher.

2.4 DDC CONTROLLER

A 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 and the attached point list.

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 the DDC Controller cabinet:

a) Analog inputs

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

(3) Thermistors
(4) 1000 ohm RTDs

b) Digital inputs

(1) Dry contact closure
(2) Pulse Accumulator
(3) Voltage Sensing

2) Direct control of pneumatic and electronic actuators and control devices. 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, sizes 1-4)

b) Analog outputs

(1) 0-20 psi
(2) 4-20 mA
(3) 0-10 VDC

D Each DDC Controller shall have a minimum of 10 per cent spare 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 and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

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

F 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, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

G 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.

H Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.

I 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.

J DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.

K 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.

L Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

M In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

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.

2.5 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.

B Control Software Description:

1) The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:

   a) Two-position control

   b) Proportional control

   c) Proportional plus integral control

   d) Proportional, integral, plus derivative control

   e) Control loop tuning

2) Control software shall include a provision for limiting the number of times 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 DDC Controllers shall have the ability to perform any or all the following energy management routines:

1) Time-of-day scheduling
2) Calendar-based scheduling
a) Events shall be able to be schedule a minimum of one year in advance
3) Holiday scheduling
4) Temporary schedule overrides
5) Start-Stop Time Optimization
6) Automatic Daylight Savings Time Switchover
7) Night setback control
8) Enthalpy switchover (economizer)
9) Peak demand limiting
10) Temperature-compensated duty cycling
11) Fan 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 Sequence of Operations.

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, exp, 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.

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 or activity at a PC workstation, local I/O device or communications with other panels on the network.

1) All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2) The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC 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.

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 50,000 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.

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.

2.6 APPLICATION SPECIFIC CONTROLLERS (ASC)

A Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs).

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. Provide the following types of ASCs as a minimum:

1) Central System Controllers

2) Terminal Equipment Controllers

C Central System Controllers:

1) Provide for control of central HVAC systems and equipment including, but not limited to, the following:

a) Rooftop units

b) Packaged air handling units

c) Built-up air handling systems

d) Chilled and condenser water systems

e) Steam and hot water systems

2) Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. 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.

3) Each 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 communication with its DDC Controller is lost and to insure protection during power outages.

4) Provide each central system 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. All programs shall be field-customized to meet the user's exact control strategy requirements. Central System controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide DDC Controllers for all central equipment in order to meet custom control strategy requirements.

5) Programming of central system controllers shall utilize the same language and code as used by DDC Controllers to maximize system flexibility and

ease of use. Should the system controller utilize a different control language, provide an DDC Controller to meet the specified functionality.

6) 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.

7) 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.

D Terminal Equipment Controllers:

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

a) Variable Air Volume (VAV) boxes

b) Constant Air Volume (CAV) boxes

c) Unit Conditioners

2) Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 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 ASCs 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 shall be thermistor type providing the following minimum performance requirements are met:

a) Accuracy: ± 1°F (±0.6°C)

b) Operating Range: 55° to 95°F (2° to 30°)

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

d) Set Point Modes: Independent Heating, Cooling, Night Setback Heating, Night Setback Cooling

e) Calibration Adjustments: None required

f) Installation: Up to 100 ft. from Controller

4) 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.

5) Each room sensor shall also include the following auxiliary devices:

   a) Setpoint Adjustment Dial
   b) Temperature Indicator
   c) Override Switch

6) The setpoint adjustment dial shall allow for modification of the temperature by the occupant. Setpoint adjustment may be locked out, overridden or limited as 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.

7) The temperature indicator shall be a digital LED and shall be visible without removing the sensor cover. In lieu of integral indication, provide a separate digital readout mounted on a stainless steel wall place adjacent to the sensor for local temperature indication.

8) 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.

9) 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) gains for all applications. All PID gains 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 shall not be acceptable.

10) 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 uninterruptible power supplies (UPSs) 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 all applications are not acceptable.

11) Variable Air Volume (VAV) Box Controllers: Shall support the following types of pressure independent terminal boxes as a minimum:

VAV cooling only
VAV with hot water reheat
VAV with electric reheat
Fan-powered VAV
Fan-powered VAV with hot water reheat
Fan-powered VAV with electric reheat

a) 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.

b) The VAV box 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 BMS 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.

c) The controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual air flow. 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 BMS contractor shall provide the velocity sensor if required to meet the specified functionality.

d) Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% 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 calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

e) 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 and shall be capable of monitoring space relative humidity.

f) 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.

