BUILDING AUTOMATION SYSTEM

PART 1GENERAL

Commentary: *Division 23 lists existing University Control Centers. This Appendix applies to* ***Student Life buildings*** *[to all building automation systems in all Student Life buildings on all University campuses and locations], except where noted otherwise in the BDS or hereinafter. For OSUWMC systems, see the separate OSUMC Appendix A - WMC. For FOD buildings see the separate FOD Appendix A - FOD. The individual Control Centers have the authority to amend the requirements of this Appendix with the approval of the University Engineer and the Student Life Building Automation Department. References to the FOD Control Center, or to the FOD Building Automation Department, or to FOD should be interpreted as meaning the appropriate Control Center for the given project. Review with the OSU Project Manager.*

DIRECT DIGITAL CONTROL SYSTEMS FOR STUDENT LIFE

PART 1 – GENERAL

1.1 Provide a complete system of automatic temperature controls (ATC) for this project, as required to accomplish the sequence of control for the various items of equipment and systems.

1.2 Related Documents

A. Drawings and general provisions of the contract, including general and supplementary conditions and Division 01 specification sections, apply to this section.

1) ASHRAE Standard 90.1 (as adopted by Division 18)
2) NFPA 70
3) National Electric Code

1.3 Summary

A. This section includes the following:

The ATC system shall be a stand-alone direct digital control (DDC) system utilizing electric actuation. The installed system shall be fully integrated into the existing Student Life Building Automation System's web client application server via BACnet over IP protocol – using typical University Internet/Intranet data connections. Testing of the new control system will be done "end to end" through the JCI ADX system. A workstation at each building is not required unless it is required to accomplish the ATC's building control architecture since all monitoring and control will be done through the JCI ADX system. System control graphics only need to reside on the JCI ADX system and do not need to be duplicated at the building level controllers. Within the scope of the project, Student Life will provide NAEs for system integration into Student Life ADX by ATC.

1) System operator application software shall be provided (two (2) copies). One (1) portable operator workstation shall be provided (refer to Part 2), fully functional for operation, maintenance, and engineering of installed systems – including all project specific software, tools, programs, tag/name files, and created graphics (and 2 soft backup copies of the "as built" same).

2) The control design allows the use of network controllers or building controllers architecture.

A. Option 1: The control system shall consist of a high-speed, peer to peer network of DDC controllers and a web based operator interface. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser.

Option 2: The BAS shall consist of central Servers and Routers, an Operator Workstation to provide access to the graphical operator interface software, stand-alone Building Controllers (BC), Custom Programmable Controllers (CPC) and Application Specific Controllers (ASC). The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of workstations, DDC panels, sensors, actuators, etc.

1) The system shall directly control HVAC equipment as specified in Section 23 09 93 - Sequence of Operations for HVAC Controls. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request based logic, and demand level adjustment of setpoints as specified in the sequence.
2) Provide for future system expansion to include monitoring of occupant card access, fire alarm, and lighting control systems.

3) System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. I/O points, schedules, setpoints, trends, and alarms specified in Section 23 09 93 - Sequence of Operations for HVAC Controls shall be BACnet objects.

1.4 Scope

A. Furnish and install a complete Native BACnet Direct Digital Control (DDC) Temperature Control System to automatically control the operation of the entire Heating, Ventilating and Air Conditioning System. The DDC system shall fully integrate into the existing Student Life native BACnet Johnson ADX system. The system shall perform the said integration through the use of BACnet/IP communications (Annex J only). BACnet over Ethernet will not be supported for campus wide communications. Failure to mention any specific item or device does not relieve the Contractor of the responsibility for furnishing and installing such items or devices in order to comply with the intent of the Drawings and/or this Specification. The University reserves the right to self-perform this work.

B. Direct Digital Control System (DDC) Contractor shall provide:

1) A fully integrated building automation system (BAS), UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control. At the Contractor's option, a DDC system as manufactured by the following, meeting all requirements of this specification may be furnished:

a) Automated Logic by EMCOR

b) Delta Controls Inc. by BCI

c) Johnson Controls (JCI)

d) Trane

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

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

4) All final electrical connections to each DDC panel. Connect to 120VAC power to the nearest emergency panel provided by the Division 26 contractor. ATC shall provide all 120VAC wiring, conduit and breakers that are not included under the base electrical contract drawings.

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

6) Surge transient protection shall be incorporated in design of system to protect electrical components in all Network and Main building DDC Controllers. Application Specific Controllers and Field Controllers do not require surge suppressors. Provide an external protection device listed under UL 1449 with minimum clamping voltage of 400 Volts and surge current capability of 26,000 Amps.

7) All 120V and low voltage electrical control wiring exposed throughout the building shall be run in conduit in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes. All low voltage wiring that is concealed in accessible ceilings may be run in plenum rated cable per the National and Local Electrical codes.

8) All 24V power required for operation of the DDC system shall be by the DDC Contractor.

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

10) The new controls shall include graphic screens on the OSU SL JCI ADX system. Testing of control system will be “end to end” through the JCI ADX system.

11) All energy meter wiring to OSU INSTEP. See drawings.

C. HVAC Contractor provides:

1) Installation of all wells and openings for water and air monitoring devices, temperature sensors, flow switches and alarms furnished by DDC Contractor.

2) Furnish and install all control valves and actuators.

3) Furnish and install all dampers and actuators, and adjacent access doors for smoke; outdoor air, return air, exhaust air, ventilation dampers and flow sensors.

5) For all projects where the Student Life BAS Shop serves as the DDC/Temperature Control Contractor, the HVAC Contractor shall furnish and install all control valves, dampers, actuators, and flow sensors. Sizing and selection of control valves, dampers, actuators, and flow sensors shall be subject to Student Life BAS Shop review and approval. HVAC shall furnish and install access doors as needed.

5) All package unit control panels, including applicable gateway for BACnet interfacing.

D. General Product Description:

1) The DDC Contractor shall supply a BACnet (ANSI/ASHRAE 135-2004 Minimum) compliant system. BACnet compatible systems that employ the use of proprietary ‘gateways’ will not be accepted unless otherwise noted. In addition, all devices shall incorporate peer to peer communications. All DDC Contractors shall supply, prior to bid, Protocol Implementation Conformance Statements (PICS) and BACnet Interoperability Building Block (BIBB) summaries to the A/E for final approval.

2) The primary Local Area Network (LAN) shall be based upon the ISO 8802-3 Ethernet standard. The installation of all Ethernet wiring, accessories, and connectors shall conform to the ISO standard and/or guidelines identified herein. The preferred connection media shall be Category 6,

shielded Twisted Pair wire. The maximum single network run shall not exceed more than 300 feet. The DDC system may utilize the customer's Local Area Network (LAN) provided the bandwidth consumption is less than 10% of the total network bandwidth. All Ethernet network devices shall be home run to Student Life managed Ethernet switch. Under no circumstances, shall the customer's LAN be subject to failure and/or abuse. In efforts to decrease liability, all BACnet devices that reside on the LAN must support the BACnet Broadcast Management Device (BBMD) scheme. Global broadcasting will not be permitted without the use of a BBMD.

