SECTION 230900 – BUILDING AUTOMATION SYSTEM – RENOVATION PROJECT
Latest Update: 10-28-2024 See Underlined Text for Edits
(Engineer shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating Equipment and/or Material Model Numbers indicated in the specifications and adding any additional specifications that may be required by the project. Also turn off "Underlines".)

PART 1 – GENERAL

1.1   RELATED DOCUMENTS

A.   Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2   SUMMARY

A.   This section includes the requirements for the BAS System for renovation projects and includes labor, materials, tools, equipment, transportation, insurance, temporary protection, supervision and incidental items essential for proper installation and operation, even though not specifically mentioned or indicated on the drawings but which are usually provided or are essential for proper installation and operation of systems related to this Section, as indicated on the drawings and specified herein.

B.   The specifications and drawings describe the minimum requirements for the installation of work, for automation systems and for equipment shown on the drawings.

C.   The Building Automation System (BAS) shall include the following systems:
      <Edit for Project>
      1.   Automatic Temperature Control (ATC)
      2.   Laboratory Pressurization Control (LPCS) – BSL3 Laboratory
      3.   University Utility Management System
      4.   Low Voltage Lighting Control Interface to CCMS

1.3   REFERENCES

A.   Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B.   Material standards shall be as specified or detailed hereinafter and as follows:

      1.   NFPA 70 – National Electric Code, latest edition adapted by the State of Maryland.
      2.   UL-916 – Energy Management Systems.
      3.   UL-873 – Temperature Indication and Regulating Equipment.
      4.   FCC; Part 15, Subpart J – Class A computing Equipment.
      5.   UL-864 – Fire and Smoke Control.

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1.4   ACTION SUBMITTALS

A.   Product Data: Provide data for each system component and software module.

1.   See Division 01 – "Submittal Procedures" for requirements.

B.   Shop Drawings:

1.   Shop drawings shall have clearly marked the appropriate specification number or drawing designation, for identification of the submittal.
2.   Disposition of shop drawings shall not relieve the Contractor from the responsibility for deviations from the drawings or specifications, unless he has submitted in writing a letter itemizing or calling attention to such deviations at time of submission and secured written approval from the University's Representative, nor shall such disposition of shop drawings relieve the Contractor from responsibility for error in shop drawings or schedules.
3.   Shop drawings shall include, but shall not be limited to, the following:

a.   Control drawings with detailed piping and wiring diagrams, including bill of material and sequence of operation for automation systems and interfaces with other manufacturers' package systems and BAS.
b.   Panel layouts and nameplate lists for local and central panels.
c.   Valve and damper schedules showing size, configuration, capacity and location of equipment.
d.   Data sheets for all control system components.
e.   Control strategies (software programs) must be included within the second shop drawing submittal. The listing of each strategy must be in English and demonstrate the desired sequence of operation. Submittal must be complete with proposed schedules, listing of setpoints and end device point listing and addresses.

1.5   INFORMATIONAL SUBMITTAL

A.   Manufacturer's Installation Instructions: Indicate manufacturer's installation instructions for manufactured components.

1.6   CLOSEOUT SUBMITTAL

A.   Project Record Documents: Record actual locations of control components, including control units, thermostats and sensors.

1.   Revise shop drawings to reflect actual installation and operating sequences.
2.   Include submittals data in final "Record Documents" form.

B.   Operations and Maintenance Data: Include a copy of the final approved submittal for each product in the operation and maintenance manuals.

1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Include inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.

C. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in University's name and registered with manufacturer.

1.7 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum ten (10) years of documented experience.

B. Installer: Company specializing in executing the scope of work specified in this section with minimum ten (10) years of documented experience and approved by the BAS manufacturer.

C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. and testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.8 MAINTENANCE SERVICE

A. Provide service and maintenance of energy management and control systems for two (2) year from Date of Substantial Completion.

B. Provide two (2) complete inspections during the two (2) years; one (1) in each season, to inspect, calibrate and tune controls as required and submit written reports.

1.9 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software, the University and the party providing the software shall enter into a software license agreement with provisions for the following:

1. Limiting use of software to equipment provided under these specifications.
2. Limiting copying.
3. Preserving confidentiality.
4. Prohibiting transfer to a third party.