12) Constant Air Volume (CAV) Box Controllers: Shall support the following types of pressure independent terminal boxes as a minimum.

CAV cooling only
CAV with hot water reheat
CAV with electric reheat

a) CAV box controllers shall meet all requirements of paragraphs 11a through 11e as previously specified for VAV box controllers.

b) 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 ASCs controlling associated air handling equipment shall also directly control all CAV terminal units in order to provide the specified reset capability.

c) 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

d) 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.

e) Terminal unit tracking shall be accomplished via actual measurement of terminal unit air volumes as previously specified. Controllers which track within a range of CFMs versus actual CFM setpoints shall not be acceptable. As an alternative, provide an 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. Terminal

unit controller shall be capable of monitoring space relative humidity.

f) Calibration of the differential pressure transducer shall be accomplished as previously specified for VAV box controllers. This method of stroking the terminal unit damper to a 0% position shall not be permitted, however, should the controlled space(s) require constant pressurization or 24-hour per day operation. Controllers performing under these requirements shall incorporate an auxiliary device(s), which functions to automatically calibrate the transducer without changing the damper position. This shall be accomplished by temporarily disengaging the transducer for the air velocity sensor so that a 0 cfm air volume reading is sensed. 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.

g) 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.

13) Unit Conditioner Controllers: Shall support the following types of terminal units as a minimum:

a) Fan coil units may be of the following types:

2-pipe heating or cooling
4-pipe heating or cooling
Cooling and electric heating
2-stage cooling and electric heating
2-stroke cooling and hot water heating

b) Induction units may be of the following types:

Unit conditioner - 2-pipe inductor
Unit conditioner - 2-pipe inductor

c) Pressure-dependent terminal boxes may be of the following types:

Heating or cooling
Hot water reheat

d) Unit conditioner controllers shall meet all requirements of paragraphs 11a, 11b and 11c as previously specified for VAV box controllers.

2.7 PORTABLE OPERATOR'S TERMINAL (POT)

A Provisions shall be made for one (1) portable operator terminal with a minimum LCD display of 80 characters by 25 lines and a full-featured keyboard. The POT shall be handheld 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.

1) Functionality for the use of a portable operator's terminal connected at any DDC Controller shall be provided:

2) Access all DDC Controllers on the network.

B Backup and/or restore DDC Controller data bases for all system panels, not just the DDC Controller connected to.

1) Display all point, selected point and alarm point summaries.

2) Display trending and totalization information.

3) Add, modify and/or delete any existing or new system point.

4) Command, change setpoint, enable/disable any system point.

5) 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:

D Provide connection capability at either the ASC or a related room sensor to access controller information.

1) Provide status, setup and control reports.

2) Modify, select and store controller data base.

3) Command, change setpoint, enable/disable any controller point.

E 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 one (1) of each type portable operator's terminals as specified in A above.

F 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.

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

2.7A PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE

A The 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 Standalone DDC panels to facilitate greater fault tolerance and reliability.

B The 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 DDC Controllers to facilitate greater fault tolerance and reliability.

C The Workstation shall be manufactured by Dell and be a Model 2650 Server Family CPU. Workstation shall consist of a 19" color monitor, personal computer with minimum 512 MB RAM, two (2) 36 GB hard drives, 3-l/2" diskette drive, 20X CD Read/Write drive, 2 MB video adapter, mouse, and 101-key enhanced keyboard. Personal computer shall be a minimum 1.8 GHZ Pentium IV processor. The above describes the minimum and should be the latest manufacturer approved platform at the time of project activation.

D The display provided for system operation shall have a diagonal screen measurement of no less than 19" and a minimum display resolution of no less than 1280 X 1024 pixels non-interlaced. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.