3) The BACnet system shall be capable of Internet Protocol (IP) communications. BACnet/IP or Annex J will be considered the basis of design. All other configurations must be submitted prior to bid, in writing, for final approval. These configurations shall include but not be limited to, Annex H or third party BACnet tunneling routers.

4) The secondary or sub-network shall utilize the Master-Slave/Token-Passing protocol, as acknowledged by the ANSI/ASHRAE 135 standard. Proprietary RS-485 or equivalent links will not be considered unless otherwise noted. The MS/TP link shall operate at a 76.8 Kbps minimum, and utilize no more than 2 repeaters in any instance.

5) The use of proprietary gateways to transmit input/output data, and/or related information, must reside on the Ethernet LAN and be approved, in writing, prior to the bid.

6) The DDC Contractor or manufacturer representative shall support the installed system for a minimum of 2 years. The support shall include all software/firmware updates, full material warranty of actual controllers, and on- site training and support per 23 05 01.

7) The DDC system shall consist of the following:

a) Stand-alone DDC Controllers

b) Central Servers and Routers

c) Building Controllers (BC)

d) Custom Programmable Controllers (CPC)

e) Application Specific Controllers (ASC).

f) Operator Workstation

g) Stand-alone Direct Digital Control (DDC) panels

h) Associated sensors and controlled devices

i) Tenable.OT rack-mounted network sensor

j) Balance Cx Data Analytics for installed control points and systems

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

9) The system architectural design shall utilize a multi-tier communications network as specified.

10) The system architectural design shall require alarming to be built at the building controller level.

11) The BAS specified herein shall be capable of integrating multiple building functions including equipment supervision and control of all field I/O points and software points, alarm management, energy management, historical data collection and archiving, data storage, report generation and graphics interaction.

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

13) Each controlled system shall have its own stand-alone DDC panel. Controllers shall not be shared across multiple controlled systems, nor shall controlled systems be split across multiple controllers. Where point counts exceed the limits of a controller, provide auxiliary input/output expansion hardware such that there is a single processor for each equipment item.

a) For large systems, the active control points and control programming shall reside in one controller, while “monitor-only” points may reside in another separate single controller.

b) If there are still too many active control points for the I/O capacity of a single controller, then all programming shall reside in a single controller and a second controller shall be utilized as a remote I/O board. In this scenario, sanity checking shall be required for the remote points, and the system shall shut down and alarm upon loss of communications or other invalid data from the remote controller.

C) Pressure and Differential Pressure control points shall be hardwired directly to controller to which associated controlled devices are hardwired.

1.5 Submittals

A. Submit 10 complete sets of drawings (and one soft copy in PDF format) showing the kind of control equipment for each of the various systems and their functions, along with indications on the drawing of all original setpoints and calibration values, and setup parameters, and sequence of operation of the automation system. These drawings shall be submitted for approval to the A/E, and to The Ohio State University Student Affairs Building Automation, and to The Ohio State University Engineer’s Office, together with a complete brochure describing the equipment and their functions and operation. Include all application software documentation (actual programs or their job-specific flow charts) with DDC system and schedule a review meeting with the University’s Representative and the A/E at least two weeks before installation and start up.

1) Manufacturer's Product Data:

a) All equipment components

b) Shop Drawings:

(1) System wiring diagrams with sequence of operation for each system as specified.

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

(3) System configuration diagram showing all pane types and locations as well as communications network and workstations.

(4) System architecture diagram and descriptions.

(5) Approved room numbers are required to be included on all temperature control submittals, and all control as-built drawings.

(6) Submit all control drawings in Visio electronic format.

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

1.6 Quality Assurance

A. Installer Qualifications: An experienced installer who is a certified installer of the DDC control system manufacturer for both installation and maintenance of BACnet based systems. The qualifications shall include all necessary debugging and calibration of each component of the system. Installers shall have minimum 10 years of experience.

B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems similar to those indicated for this project and with a record of successful in-service performance. Equipment and Installer shall have a support facility within 150 miles of the site with technical support staff.

C. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

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

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

1) FCC Regulation, Part 15, Section 156.

2) National Electric Manufacturers Associations (NEMA).

3) Comply with ASHRAE 135-2004 (at a minimum) for DDC system control components.

4) DDC Product manufacturer shall be ISO 9001 Registered at the time of bid.

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

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

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

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

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

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

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

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

1.7 System Checkout

A. Provide necessary personnel as required to assist the Associate and Commissioning Agent in providing complete system operational testing. Refer to Section 01 91 13 - Commissioning.

1.8 An interconnecting wiring conduit system shall be installed between all DDC panels within the Building. The interconnecting conduit system shall be extended to the appropriate point to provide the link to the remote communications network. All communications cables required to provide the communications link between the DDC controllers and the external communications network shall be installed as a part of the project.

1.9 The basic control system shall include all sensors, controllers, instruments, valves, actuators, devices, installation and service for a complete and functional control system. All control devices (valves, dampers, actuators, etc.) shall be included under the ATC Sub-Contract unless specifically specified elsewhere in the HVAC Specification. Where Student Life BAS shop self-performs the control project, the HVAC Contractor shall be responsible for correctly sizing control valves and dampers.

1.10 All wiring shall be in compliance with Division 26 Electrical. All wiring shall be run in conduit.

1.11 Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Network Controllers, Building Controllers and Advanced Application Controllers. Application Specific Controllers outside the mini plant do not require surge protection. Provide an external protection device listed under UL 1449 with minimum clamping voltage of 400 Volts and surge current capability of 26,000 Amps.

1.12 In addition to Division 01 Allowances, the contractor shall include in his bid price the following for EACH building of the bid package: 4 additional digital points and 4 additional analog points with 100 ft of conduit and wire per point per building. Bid price shall include material and labor to install.

PART 2 - PRODUCTS

2.1 Networking Communications

A. Option #1: The design of the DDC network shall integrate web-based operator interface and stand-alone DDC Controllers on a peer to peer communications network, and other devices on other networks. The network architecture shall consist of the following levels:

1. A campus-wide Ethernet communications network based on TCP/IP protocol. Building to campus network shall be BACNET IP compatible.

2. A building-wide peer to peer communications network between DDC Controllers. Building network shall be BACNET IP compatible.

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

B. Option #2: The design of the DDC network is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate the ANSI/ASHRAE Standard 135-2001 (BACnet) interoperable system. The network architecture shall consist of the following levels:

1. A campus-wide Ethernet communications network based on TCP/IP protocol. Building to campus network shall be BACNET IP compatible.

2. A building-wide peer-to-peer communications network between servers, routers, operator workstations and building controllers. Building network shall be BACNET IP compatible.

3. Many local area networks extended from appropriate Building Controllers to Routers, Custom Programmable Controllers and Application Specific Controllers, and shall communicate bi- directionally with the building-wide control network.