1.10 SYSTEM DESCRIPTION <Edit for Project>

A. Furnish and install and program a total building management automation and automatic temperature control system, hereinafter referred to as the BAS, as manufactured by their

corporation. In addition, the BAS Manufacturer shall be responsible for providing the interface with the Laboratory Pressurization Control System specified.

B.   The system components shall be as follows:

Device	Type

1.   Supply Air Terminal Boxes/Valves

a.	Logic	DDC
b.	Hot Water Valve(s)	Electronic
c.	Damper Actuator	Electronic

2.   Exhaust Terminal Boxes

a.	Logic	DDC
b.	Damper Actuation	Electronic

3.   Fume Hood Exhaust Terminal Boxes

a.	Logic	DDC
b.	Damper Actuation	Electronic
c.	FH Alarm	Electronic

4.   Chilled Beam Units

a.	Logic	DDC
b.	Damper Actuation	Electronic
c.	Control Valves	Electronic

5.   Fan Coil Units/Unit Heaters/Cabinet Heaters

a.	Logic	DDC
b.	Valve Actuation	Electronic
c.	Fan Status	DDC

6.   Convectors

a.	Logic	DDC
b.	Valve Actuation	Electronic

7.   Computer/NMR Room Air Handling Units

a.	Logic	Integral by Unit Manufacturer
b.	Actuation	Electronic

8.   Supplemental A/C Units

a.   Logic   Integral by Unit Manufacturer
b.   Actuation   Electronic

C.   Microprocessor components shall be as manufactured or approved by the BAS Manufacturer. Control system shall be installed by competent control mechanics, electricians and technicians regularly employed by the BAS contractor.

D.   Provide electric wiring and connections as required for all systems, including the general lab room control and BSL-3 Laboratory control.

E.   The BAS manufacturer shall be responsible for the coordination, of systems or equipment provided by others that interface with the BAS System.

F.   Review all HVAC drawings and the specifications to understand equipment and system operations and to verify quantities and types of dampers, operators, alarms, sensors and monitors. Numerous references to the BAS are made throughout this specification identifying work to be performed under this Section, in addition to work specifically indicated herein.

G.   Except as otherwise noted, the control system provided shall consist of microprocessors, transmission network, digital system controllers, central monitoring and control system I/O devices, software, sensors, transducers, relays, thermostats, dampers, damper operators, PE and EP switches, control panels, [dryer], [filter], [drains], [air pressure reducing stations], [compressed air supply piping] and other accessory equipment, along with a complete system of electrical interlocking wiring [and pneumatic tubing] to fill the intent of the specification and provide for a complete and operable system. All control equipment shall be fully proportioning. Except as otherwise specified, provide operators for equipment such as dampers, where such operators are not required to be provided by the equipment manufacturers. <Edit for Project>

H.   Interlock wiring and installation of control devices associated with the air handling units, pumps, etc., shall be provided under this Section. When the DDC system is fully installed and operational, the BAS manufacturer, Contractor and University's Representative will review the operation and check out the system. At this time the BAS Manufacturer and Contractor shall demonstrate to all present the operation of the system and prove that it complies with the intent of the drawings and specifications.

I.   The BAS scope of work shall include the following:

1.   Building Automation System commissioning and acceptance procedures.
2.   Equipment labels and graphic designations.
3.   Operation and maintenance manuals.
4.   Instructional classes on equipment and systems operation for University's facilities personnel.
5.   Testing of systems.

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J.   System Overview: <Edit Paragraph for Project Requirements>

1.   The Building Automation System shall be capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management, and historical data collection and archiving.

2.   The Building Automation System (BAS) shall consist of the following:

    a.   Air terminal box controllers (ATBC).
    b.   Communication transmission network (hard-wired topography).
    c.   Power wiring, pneumatic tubing, temperature control, and remote monitoring and reset of the integrated Laboratory Pressurization Control System (LPCS).
    d.   Operator workstations.

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

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

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

6.   Workstation/DDC Panel Support:

    a.   Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.

7.   Dynamic Data Access:

    a.   Operator devices, either network resident or connected via dial-up modems, shall have the ability to access point status and application report data, or execute control functions for any other devices via the local area network. Access to data shall be based upon logical identification of building equipment.
    b.   Access to system data shall not be restricted by the hardware configuration of the building automation system. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.