E Provide a printer at each workstation location for recording alarms, operator transactions and systems reports, meeting the following minimum requirements: ***System printer shall be Hewlett Packard Business DeskJet 5850 or equal. [Add6-17.a]***

1) 132 column/160 character per second print speed
2) 9 x 9 DOT matrix character structure switchable to 9 x 18 DOT matrix for letter quality output.
3) Compressed mode option for 220 characters per line.
4) Software selectable under, emphasized, double strike and expanded (double width) characters capability.
5) Adjustable line spacing of 6 or 8 lines per inch.
6) Adjustable tractor for 5 inch to 15 inch paper widths.
7) 96 ASCII upper and lower case character set.

2.7B WORKSTATION OPERATOR INTERFACE Software features

A Basic Interface Description

1) Operator workstation interface software shall minimize operator training through the use of English language prompting, 30 character English language point identification, on-line help, and industry standard PC application software. Interface software shall simultaneously communicate with up to 4 Building Level Networks and share data between any of the 4 networks. The software shall provide, as a minimum, the following functionality:

   a) Real-time graphical viewing and control of environment
   b) Scheduling and override of building operations
   c) Collection and analysis of historical data
   d) Point database editing, storage and downloading of controller databases.
   e) Alarm reporting, routing, messaging, and acknowledgment
   f) Display dynamic data trend plot.
   g) Definition and construction of dynamic color graphic displays.
   h) Program editing
   i) Transfer trend data to 3rd party software
   j) Scheduling reports.

2) Provide a graphical user interface which shall minimize the use of keyboard through the use of a mouse or similar pointing device and "point and click approach to menu selection. There shall be a minimum of 8 pre-defined function keys to allow quick access to frequently used applications.

3) The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BMS software shall run within a 32 bit server operating system such as WINDOWS 2000 SERVER. These Windows applications shall run simultaneously with the BMS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information,

   a) Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via user-sized windows. Operator shall be able to drag and drop information between applications, reducing the number of steps (i.e. Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend).

      (1) Dynamic color graphics and graphic control

(2) Alarm management, routing to designated locations, and customized messages

(3) Year in advance equipment and report scheduling

(4) Dynamic trend data definition and presentation

(5) Graphic definition and construction

(6) Program and point database editing on-line

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

c) Report and alarm printing shall be accomplished via Windows Explorer allowing use of network printers.

4) Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow/' the operator to any workstation logged onto (up to 200 passwords shall be supported).

5) Operator Activity Tracking - An audit trail report to track system changes, accounting for operator initiated actions, changes made by a particular person or changes made to a specific piece of equipment, designated time frame, shall be printable and archived for future use. The operator activity tracking shall be in a tamper -proof buffer file.

6) Reports shall be generated on demand or via pre-defined schedule and directed 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 or selected points in the network
b) List of all points currently in alarm
c) List of all points currently in override status
d) List of all disabled points
e) List of all points currently locked out
f) List of user accounts and access levels
g) List all weekly schedules
h) List of holiday programming
i) List of limits and deadbands
j) Custom reports from 3d party software
k) System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
l) List of programs

7) Scheduling and override

a) Provide a graphical spreadsheet-type format for simplification of time-of day scheduling and overrides of building operations. Schedules reside in both the PC workstation and DDC Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key. Provide the following spreadsheet graphic types as a minimum:

(1) Weekly schedules
(2) Zone schedules, minimum of 200 unique zones
(3) Scheduling for up to 365 days in advance
(4) Schedule reports to print at PC.

8) Collection and Analysis of Historical Data

a) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at timebased intervals or change of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

b) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel.

B Dynamic Color Graphic Displays

1) Create Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, and room level terminal units, shall be provided by the BMS contractor as indicated in the point 1/0 schedule 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. Graphics software shall permit the importing of AutoCAD or scanned pictures for use in the system.

3) Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

a) Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.

b) Override the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.

c) Equipment state can be changed by clicking on the point block or graphic symbol and selecting the new state (on/off) or setpoint.

4) Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.

5) The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

6) A clipart library of dynamic HVAC and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard duckwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library.

7) A dynamic display of the site specific architecture showing status of all controllers, PC workstations and networks shall be provided.

C Workstation Communications

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).

(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.

2.8 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.

All electric wiring that serves as power for the computer system, microprocessors, or other field panels shall have lightning arrestor networks installed. Unit shall provide continuous non-interrupting protection with no degradation in protection capabilities. Instant automatic reset after safely eliminating transient surges from switching and other forms of transient over voltages is required. Voltage clamping level shall be 120 percent of nominal line voltage.