4. This communications network shall be limited to Building Controllers/Routers, Custom Programmable Controllers and Application Specific Controllers, and shall communicate bi- directionally with the building-wide communications network.

5. Acceptable protocols for this communications network are as follows a. BACnet via Master-Slave/Token-Passing protocol (MS/TP), as acknowledged by the ANSI/ASHRAE 135 standard.

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

D. Campus-wide Ethernet Communications Network:

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

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

E. Option#1: Building-wide peer to peer Communications Network:

1. Web-based Operator interface and DDC Controllers shall directly reside on a network such that communications may be executed directly between DDC Controllers and workstations on a peer-to-peer basis, without requirement for any device to operate or manage the network. A portion of the network management is built into each of the 'peer-to-peer members. 'Peer-to-peer' refers to controllers that (when interconnected) will act independently as equals, without a network manager, and will communicate in a token passing protocol with each other to pass data packet information for the purpose of building-wide monitoring and control. A special data packet called the 'token' is constantly and

continually 'passed' to every member of the peer-to-peer communications network. Any peer-to-peer device on the network can send a packet of data only when it has the 'token'. Any peer-to-peer device on this network can request data from, or send data to, any other device on the network. With this procedure, token ensures that data collisions do not occur, and assures that all members of the network get equal opportunity for all data on the network.

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

3. All operator devices shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the peer-to-peer network data.

4. Network design shall include the following provisions:

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

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

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

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

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

F. Option #2: Building-wide peer to peer Communications Network:

1. The building-wide control network shall be based upon the ISO 8802-3 Ethernet standard (IEEE 802.3), utilizing Internet Protocol (IP) communications and operate at a minimum of 10/100 Mb/sec. The installation of all Ethernet wiring, accessories, and connectors shall conform to the ISO standard.

2. The preferred connection media shall be 10 Base-T, Category 6, shielded Twisted Pair wire. The maximum single network run shall not exceed more than
250 feet. If additional distance is needed, the use of hubs or other Ethernet media will be acceptable. However, the 'cascading' of more than 3 hubs on a single segment will not be accepted.

3. The BAS shall utilize the building-wide control network for communications between the servers, routers, operator workstations and building controllers.

4. The BAS shall not utilize the building-wide control network for Direct Digital Control (DDC) panels, Custom Programmable Controllers (CPC) and Application Specific Controllers (ASC) without written permission from the owner. These controllers shall be located on the local area networks unless approved by the owner.

5. The BAS contractor shall provide their own Ethernet wiring/cabling to allow BAS web access from the owner's network.

6. With written permission from the Owner and the Owner's IT staff, the BAS system may utilize the Owner's IT infrastructure within the facility for the building- wide control network provided the bandwidth consumption is less than 5% of the total network bandwidth. Under no circumstances, shall the Owner's network be subject to failure and/or abuse.

a) The BAS Contractor shall be responsible for coordination with the Owner's IT staff to ensure that the BAS will perform in the Owner's environment without disruption to any other activities taking place on the infrastructure.

b) If permission is granted to use the Owner's IT network:

(1) The Owner shall provide the IP address(es) for the control system to utilize the Owners IT infrastructure.

(2) The BAS contractor is still responsible for the communications wiring between the BAS equipment and the Owner designated connection locations. Final connections shall be coordinated with the Owner's IT staff.

(3) The BAS Contractor shall conform to the Owner's IT standards for all wiring/cabling and connection details.

7. Acceptable protocols for this communications network are as follows
a) BACnet/IP protocol (Annex J) as defined by ANSI/ASHRAE Standard 135-2001.

b) The system shall be a minimum conformance class 3, as identified by the standard. BACnet compatible systems that employ the use of proprietary 'gateways' will not be accepted unless otherwise noted.

8. All tools required to manage the ELCN shall be provided with the system

G. Local Area (Communications) Network (LAN):

1. This communications network shall be limited to Building Controllers/Routers, Custom Programmable Controllers, Supplementary Controllers and Application Specific Controllers, and shall communicate bi-directionally.

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

3. The BAS shall utilize the BLCN for communications between the BCs and the CPCs/ASCs and communications between CPCs and ASCs. All tools required to manage the BLCN shall be provided with the system.

4. Acceptable protocols for this communications network are as follows a. BACnet via Master-Slave/Token-Passing protocol (MS/TP), as acknowledged by the ANSI/ASHRAE 135 standard. The MS/TP link shall operate at a 76.8 Kbps minimum and utilize no more than 2 repeaters in any instance.

5. Unless otherwise approved by Student Life, a maximum of 32 Supplementary Controllers and Application Specific Controllers may be configured on any individual LAN trunk from any DDC Controller to insure adequate global data and alarm response times. Each supplemental controller is limited by 64 to each BACnet MSTP trunk of a network controller, each network controller is limited by its own BACnet MSTP trunk count.

2.2 DDC Network Controller

A. DDC (stand-alone) Controllers shall be microprocessor-based with a minimum word size of 16 bits. They shall also be multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification.

B. Each DDC Controller shall have sufficient memory, a minimum of 3 megabyte, to support its own operating system and databases, including:

1. Control processes

2. Energy management applications

3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.

4. Historical/trend data for points specified

5. Maintenance support applications

6. Custom processes

7. Operator I/O

8. Dial-up communications

9. Manual override monitoring

C. Each DDC Controller shall support:

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

a) Analog inputs

(1) 4-20 mA

(2) 0-10 Vdc

(3) Thermistors

(4) 1000 ohm RTD’s

b) Digital inputs

(1) Dry contact closure

(2) Pulse Accumulator

(3) Voltage Sensing

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

a) Digital outputs (contact closure)

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

b) Analog outputs (1) 4-20 mA
(2) 0-10 Vdc

D. Each DDC Controller shall have a minimum of 10 percent spare (panel real estate) capacity for future point connection in mechanical rooms, commercial kitchens and for air handling units (spare points are not required on field controllers for fan coils, valances and unitary equipment). The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two spares of each implemented I/O type. Provide all processors, power supplies, database memory, program sequence memory, and communication controllers complete so that the implementation of any added point (within the above 10% spare) only requires the addition of the appropriate point input/output termination module, point sensor, and wiring.

1. Provide sufficient internal memory for the specified control sequences and have at least 40% of the memory available for future use.

E. [Deleted.]

F. The operator shall provide means or the ability to manually override automatic or centrally executed commands at the DDC Controller. These override switches shall be operable whether the panel processor is operational or not.

1. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides or be located within the DDC system software to electronically override locally on controller panel display using password protected keypad.

2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

G. DDC Controllers shall provide local visual status indication for each digital and analog input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Status indication shall be visible at the local panel.

H. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

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

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

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

K. Application Specific Controllers are not acceptable for Air Handlers or chiller plants.

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

M. DDC Controllers or a Custom Programmable Controller (CPC) will be used in each equipment room where major or more than two pieces of equipment are being controlled.