8.   General Network Design:

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a.   Network design shall include the following provisions:

1)   High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices. The minimum baud rate shall be 19,200.

2)   Support of any combination of controllers, and operator workstations directly connected to the local area network. A minimum of fifty (50) devices shall be supported on a single local area network.

3)   Detection and accommodation of single or multiple failures of either workstations, DDC panels or the network media. The network shall include provisions for automatically reconfiguring itself to allow operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

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

5)   Error detection, correction, and retransmission to guarantee data integrity.

6)   Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

7)   Commonly available, multiple sourced, networking components and protocols shall be used to allow the BAS to coexist with other networking applications such as office automation. ETHERNET and Siemens Protocol II are campus standard technologies.

8)   Use of an industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst case network loading.

9)   Synchronization of the real-time clocks in all DDC panels.

9.   System Configuration/Architecture:

a.   In general, the actual number of stand-alone DDC panel(s) shall be determined by the actual, "realistic" point capacity of each panel's capacity.

b.   As a minimum, each supply air handling unit (AHU) shall be equipped with one stand-alone DDC panel.

10.   Existing Central Control and Monitoring System:

a.   The Existing Central Control Monitoring System (CCMS) for UMB's Campus operates on software developed by Siemens and/or Johnson Controls. Modifications to the Building Automation System (BAS) shall be an extension of and integration into one of these CCMS Systems as directed by UMB.

b.   The existing CCMS shall be expanded to include all CCMS workstations, software and connected field panels for this project.

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c.   The BAS contractor shall provide any upgrades or software revisions necessary and/or available at the time of connection of this project to bring the entire venders CCMS up to current product and software offering. The BAS contractor shall provide training and documentation on any new software revisions, their operation and functionality prior to implementation.

d.   It is the intent of this specification the manufacture, provide their current GUI application software and server/client hardware for the main CCMS system during the construction of the Dental School project and connect this project to that system.

e.   Providing a third system is not acceptable.

11.   Existing University Utility Management System:

a.   The existing Utility Management System server resides in the Facilities Operations Center. This system utilizes the Universities wide area network to gather and process data supplied by utility meters and chiller plants sensors connected to the Campus Chilled Water Loop.

b.   The BAS Contractor shall expand the Utility Management System (UMS) to include the data points on the Input/Output Summary identified as "Connected to Existing Utility Management System".

12.   Agency Approvals:

a.   The entire control system shall be UL approved and listed (UL-916 Energy Management and UL-864 Fire Control) for serial interface between the Building Automation System and Fire Alarm System.

1.11   INCIDENTAL WORK SPECIFIED IN OTHER SECTIONS

A.   Work specified in the mechanical specifications:

1.   Install automatic temperature control valves furnished by BAS Manufacturer.
2.   Install pressure taps and sensing wells furnished by BAS Manufacturer.
3.   Install steam, hot water, and chilled water meters furnished by BAS Manufacturer.
4.   Provide access doors in ductwork as required for access to control equipment.
5.   Furnish access panels for installation in walls and ceiling as required for access to concealed control equipment.

B.   Work specified in the electrical specifications:

1.   Provide power wiring to junction boxes (one 120V/20A circuit per junction box) located above ceiling and as indicated on the electrical drawings. Power wiring from these junction boxes to DDC panels, terminal box controllers, laboratory pressurization control panels, sensors, and monitors shall be as specified in this section.

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2. Provide H.O.A. switches at the Fire Command Center for interface with the smoke control/evacuation sequence of operation as specified in this section.
3. Provide power wiring as indicated on the Electrical Drawings.

1.12   ELECTRICAL WIRING (BAS)

A. Electric wiring, wiring connections and interlock wiring required for the installation of the building automation system, as herein specified, shall be provided as specified in this section, unless specifically shown on the Electrical drawings or called for in the Electrical specifications. Electrical power requirements, including junction boxes, for all BAS control devices and equipment shall be provided by the electrical contractor as indicated on the electrical drawing and in the electrical specifications. Extension of power wiring from junction boxes to control devices shall be provided by the BAS contractor.

B. Coordinate necessary auxiliary contacts on magnetic starters with the requirements in the electrical specifications.

C. Furnish labor and material to install the necessary wiring to accomplish the successful and complete operation of the new automation system (DDC).