2.10 Temperature Sensors:

a. Resistor Temperature Detector (RTD): RTD shall have range of minus 30ºto plus 500ºF, with an accuracy of plus or minus 0.1 percent at 32ºF. RTD's shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum or copper.

All electronic temperature sensors that utilize nickel wire sensing shall have a reference resistance of 1,000 ohms at 70ºF.

b. Room sensors shall be designed for surface mounting to a standard wall box with provisions for a remote control adjustment. Provide concealed or exposed as required.

c. Provide averaging elements that cover the entire coil surface area, not less than eight (8) feet in length for those duct-sensing applications so specified.

d. Provide separable wells with thermal compound for those applications of liquid temperature sensing. Thermowells shall be series 300 stainless steel for use in water & steam lines.

e. Elements other than for room sensing applications shall be complete with mounting boxes or connectors for direct connection of EMT.

2.11 Humidity Sensors:

a. General. Humidity sensors shall employ a CAB (Cellulose Acetate Butyrate) element to produce a resistance output change proportional to the sensed relative humidity for input to controllers or indicating meters.

b. Room Humidity Sensors. Provide surface mount device for mounting on standard electrical switch box. Cover shall match room temperature element.

c. Duct Humidity Sensors. Provide units with integral conduit mounting box and shield to protect element from damage.

d. Relative humidity sensors shall use nonsaturating sensing elements. Sensors shall have a range of 20 to 99 percent, with an accuracy of plus or minus 3 percent of full scale.

2.12 Pressure Instruments:

a. Pressure Sensors: Pressure sensors shall withstand up to 150 percent of rated pressure. Pressure sensor accuracy shall be plus or minus one percent of full scale. Pressure sensors shall be either capsule, diaphragm, bellows, bourdon tube, or solid state.

Multi-point, multi-axis flow ring or cross sensor to be furnished. Single point or flow bar sensors are not acceptable. Sensors shall be capable of maintaining airflow to within +/- 5 percent of rated unit airflow setpoint with 1.5 duct diameters straight duct upstream from the unit.

b. Static Pressure Transmitters: Provide Setra Model 261 Very Low Differential Pressure Transducers at locations shown on the drawings for static control. Output shall be 4-20mA.

c. Pressure Switches: Pressure switches shall have a repetitive accuracy of plus or minus one percent of their operating range and shall withstand up to 150 percent of rated pressure. Sensors shall be diaphragm or bourdon tube. Switch operation shall be adjustable over the operating pressure

range. The switch shall have a snap-acting Form C contact rated for the application. Switch contacts shall be self-wiping contacts of platinum alloy, silver alloy, or gold plated, and shall have an adjustable differential setting. Provide switches for water or air applications as appropriate.

2.13 Control Relays:

a. Control relay contacts shall be rated for the application, with a minimum of two sets of Form C contacts, enclosed in a dustproof enclosure. Relays shall have silver alloy contacts with a minimum life span rating of one million operations. Operation shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression limiting transients to nondamaging levels.

2.14 Dampers Smoke and Fire/Smoke

1) Coordinate with Division 16 for power supply and Division 16 for fire alarm interaction.

2) Provide motor-driven fire/smoke & smoke dampers (damper and actuator must comply with UL 555, UL 555s and NFPA 90A) in types and sizes indicated, with frame constructed with minimum 16 gauge galvanized steel, and factory supplied sleeve constructed of 20 gauge galvanized steel for dampers 84" wide or smaller and 18 gauge galvanized steel for dampers 85" and up (except, sleeve gauge must be at least equal to the gauge of the duct) with bonded red acrylic enamel finish, fusible link 160 to 165° F (not required with smoke damper), unless otherwise indicated, and steel interlocking blades, with electric motor equipped with instant closure clutch, stainless steel cable damper blade linkage, motor mounting bracket, and motor mounted outside air stream.

3) Fire/Smoke & Smoke damper must be fully operational while HVAC system is in operation

4) Activation of the fire alarm panel shall close all smoke dampers. The smoke dampers on each air handling unit system shall also close upon any manual or automatic shut down of the fan. Smoke damper shall open automatically upon restoration of the fire alarm "all clear" signal. Coordinate the wiring of the combination smoke/fire dampers with the fire alarm contractor accordingly. Wiring between each air handling unit starter and associated smoke dampers shall be by Division 17 contractor.

5) Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire and smoke dampers which may be incorporated in the work include the following:

a) Air Balance, Inc.

b) American Warming and Ventilating, Inc.
c) Arrow Louver & Damper; Div. Of Arrow United Industries, Inc.
d) Louvers and Dampers, Inc.
e) Penn Ventilator Co.
f) Phillips-Aire.
g) Ruskin Mfg. Co.

2.15 Dampers Automatic Control

1) Provide automatic control dampers as indicated, with damper frames not less than formed 16-ga galvanized steel. Provide damper blades not less than formed 16-ga galvanized steel, with maximum blade width of 8".

2) Secure blades to 1/2" diameter plated steel axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings at each end of every blade.

3) Parallel blade operation shall be used for all two position applications and opposed blade configurations for all modulating applications.

4) Performance Data

a) Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.

(1) Closed Position: Maximum pressure of 5 inches w.g. (1.2 kPa) @ a 12 inch (305) blade length.

(2) Open Position: Maximum air velocity of 2,000 feet per minute (610 m/min).

b) Leakage: Maximum 3.7 cubic feet per minute per square foot (1.1 $m^3/min/m^2$) at 1 inch w.g. (0.25 kPa) for all sizes 36 inches (914 mm) wide and above.

c) Pressure Drop: Maximum 0.07 inch w.g. (0.02 kPa) at 1,500 feet per minute (457 m/min) across 24 inch x 24 inch (610 x 610 mm) damper.

2.16 Damper and Valve Actuators:

a. Damper and valve actuators shall be capable of providing smooth, proportional control under design temperature and pressure conditions. All actuators shall have DDC capabilities and be wired into the DDC controller by two wires. The actuators will be of such design that the DC board in the actuators can be field replaceable. They will receive and

interpret commands from the controller and will send response information back to the controller. Actuators to be factory selected, mounted and tested for proper operation based on unit size, type and torque requirements.

2.17 Control Valves:

a. General. Provide factory fabricated control valves of the type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in the piping system. Provide actuators as indicated elsewhere to comply with sequence of operation.

b. Automatic control valves shall be fully proportioning with modulating plug, unless otherwise specified. The valves shall be quiet in operation and fail safe in either normally open or normally closed position in the event of control signal failure.

c. Valves shall employ cage type trim providing seating and guiding surfaces for the plug on the top and bottom. Stems shall be of stainless steel and plugs of brass with composition disks. Packings shall be of Teflon.

d. Valve CV shall be selected by Control Contractor for a 3 to 5 psi pressure drop.

e. Valves utilized for steam service exceeding 15 psi, or system temperatures above 125ºF, shall be provided with stainless steel stems, plugs and seat rings. For steam service exceeding 10 psi the valve shall be sized based on the critical pressure drop.

f. On cooling tower valves (over 6") Butterfly valves shall be used for automatic control. Valves shall be lug type rated for 125-psi non-shock water service to 180ºF. Valve body shall be ductile iron with B-Nitrite (BUNA N) or EPDM molded seat and seals. Disc material shall be cast bronze or aluminum-bronze with ASTM A-492 Type 416SS stainless steel stem and fittings. Valves shall be tight close off suitable for end of the line service. Butterfly valves used for two-position control shall be line size. Valves used for modulating control shall be sized for a minimum 5 psig differential pressure at full flow. Three way valve mixing or diverting configurations shall have factory provided linkage kits specifically manufactured for the piping arrangement and actuator used. Provide capacity and torque ratings with manufacturers' shop drawings.

2.18 Room Thermostats (Electric):

a. General. Provide room thermostats with tamper proof covers, and with concealed or readily accessible adjustment devices, as indicated. Where indicated, provide heavy-duty "asylum type", clear plastic, or wire guards.

b. Two Position Thermostats. Provide thermostats of bimetal actuated open contact, or bellows actuated enclosed snap-switch type, UL listed at an electrical rating comparable with application. Provide bimetal thermostats that employ heat anticipation. Equip thermostats that control electric-heating loads directly, with OFF position on the dial wired to break ungrounded conductors. Low voltage thermostats may employ a mercury bulb switching mechanism.