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

2.3 Stand Alone Building Controllers (BC)

A. Stand-alone BC panels shall be microprocessor based, multi-tasking, multi-user, real- time digital control processors. The BC shall provide an interface between the enterprise level operator interfaces and databases, and the building level controllers.

B. Each panel shall have sufficient memory to support its own operating system and database. Non-volatile memory shall be incorporated for all critical controller configuration data and 72-hour battery back-up shall be provided for all volatile memory.

C. All BCs shall communicate on the ELCN as well as the BLCN.

D. Each BC shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASC) and Custom Programmable Controllers (CPC).

E. The BC shall have the following minimum capabilities:

1. Global control processes
2. Energy Management Applications
3. Scheduling
4. Alarm Management
5. Historical/Trend Data for all points
6. Time and Calendar synchronization
7. Maintenance Support Applications
8. Operator I/O
9. Dial-Up Communication
10. Manual Override Monitoring
11. Integration of BACnet controller data

F. The BC shall monitor the status or position of all hardware overrides and include this information in logs and summaries to inform the operator that automatic control has been inhibited. BCs shall also collect override activity information for daily and monthly reports.

G. Each BC shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. The BC 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 BC and shall not require the connection of an operator I/O device.

H. 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 run in the same conduit as high voltage wiring where acceptable by electrical code.

I. In the event of the loss of normal power, there shall be an orderly shutdown of all BCs to prevent the loss of database or operating systems software. Upon restoration of normal power, the BC shall automatically resume full operation without manual intervention. Should BC memory be lost for any reason, the user shall have the capability of reloading the BC via the ELCN or via the local RS-232C port.

J. Each BC shall automatically and continuously maintain a history of all associated temperatures to allow users to quickly analyze comfort and equipment performance over the past 24 hours. A minimum of two samples per hour shall be stored.

K. Each BC shall have the ability to collect data for any property of any point connected on its BLCN.

L. The BC shall have the ability to back-up its database of points, control processes, logs, trends, histories etc. to the central server.

M. BCs used in conditioned ambient space shall be rated for operation at 32°F to 122°F and 5 to 95% RH, non-condensing. BCs used outdoors shall be rated for operation at -40°F to 140°F and 5 to 95% RH, non-condensing.

N. Each Building Controller shall have a minimum of 10 percent spare (panel real estate) capacity for future point connection in mechanical rooms, commercial kitchens and for air handling units (spare points are not required on field controllers for fan coils, valances and unitary equipment). The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than two spares of each implemented I/O type. Provide all processors, power supplies, database memory, program sequence memory, and communication controllers complete so that the implementation of any added point (within the above 10% spare) only requires the addition of the appropriate point input/output termination module, point sensor, and wiring.

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

2.4 DDC and Building Controller Resident Software Features

A. General:

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

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

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

B. Control Software Description:

1. The DDC Controllers shall have the ability to perform any or all of the following pre-tested control algorithms:

a) Two-position control

b) Proportional control

c) Proportional plus integral control

d) Proportional, integral, plus derivative control

e) Automatic control loop tuning

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

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

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

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

1. Time-of-day scheduling

2. 365 day Calendar-based scheduling

3. Holiday scheduling

4. Temporary schedule overrides

5. Start-Stop Time Optimization

6. Automatic Daylight Savings Time Switch over

7. Night setback control

8. Enthalpy switch over (economizer)

9. Peak demand limiting

10. Temperature-compensated duty cycling

11. Fan speed/ control

12. Heating/cooling interlock

13. Hot water reset

14. Chilled water reset

15. Condenser water reset

16. Chiller sequencing

17. Chiller load monitoring

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

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

   a) Any system measured point data or status

   b) Any calculated data

   c) Any results from other processes

   d) User-defined constants

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

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

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

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

   a) Time interval

   b) Time-of-day

   c) Date

   d) Other processes
   e) Time programming

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

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

4. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device.

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

E. Alarm management shall be provided to monitor and direct alarm information to operator devices.
Alarm reporting and storage shall be done on the NAE(s) controllers, through the existing SL BAS Metasys server. Independent storage of alarms by the local controllers is not permitted.
.
At no time shall the DDC Controllers ability to report alarms be affected by either operator activity at a PC workstation, local I/O device or communications with other panels on the network.

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

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

reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

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 Building Controller. Two methods of collection shall be allowed; either by a pre-defined time interval, or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM- based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.

2. Trend data shall be stored at the Building Controller. All trend data shall be available for use in 3rd party personal computer applications. File format type to be comma delineated.

3. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary. Provide capability to view or print trend and tuning reports.

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

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

c) Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

G. DDC Controllers shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary.

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

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

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

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

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

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

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

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

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

J. Supplementary Controllers:

1. Each DDC Controller shall be able to extend its performance and capacity through the use of remote Supplementary Controllers. Each Supplementary Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Supplementary Controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. Provide for control of central HVAC systems and equipment including, but not limited to, the following:

a) Heating and ventilating unit

b) Built-up air handling systems
c) Chilled and condenser water systems

d) Hot water systems

2. Supplementary Controllers must comply with Section 2.03, items A, B, C, D, G, H and I with the exception of global type programs and online programming. Supplementary Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides or be located within the DDC system software to electronically override locally on controller display with password.

3. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden. As a minimum, 50% of the point inputs and outputs shall be of the Universal type, allowing for additional system flexibility. In lieu of Universal inputs and outputs, provide a minimum of 50% spare points of each type via additional point termination boards or controllers. A minimum of 12 global points (i.e. chilled water temperature, hot water temperature, etc.) must be able to be accessed through the Supplementary Controller. If global point access is unavailable with the Supplementary then a Master DDC Controller must be furnished.

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

5. Provide each Supplementary Controller with sufficient memory to accommodate point databases, operating programs. All databases and programs shall be stored in non-volatile EEPROM or a minimum of 72-hour battery backup shall be provided. Supplementary Controllers must be fully programmable. All programs shall be field-customized to meet the user's exact control strategy requirements. Supplementary Controllers utilizing pre-packaged or canned programs shall not be acceptable. As an

alternative, provide Master DDC Controllers for all central equipment in order to meet custom control strategy requirements.

6. Programming of Supplementary Controllers shall utilize the same language and code as used by DDC Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide a DDC Controller to meet the specified functionality.

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

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

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

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

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

a) Building Primary Hot Water Supply Temperature

b) Building Primary Chilled Water Supply Temperature

c) Building Common Outside Air Temperature

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

2.5 Custom Programmable Controllers (CPC) and Application Specific Controllers (ASC's)

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

B. Each Custom Programmable Controllers and Application Specific Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network.

C. Each controller shall retain its program, control algorithms, and setpoint information in non-volatile memory such that a power failure of any duration does not necessitate reprogramming of the controller, and it shall return to normal operation upon restoration of power.

D. The controller's setpoints and input/output point data shall be accessible through any operator, portable operator's terminal, or any BC connected to the BAS system.