2.19 Low Temperature Protection Thermostats (Electric):

a. Provide low temperature protection thermostats of automatic or manual-reset type as required by the sequence of operations, with sensing elements 8' or 20' in length. Provide thermostat designed to operate in response to coldest 1'-0" length of sensing element, regardless of temperature at other parts of element.

b. Support element properly to cover the entire duct width.

c. Provide separate thermostats for each 25 square feet of coil face area or fraction thereof.

2.20 Ionization Smoke Detectors:

For each air handling unit and air system provide UL listed ionization smoke detectors where indicated and in main supply and return air ducts. Connect detectors into control circuits to stop fans in event of presence of smoke. Smoke detectors shall be furnished under section 17400.

2.21 Water Flow Switches:

Provide water flow switches of stainless steel paddle types. Where flow switches are used in chilled water applications, provide vapor-proof type to prevent condensation of electrical switch. Provide pressure flow switches of bellows actuated mercury type or snap-acting type, with appropriate scale range and differential adjustment for service indicated. Flow switches for use as safeties for chiller or boiler equipment shall be provided and installed by others.

2.22 Hardware Override Switches:

The operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, 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. (Not required for AHU, FCU and VAV/FTU Box DDC panels).

The 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.

2.23 Electrical Devices: Provide electric pneumatic or pneumatic electric switches, electrical devices and relays that are UL listed and of a type meeting current and voltage characteristics of the project.

2.24 Transformers and Power Supplies:

The transformers shall be either 120/208/240/480 to 24/12 VAC as required by the voltage and/or application. Provide for each transformer a resettable circuit breaker at the secondary side. Each transformer shall be UL approved class 2 unit with an operating ambient temperature range from -40ºF. to 120ºF. and a humidity level from 10% to 90% noncondensing.

2.26 Hot Water Recording Flow Meters:

Provide hot-water recording flow meters for hot water boiler machines to record the hot water flow rate in gallons per hour and totalize water flow for at least a 24-hour period.

2.27 Surge and Transient Protection (Electronic):

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.

All electric wiring that serves as power for the computer system, microprocessors, or other field panels shall have lightning arrestor networks installed. Unit shall provide continuous non-interrupting protection with no degradation in protection capabilities. Instant automatic reset after safely eliminating transient surges from switching and other forms of transient over voltages is required. Voltage clamping level shall be 120 percent of nominal line voltage.

3.0 EXECUTION:

3.1 Installation:

a. General. Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Mount controllers at convenient locations and heights.

Field verify exact location of all equipment, devices and/or openings and coordinate with other trades.

All installation of the BMS system shall be performed by mechanics, electricians and technicians in the direct supervision of the system supplier. Coordinate installation with all other affected trades. Provide necessary project management personnel for this section.

3.2. Control Electric Wiring:

a. Provide all electrical work required as an integral part of the digital control work. Install a complete wiring system for the temperature control system including wire, conduit and miscellaneous materials as required for mounting and connecting control devices. Conceal wiring except in mechanical rooms and areas where other conduit and wiring are exposed. All wiring to sensors and bus connections is low voltage and shall be in accordance with local regulations and the National Electrical Code.

a. Low voltage control wiring may be plenum wire not installed in conduit in accordance with local regulations and the National Electrical Code. Plenum wiring will comply with the applicable requirements of Section 17600 for the installation of electrical plenum wiring incidental to the BMS.

b. Electrical control and power wiring required for DDC equipment and the BMS, damper and valve actuators and local control panels and not specifically identified in the Division 16 sections as electrical work or shown on the electrical drawings, is work of this section. Comply with the applicable requirements of Section 17600 for the installation of electrical wiring incidental to the Building Management System. If additional circuits need to be designated for this equipment, the Contractor shall include the cost to add these circuits.

3.3 Unit Mounted Equipment:

a. Where control devices are indicated to be unit mounted, ship relays, transformers, switches, valves, dampers, and damper actuators to unit manufacturer for mounting and wiring at factory. Unit manufacturers shall mount and wire controllers per control manufacturers instruction.

Mount electrical components in control box with removable cover. Incorporate single point electrical connection to power source.

b. Mount transformer for control voltage in the control box. Provide physical separation of high and low voltage wiring in control box.