E. (not used)

F. The controller shall provide the ability to download and upload configuration data, both locally at the controller and via the BAS communications networks.

G. Provide HOA switches for each digital output and label accordingly.

H. Two copies of any programming tool required to configure or program the controllers shall be provided to the Owner along with all appropriate documentation.

I. Controllers used in conditioned ambient space shall be rated for operation at 32°F to 122°F and 5 to 95% RH, non-condensing. Controllers used outdoors shall be rated for operation at -40°F to 140°F and 5 to 95% RH, non-condensing B.

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

K. Unitary Thermostat Controllers (UTC) are NOT permitted due to replacement cost.

L. Custom Programmable Controllers (CPC)

1. Controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Controllers shall be minimum BACnet conformance class 3.

2. Standard BACnet object types supported shall include as a minimum–Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

3. All controllers shall have BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.

4. Stand-alone CPCs shall be provided for, but not limited to, the following types of applications as shown on the drawings: Custom Air Handling Units, Boiler Plant and Chiller Plant.

5. The Custom Programmable Controller (CPC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.
6. The CPC shall include troubleshooting LED indicators or local display.

7. The CPC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the Field LAN or the SA Bus.

8. Each stand-alone controller for major central station systems, i.e., air handling units, heat exchangers, pumping systems, etc., shall have a local display with operator keypad to view/adjust setpoints and start/stop equipment. Provide a means to prevent unauthorized personnel from accessing setpoint adjustments and equipment control functions.

9. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a minimum of one (1) spare outputs of each type. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators.

M. Application Specific - Terminal Equipment Controllers:

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

a) Variable Air Volume (VAV) terminal boxes

b) Constant Air Volume (CAV) terminal boxes

c) Fan Coil Units (FCU)

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs shall be of the universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. In lieu of universal outputs, provide a minimum of one (1) spare outputs of each type via additional point termination boards or controllers. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators. As an alternative, provide DDC Controllers or other ASC's with industry standard outputs for control of all terminal equipment.

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

a) Accuracy: ± 1°F (± 0.6°C)

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

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

d) Set Point Modes:

(1) Independent Heating

(2) Independent Cooling

(3) Night Setback Heating

(4) Night Setback Cooling

e) Calibration Adjustments: None required

f) Installation: Up to 100 ft. from Controller

g) Each room zone sensor thermostat 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.

h) Refer to "Field Devices" section for sensor requirements.

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

5. Provide each terminal equipment controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without

user intervention after a power failure of unlimited duration. Provide un-interruptible power supplies (UPS's) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field- selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of any applications are not acceptable.

6. Fan Coil (FCU) Controllers:

a) As a minimum, shall support the following types of applications for pressure independent terminal control:
(1) Two and four pipe Fan Coil Units

b) Fan Coil Unit Controllers shall support, but not be limited to, the operational sequences as described in the 230993 "Sequence of Operations for HVAC Controls" section of this spec.

c) The modes of operation supported by the Fan Coil Unit Controllers shall minimally include, but not be limited to, the following:

(1) Daily / weekly schedules
(2) Occupancy mode
(3) Unoccupied mode
(4) Temporary override mode

d) At a minimum, Fan Coil Unit Controllers shall support the following types of point inputs and outputs:

(1) Modulated heating and cooling control outputs
(2) Space temperature inputs
(3) Analog space temperature setpoint adjustment inputs

7. Variable Air Volume (VAV) Box Controllers:

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

(1) VAV, with hot water reheat
(2) VAV Zone Damper, with hot water reheat

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

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

Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

d) The VAV controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm (0 to 20.4 m/s) and measurement accuracy of ±5% at 400 to 4000 fpm (2 to 20 m/s), insuring primary air flow conditions shall be controlled and maintained to within ±5% of setpoint at the specified parameters. The BAS contractor shall provide the velocity sensor if required to meet the specified functionality.

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

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

g) The VAV box controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve, 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.

2.6 Portable Operator's Terminal (POT)

A. Provide one (1) portable operator terminal (POT) with a minimum LCD display of 80 characters by 25 lines and a full-featured keyboard and two (2) copies of system software tool. The POT shall be hand-held and plug directly into individual distributed control panels as described below. Provide a user-friendly, English language-prompted interface for quick access to system information, not codes requiring look-up charts.

B. Functionality of the portable operator's terminal connected at any controller:

1. Access all controllers on the network.

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

3. Display all point, selected point and alarm point summaries.

4. Display trending and totalization information.

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

6. Command, change setpoint, enable/disable any system point.

7. Program and load custom control sequences as well as standard energy management programs.

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

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

2. Provide status, setup and control reports.

3. Modify, select and store controller database.

4. Command, change setpoint, enable/disable any controller point.

D. If the same portable operator's terminal cannot be used for both Building Controllers, Advanced Application Controllers and Application Specific Controllers provide separate POT's to accomplish the above functional requirements.

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

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

E. Connection of a POT to a distributed control processor shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.

F. Every workstation or portable operator terminal shall have the required "software keys" for operation.

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

H. The minimum hardware requirements for the Portable Operator Terminal (Laptop) are as follows:

3.0 GHz Intel Centrino Processor
2.0 GB RAM
1 serial and 1 parallel port
4 USB ports
120 GB IDE Hard Drive
15.4" Widescreen SVGA display Internal 10/100 Ethernet N.I.C. port DVD Read/Write Drive
Built-in wireless card, 802.11g compliant
Operating system compatible with current version of Workstation Interface Software (Windows 7)
Integrated keyboard and touchpad
2 Lithium battery packs, 110 VAC adapter/charger 2 type II (or 1 Type III) PCMCIA slots
56 K internal Modem Carrying Case
Three-year limited warranty All Software updates (good through one year after final building acceptance)

2.7 Web-Based Operator Interface

A. Basic Interface Description

1. Graphic user interface shall be provided at the building controller and at the remote JCI ADX monitoring station.

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

a) Graphical viewing and control of environment

b) Scheduling and override of building operations

c) Collection and analysis of historical data

d) Definition and construction of dynamic color graphic displays

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

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

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

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

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

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

(1) Dynamic color graphics and graphic control

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

(3) Time-of-day scheduling

(4) Trend data definition and presentation

(5) Graphic definition

(6) Graphic construction

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

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

a) Customizable such that operators can monitor, command, or edit an application or group of points. An operator can be defined with privileges for access to a building, group or buildings, or areas

(labs-- point names with the designation “lab”), by application: the operator has monitor, command, and edit capability for time of day schedules and calendars (only) for the entire campus: or by function: the operator (i.e. security guard) has ability to view/monitor all areas of the campus and receive alarms, etc.

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

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

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

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

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

a) Start-up or shutdown selected equipment

b) Adjust setpoints

c) Add/modify/delete time programming

d) Enable/disable process execution

e) Lock/unlock alarm reporting for points

f) Enable/disable totalization for points

g) Enable/disable trending for points

h) Override PID loop setpoints

i) Enter temporary override schedules

j) Define holiday schedules

k) Change time/date

l) Automatic daylight savings time adjustments

m) Enter/modify analog alarm limits

n) Enter/modify analog warning limits

o) View limits

p) Enable/disable demand limiting for each meter

q) Enable/disable duty cycle for each load

r) Modify states text

7. Operator shall have ability to schedule reports to print at a pre-specified time and frequency 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 points in the network

b) List of all points currently in alarm

c) List of all points currently in override status

d) List of all disabled points

e) List of all points currently locked out

f) DDC Controller trend overflow warning

g) List all weekly schedules

h) List of holiday programming

i) List of limits and dead bands

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

B. Scheduling

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

a) Weekly schedules

b) Zone schedules

c) Monthly calendars

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

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

4. Monthly calendars for a 24-month period shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the

pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

C. Collection and Analysis of Historical Data

NOTE: Graphics Trending described are intended to describe intent. Exact configuration shall be as allowed within the capabilities of the existing front end software.

1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting.

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

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

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

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

D. Dynamic Color Graphic Displays

NOTE: Graphics described are intended to describe intent. Exact configuration shall be as allowed within the capabilities of the existing front end software. Graphics shall only be created in the SLBAS Johnson Controls server.

1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water systems, room level terminal unit equipment shall be provided by the DDC contractor to optimize system performance analysis and speed alarm recognition.

2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text- based commands.

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

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

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

a) The DDC contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.

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

(1) Define symbols

(2) Position and size symbols

(3) Define background screens

(4) Define connecting lines and curves

(5) Locate, orient and size descriptive text

(6) Define and display colors for all elements

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

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

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

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

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

E. System Configuration and Definition

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

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

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

b) Add/delete/modify operator workstations

c) Add/delete/modify application specific controllers

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

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

f) Add/delete/modify control loops

g) Add/delete/modify energy management applications

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

i) Add/delete/modify totalization for points

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

k) Add/delete/modify custom control processes

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

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

n) Add/delete/modify all operator passwords

o) Add/delete/modify alarm messages

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

a) Libraries of standard application modules such as temperature, humidity and static pressure control may be used as "building blocks" in defining or creating new control sequences. In addition, the user shall have the capability to easily create and archive new modules and control sequences as desired via a word processing type format.

b) Provide a library of standard forms to facilitate definition of point characteristics. Forms shall be self-prompting and incorporate a fill-in- the-blank approach for definition of all parameters. The system shall immediately detect an improper entry and automatically display an error message explaining the nature of the mistake.

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

d) Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Similarly, changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.

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

2.8 Portable Operator Software, Programming and Commissioning

A. Provide hard copies of all programs when University Representative has signed off as complete.

2.9 Field Devices

A. All devices and equipment shall be approved for installation. All devices shall be manufactured by Delta, Automated Logic, Trane, or Johnson Controls.

B. All analog inputs and outputs to/from all items, relating to the monitoring and control of variable speed drives for chilled water, shall be 4-20 MA DC or 0-10 VDC devices, loop- powered, isolated, allowing any single sensor to report identically to multiple systems. Refer to BDS articles 23 05 14 and 26 10 00.3 for design requirements.

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

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

2. Thermostat guards shall be provided where specified, indicated on control diagrams / floor plans and in open dining seating and recreational fitness areas. Guards shall be firmly attached to wall and thermostat cover shall be visible through the guard. All room sensors in open public areas shall have concealed setpoint adjustment.

3. All temperature sensors that serve corridors, dining (seating areas), fitness areas and lobbies shall have temperature sensor that is located behind a flush stainless steel cover. There will be no display, local adjustment or override on these sensors. These sensors will have setpoint adjustment through the BAS only.

4. All room sensors in student rooms, apartments, offices, conference rooms, workshops, upper floor lounges, classrooms, large assembly rooms, floor lounges, kitchen cooking, storage spaces shall have exposed set point adjustments to provide adjustment plus or minus 3 degrees from room setpoint. Setpoint shall be set from the operator's workstation. These sensors shall have override pushbuttons if they are associated with a fan coil or air handling unit system. Remote adjustment shall be able to be locked out at the operator's workstation. Due to the cost of replacement, thermostats and space temperature sensors that contain I/O controllers are not permitted.

5. Temperature sensors mounted on exterior walls shall be installed on an insulated base to prevent false reading of the exterior wall temperature.

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

7. Duct Sensors: DDC duct sensors shall match the requirements of the associated controller incorporating an electrical signal to insure exact and proportional relationship between the measured

variable and the transmitted signal. Static pressure sensors shall be mounted in temperature control panels with connecting sensor lines in hard copper. Where a device is used for sensing of Mixed Air Temperature or Preheat applications and the duct area is in excess of 24 square feet the instrument shall incorporate a capillary averaging element with a minimum length of 96 inches or a suitable array of duct sensors wired as a single input. Averaging sensors shall be used on any duct application where duct area exceeds 24 square feet.

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

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

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

F. Control Dampers (Multiple Blade Dampers): Automatic dampers shall be single blade or multiple blades as applicable. All dampers are to be sized to the application by the manufacturer using methods similar to control valve sizing. Dampers other than those within air handling units are to be installed by the HVAC Contractor under the supervision of the Temperature Control Contractor. All dampers furnished by air handling unit manufacturers must meet the requirements listed in this section. Manufacturer's catalog information shall be de-rated 50 percent for application to provide positioning of the dampers. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the HVAC Contractor. All damper frames are to be constructed of extruded aluminum hat channel with a 0.125" minimum wall thickness and shall have flanges for duct mounting. Damper blades shall not exceed 6 inches width. All blades are to be airfoil type construction in ducts with air velocities above 1500 FPM and will be equal to Ruskin CD 50 control dampers with blade and jamb seals. Blades are to be suitable for high velocity performance. All damper bearings are to be made of nylon. Bushings that turn in the bearings are to be oil impregnated sintered metal. Dampers hung with blades mounted vertically shall be provided with thrust bearings. Butyl rubber seals are to be installed along the top and bottom of the frame and along each blade edge. Independent, self-compensating, stainless steel end seals shall be installed to insure minimum leakage between blade ends and damper frame. Seals shall provide a tight closing low leakage damper. Damper sections shall not exceed 48" in length or 12 sq. ft. and shall have minimum of one operator per damper section. All dampers in modulating applications shall have opposed blades. Where sequence requires, submittals shall include damper sizes and leakage characteristics. Leakage shall not exceed 3 cfm/sq. ft. at 1" of static pressure and shall be AMCA licensed as a Class 1A damper. Outboard shaft supports with nylon bearings shall be provided at all damper operator connection points to prevent shaft deflection.

1. Control dampers used for outside air, relief air, or exhaust air applications shall be thermally insulated type, equal to TAMCO 9000 series, and shall be installed a minimum of 6" away from wall penetrations to allow for external mounting of their respective damper motors. Jack-shafting in these applications will only be allowed to prevent having to mount motors in the outside airstream. When internal damper motor mounting is required the sheet metal contractor shall provide access panels at each motor location to allow for ease of service. Provide in-line coalescing filters for pneumatic lines exposed to freezing air.