3.4 Field Equipment:

a. Enclosures: All exterior wall penetrations shall be sealed to preclude the entry of water using a silicone sealant.

b. Temperatures: RTD's may be used in ducts, piping, or space. When the RTD is installed in pipes or is susceptible to corrosion and vibration, the RTD shall be installed in thermowell. All thermowells shall be provided under this section and installed by the piping Subcontractor. When installed in air streams or space, the RTD shall be rigidly supported. RTD's which are attached to surfaces may be clamped or bonded in place. The surface shall be thoroughly cleaned, degreased, and after RTD installation shall be insulated from ambient temperature effects. RTD's used for space temperature sensing shall include a suitable housing for wall mounting. RTD's used for OA sensing shall have an instrument shelter to minimize solar effects, and shall be mounted to minimize building OA effects. All RTD assemblies shall be readily accessible and installed in such a manner as to allow for easy replacement.

c. Pressure: All pressure sensors shall have valves for isolation, venting, and taps for calibration. Pressure sensors shall be verified by calibration.

d. Relays: Install relays in new control cabinets. Contact ratings and duty shall be selected in accordance with NEMA Standards.

e. Mount space temperature sensors and thermostats 48" Max AFF whenever possible as shown on the drawings. Prior to installation coordinate and adjust the final device location with all casework, shelving, furniture, bulletin boards or other wall mounted furnishings.

f. Layout: Layout of DDC and control equipment must include ample space around equipment for inspection and maintenance.

3.5 Software Installation:

a. General: Install all components and load all system software in accordance with manufacturer's recommendations.

b. Load and debug all software required for an operational BMS, including database, operational parameters, and system and applications programs. Load and debug all direct digital control software necessary to implement all sequences of operation and as shown on the drawings.

3.6 Final Adjustment of Equipment:

a. After completion of the installation, adjust thermostats, control valves, actuators and similar equipment provided as work of this section. Provide a copy of the verification report showing actual values of each point versus system display for all system points during the validation of the system.

Final adjustment shall be performed by specially trained personnel in the direct employ of the manufacturer of the Building Management System.

b. Checkout: Prior to requesting final acceptance of the system, demonstrate to the Engineer and the Owner's Representative that all requirements of Section 17250 and this section have been fully complied with.

c. Calibration: Provide a report showing actual value of each AI point versus system display for at least 30% of all system points as means of verification of system calibration. Verification shall be witnessed by Owner's Representative or the Engineer at their options.

3.7 COMMISSIONING, TESTING AND ACCEPTANCE

????????Paragraph 3.7.1 - Delete this paragraph. [Add6-17.b]????????

A. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets which shall be submitted prior to acceptance testing. Commissioning work which requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.

1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:

a. Sensor accuracy at 10, 50 and 90% of range.

b. Sensor range.

c. Verify analog limit and binary alarm reporting.

d. Point value reporting.

e. Binary alarm and switch settings.

f. Actuator ranges.

g. Fail safe operation on loss of control signal, electric power, network communications.

B. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy's. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.

C. After all BMS programs have been commissioned, the contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to:

1. Data communication, both normal and failure modes.

2. Fully loaded system response time.

3. Impact of component failures on system performance and system operation.

4. Time/Date changes.

5. End of month/ end of year operation.

6. Season changeover.

7. Global application programs and point sharing.

8. System backup and reloading.

9. System status displays.

10. Diagnostic functions.

11. Power failure routines.

12. Battery backup.

13. Smoke Control, stair pressurization, stair, vents, in concert with Fire Alarm System testing.

D. Submit a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy's and the system performance does not degrade over time.

E. Using the commissioning test data sheets, the contractor shall demonstrate (30% minimum unless specifically scoped otherwise) of all system points. The contractor shall also demonstrate all system functions. The contractor shall demonstrate point and system functions until devices and functions meet specification.

F. The contractor shall provide all instruments for testing

Test Instrument Accuracy:

Temperature: 1/4F or 1/2% full scale, whichever is less.

Pressure: High Pressure (psi): ½ psi or 1/2% full scale, whichever is less.

Low Pressure: 1/2% of full scale (in w.c.)

Humidity: 2% RH

Electrical: 1/4% full scale

G. After the above tests are complete and the system is demonstrated to be functioning as specified, a five day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

END OF SECTION