G. Automatic Control Valves: General Design – Hydronic control valves shall be either equal percentage plug type or characterized ball type (note: plate and frame auto control valves may be butterfly type, as noted on the drawings). Unless noted otherwise, automatic control valves shall be constructed for 125 lb. WSP, with stainless steel stem, brass trim, Teflon or other suitable packing and replaceable or renewable seats. Valve bodies 2" and smaller shall be all bronze with screwed, sweat or flared ends, and larger valves cast iron body with flanged ends. The characterized ball type shall be specifically designed for modulating hydronic service, ANSI Class 125 working pressure, 0°F - 250°F

operating range, stainless steel ball and stem, tested per MSS SP-72 and rated for 200,000 cycles, ISO 9001 compliant. Electric actuation on hydronic valves. All valves are to be sized by the Control Contractor and shall submit pressure drop calculations and guarantee sufficient size to meet the requirements of the equipment being served. Actuators shall be selected and furnished to be of sufficient size to position the valve stem at all positions under all static and dynamic forces within the piping system, e.g., must fully close plus fully open upon any and all system conditions. Select the largest available actuator optionally available for that valve and valve size. BLX positioners are prohibited. Positioning relays shall be furnished for all normally closed valve applications.

1. Hot water control valves shall close off against a pressure of 75 PSID. Chilled water control valves shall close off against a pressure of 75 PSID.

Air handling hot water coils shall fail open to coil. Air handling chilled water coils shall fail closed to coil.

2. Reheat valves controlled by Application Specific Controllers shall utilize floating point electronic actuation. Controllers shall have declutching mechanism to allow manual positioning of valve.

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

4. Butterfly valves for air handling unit coil control are unacceptable. If high GPM requirements dictate the valve size to be greater than 6", then Temperature Control contractor shall provide two control valves for the application, and the HVAC Contractor shall install the two control valves, for parallel and/or sequenced operation. Two position “isolation” valves shall be bubble tight butterfly valves rated for dead end service.

5. The actuator on these valves shall have position indicator and manual override with a hand wheel operator. These are used on the district chilled water piping, boilers and heat exchangers as indicated on the drawings.

District chiller water valves shall close off against a pressure of 125 PSID. The other isolation valves shall close off against a pressure of 75 PSID.

H. Air Volume Measurement: Air flow measuring stations will be provided on supply air, return air and outside air of air handling units, utilizing electronic air flow traverse probes and transmitters designed to continuously monitor duct airflow volume or fan inlet volume. Each outside air airflow station shall have an auto-zeroing function, temperature compensation, and a digital cfm readout on the face. Each airflow measurement system will consist of single or multiple probes with velocity measuring sensors. Minimum accuracy for outside air airflow stations shall be 2% of reading with a field installed system accuracy of 5% or better, through a velocity range of 150 to 2500 fpm. Minimum accuracy for fan inlet airflow stations shall be 2% of reading or better, through a velocity range of 1000 to 8000 fpm. Each sensor will utilize the principle of vortex shedding or precision thermistor technology with temperature compensation. Signal amplifying sensors requiring flow corrections for field calibration are not acceptable. Airflow measuring stations shall be Ebtron Gold Series or Paragon Controls. Warranty of equipment including parts and labor will be for a period of two years. Provide access doors to allow visual inspection of airflow monitor if not accessible through the air handling unit or plenum.

Piezo airflow measuring tube will be furnished on the AHU and MUA supply and exhaust fans. Provide a DP sensor to monitor flow on each fan.

I. Smoke detectors are installed by the HVAC Contractor and furnished and wired by the Electrical Contractor.

J. Air static and velocity pressure transmitter: The pressure transmitter shall be used for measuring duct static or velocity pressure in variable air volume fan systems. Duct static pressure sensor shall be pitot-tube type with stainless steel pressure tip. Transmitter shall be equal to Dwyer Series 676.

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

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

M. Fan and Pump Proof: Proof points for air handling unit fans, exhausts fans and pumps will be accomplished through the use of current sensing relays at the motor control center or VFD's / motor starters. Current sensing relays shall be split-core design, for installation over any single power lead. Current sensing relays shall include field adjustable set screw for amperage setpoint adjustment, and shall include integral LED status light to locally indicate the "on" and "off" condition. Current sensing relays for motors on VFD's shall be designed for VFD applications, and shall be installed to read regardless of the position of the VFD H-O-A switch.

N. Carbon Dioxide Sensors

1. Carbon dioxide sensors shall be duct mounted non-dispersive infrared transmitters. Sensors shall include a relay with N.O. and N.C. output contacts, either a 4-20 MA or 0-10 VDC analog output, and angled display to indicate concentrations at the sensor.

Sensors shall be capable of measuring levels from 0-2000 PPM with an accuracy of 75 PPM in an operating temperature range of 32°F to 122°F and a relative humidity of 0 to 99% non-condensing. Sensors shall operate on 24 volt AC 2.5 watt single phase power.

2. Main sampling sensor shall be mounted in PCT enclosure with pump. Extend sampling tubes to exterior.

3. Typical Sensors:

a. Manufacturer and Model No. - Vulcain 90DM3ADT

b. Main Sampling Station: Manufacturer and Model No. - Vulcain 90DM4 with PCT enclosure.

O. Carbon Monoxide Sensors

1. CO sensors shall be surface mounted in loading dock according to manufacturer's recommendations. The sensor shall have a 4-20 MA or 0-10 VDC output. Sensors shall be capable of operation in an ambient of 0°F to 100°F. Minimum accuracy of 3% across range of 0 to 500 PPM.

2. Manufacturer and Model No. - Vulcain VA20IT Q1CO

P. Point Water Detector

1. Point water detectors shall be BAPI BA/LDT1-PS-BB for mechanical rooms and Windland WB-200 for elevator pits. Unit shall have supervised operation and be suitable for floor mounting.

Q. Heat Tracing System

1. The following systems shall be heat traced for freeze protection:

a) Commercial Kitchen - condensate piping in Walk in Freezers.

b) Commercial Kitchen - Exterior fryer oil piping (supply and return) at loading dock.

c) Make up air units – chilled water piping above the roof that is not in a heated enclosure.

2. The system shall be engineered by Raychem and shall include, but not limited to, Raychem XL-TRACE self-regulating plastic insulated resistance cables having heating density as recommended by the manufacturer for the application, power distribution panel containing ground fault circuit breakers, one or more electronic monitoring panels that monitors each heat trace circuit's the ground fault status and the integrity of the heat trace circuit (high and low current) and shall include contacts for remote monitoring thru the B.A.S.

The Power Distribution Panel shall be equal to Tyco Thermal Controls DigiTrace HTPG with 40 amp 208-volt 3-phase main breaker. Individual heat tracing circuits shall be 120-1 phase. Locate the Panel inside the building and in a location that is serviceable.

3. Installation shall be in strict accordance with the manufacturer's recommendations, including wrapping with insulating tape. The ATC shall extend power from the emergency power panel. All control, wiring, transformers, etc.…shall be included in the ATC contract.

2.10 Differential Pressure Transmitters

A. Differential pressure transmitters shall be diaphragm operated. Veris or Setra

B. Wiring terminals and electronics shall be in separate compartments, so the electronics remain sealed during installation. Reverse polarity protection shall be included to keep wiring mishaps from damaging the transmitter.

C. Transmitter output shall be a 4-20 mA or DC voltage signal, linear over the transmitter span, and the transmitter range shall be selected for the application and shall not exceed the nominal system working pressure of 50% minimum.

D. Differential pressure transmitters shall meet or exceed the following specifications:
1. Minimum accuracy shall be +/- 1% of calibrated span.
2. Damping: Adjustable time constant.
3. Calibration: Zero point and span adjustable to within 0.5% of full span.
4. Housing: Carbon steel or aluminum, NEMA 4 f. Over-range Limit: 200% of transmitter range 4.
5. Includes combined effects of linearity, hysteresis and repeatability. Stability shall be +/- .25% of upper range limit for six months. No internal mechanical linkages shall be used in the transmitter(s).

E. Transmitters shall be furnished with a 3-valve balancing manifold, as a complete assembly.

F. The DP transmitter shall be hard-wired to the system controller directly, and shall control the pumps. These analog values shall not be passed across the B.A.S. Network, and the closed-loop control of pump speed shall not occur over the B.A.S. Network.

PART 3 - EXECUTION

3.1 On-Site Testing

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

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

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

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

User_ Date A/E_ Date

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

User_ Date A/E_ Date

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

User_ Date A/E_ Date

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

User_ Date A/E_ Date

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

User_ Date A/E_ Date

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

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

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

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

User_ Date A/E_ Date

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

User_ Date A/E_ Date

3.2 Service and Guarantee

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

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

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

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

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

3.3 Training

A. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 7:00 a.m. to 3:30 p.m. weekdays as follows:

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

1. Explanation of drawings, operations and maintenance manuals

2. Walk-thru of the job to locate control components

3. Operator workstation and peripherals

4. Building Controller, Advanced Application Controller and ASC operation/function

5. Operator control functions including graphic generation and field panel programming

6. Operation of portable operator's terminal

7. Explanation of adjustment, calibration and replacement procedures

C. Provide 24 hours of additional training for a period of one year from final completion of the project.

D. Provide 8 hours of A/E-directed engineering labor per each building.

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

F. The DDC contractor shall work with the commissioning team to identify and complete the graphics programming (input and output) that will be required for the DDC system. The DDC system shall have the ability to link into the video and audio equipment for use with the DDC system. Training videos are intended to be part of the overall system.

G. The DDC contractor shall work with the commissioning team to provide the materials in a format that will become part of the training for OSU personnel.

3.4 Controller and Point Naming

Controllers shall be named using the building name, followed by equipment type, followed by the location (e.g.-Scott Hall, FCU, Rm 289)

The physical and virtual (pseudo) point naming convention has been standardized and in most cases will follow the pattern of designators as listed below.
A meeting between OSU SL BAS and the control contractor shall be scheduled to confirm point naming.

The first character is the type of mechanical system

Ahu = Air (Handler)
C = (Main) Cooling (Chiller System) Z = Zone
H = (Main) Heating (System) Rh = Reheat
RH = Relative Humidity D = Domestic
Rad = Fin Tube (Radiation) Ph = Preheat
Ch = Chilled
Con = Condenser P = Primary
S = Secondary E = Exhaust
The second character is the system or equipment number (used even if only one in group). Numbers only (no letters)

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- 99

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

SW-T = Supply Water Temp RW-T = Return Water Temp. P1-C = Pump #01 Start/Stop
P1-S = Pump #01 Status or Proof CD-SP = Cold Deck Setpoint
HD-O = Hot Deck Output
SF1-C = First or only Supply Fan Start/Stop RF2-S = Second Return Fan Status
SF1-V = First or only Supply Fan Velocity

3.5 Commissioning

The ATC Contractor shall take special care in reviewing and studying the Commissioning Specification 01 91 13 with regard to additional responsibilities and duties.

3.6 Testing and Acceptance

A. The DDC system shall be tested for acceptance by the commissioning team by providing operation of the DDC system for 120 continuous hours during which there shall be no major malfunction of the DDC system (major system failure requires a retest). Any other failures during the test shall be identified and an action plan developed to fix and retest that part (this does not require a full retest). This test shall begin upon the completion of the commissioning functional testing and the resolution of identified issues. The entire commissioning team shall approve commencement of the 120 hour tests. Upon completion and acceptance of this test, the DDC system warranty period can begin.

3.7 Record Program CD copy

A. After commissioning, testing and acceptance and final adjustments the ATC shall burn a CD and a USB flash drive of the DDC building programs and turn this over to OSU SL BAS. Disk shall identify the building Name and date of backup.

2.5 N, Steam Desuperheater Control:

Provide a modular controller with associated input/output modules and touch-screen display mounted in a panel located in
an area not subjected to high temperature or relative humidity. Desuperheater control valve shall be as described in Division 23 for medium pressure steam service and shall have electro-pneumatic positioner and Class V shutoff. Provide high temperature sensor and transmitter.

Sensor:
Sensor Type 1000 Ohm +/- 0.1% @ 32 F Temperature Coefficient 0.00375 Ohm/Ohm/Degree C
Sensitivity 2.1 Ohm/F @ 32 F
Measurement Range -58 F to 932 F
Probe Material 304 Stainless Steel
Wiring Terminations Two-wire nickel coated stranded copper, 24 inch long 22 AWG fiberglass insulated
Warranty 3 years
Model Number S241HC (Minco, or equivalent)

Transmitter:
Supply Voltage 8.5 – 35 VDC unregulated
Sensor Input 1000 Ohm platinum 0.00375 Ohm/Ohm/Degree C
Measurement Range 0 F to 800 F
Signal Output 4 – 20 mA
Maximum Output Impedance 775 Ohm +/- 0.1% @ 24 VDC min Accuracy Calibration accuracy +/- 0.05% of span
Operating Temperature -58 F to 160 F Well Operating Pressure 3000 PSIG max

Well Material 304 Stainless Steel
Warranty 3 years
Model Number TT111H-0800 (Minco, or equivalent) Provide the following inputs and outputs:
Desuperheater Control Valve Analog Output
Desuperheater Pump 1 Status Binary Input
Desuperheater Pump 2 Status Binary Input Desuperheated Steam Temperature Analog Input

Desuperheater control valve shall modulate to maintain steam temperature at 15 F above saturation temperature. Provide alarm for high temperature and pump failure.

Desuperheater pump package will be controlled by its own microprocessor controller.

END OF STUDENT LIFE APPENDIX A-SL