D. Furnish labor and material to install necessary relays, general purpose enclosures and appurtenances to control designated devices relative to the BAS.

E. Wiring throughout shall be concealed where possible.

F. Conduit used shall be EMT, three quarter (3/4) inch minimum size. Conduit sizes shall be large enough to permit the individual conductors to be readily installed or withdrawn without damage to the conductors or their insulation. Splicing of wires will be permitted only in junction boxes or pull boxes.

G. Conduit is never to be relied upon for a fault current and safety ground return conductor.

H. The ground system must never be used as a current carrying conductor except for faults and noise suppression. The stand-alone DDC panel grounding system shall be used to control noise and transients which might affect the operation of the automation system. As such, the ground requirements are in excess of a grounding system used solely for minimum physical protection.

I. The bond to ground shall be as short as possible. A ground point shall be derated by one (1) point (in order of preference) for each fifty (50) feet of conductor run between it and the automation equipment to be grounded. Therefore, a water pipe bond located ten (10) feet away will be preferable to a structural steel bond located one hundred fifty (150) feet away.

J. Set screw connectors shall be galvanized or plated steel. White metal cast type will not be permitted.

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K.   Flexible conduit shall be used at field devices, including, pressure switches, flow switches and temperature sensors. Convolutions shall be steel, interlocked continuously. Aluminum will not be permitted. "Liquidtight" or equal shall be used in wet locations.

L.   Only core drilling is permitted to pierce the floors in the electrical closets and elsewhere. The use of water for drilling shall be controlled by a suitable vacuum system, using proper dams to prevent damage to floors below.

M.   Low voltage wiring in exposed areas, outside air plenums, mechanical/electrical rooms and areas which may be subject to mechanical abuse shall be run in EMT or as noted below:

1.   Sensor to Panel (Stud Wall)   EMT in Wall
2.   Sensor to Panel (Cable Tray)   In Cable Tray
3.   Sensor to Panel (Mechanical Room)   In New Conduit/EMT
4.   Panel to Operator Workstation
      within New Building   In New Conduit/EMT

N.   Wiring:

1.   Control wiring, low voltage, 20 AWG pair
2.   Control wiring, 120VAC, 14 AWG pair
3.   Local area network, LAN, 18 AWG twisted shielded pair
4.   Building network, 24 AWG, pair, low capacitance type

O.   Low voltage wiring not used for life safety/smoke control applications, above suspended ceilings and in accessible concealed areas may be plenum rated cable.

P.   Wiring used for life safety/smoke control shall be in EMT or flexible metal clad conduit. Air handling unit and stair pressurization fan controls, including wiring from Fire Command Center to AHU control panel shall be in EMT.

Q.   Do not permit the shield from different signal cables to come in contact with each other and make sure that adequate isolation and insulation have been provided.

R.   Transmission Network:

1.   Network Configuration: The network configuration shall be a hardwired topography.
2.   System Capabilities: The new network shall be 100% compatible with a hardwired based network. No additional or third party software bridges shall be required.
3.   Server Client Network shall use UM CCMS, CFMS wide area network for connection of the building workstation to the server at the operation centers.
4.   Use CCMS, CFMS wide area network for connection of field panels to network server.

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5.   The UMS shall use the CFMS wide area network to communicate to the UMS server located in the Operations Center. Provide all field data gathering panels and data points necessary to meet the Input/output summary and sequence of operation.

S.   At every DDC control panel, application specific controller, and terminal unit controller (such as CV boxes, FCU's, etc.) provide a low voltage toggle-type disconnect switch in the incoming 24 VAC service line. Switch to be mounted in a junction box.

T.   Provide Uninterrupted Power Source (UPS) at work stations and field panels.

1.13   BSL-3 LABORATORY

A.   All Contractors shall take special care to tightly seal and caulk all penetrations of walls surrounding and within the BSL-3 Laboratory. All thermostat sensors shall have their wiring entrance point caulked so that negative pressure air is not drawn into the back side of the thermostat and provide inaccurate space readings. <Delete if not Required>

1.14   WARRANTY/GUARANTEE

A.   See Division 23 Specification Section "Basic Mechanical Requirements – HVAC" for warranty and guarantee requirements.

B.   Furnish to the University a written guarantee for field programmable microprocessor based units against all defects in materials and workmanship, including without limitation against hardware failure for two (2) years from date of acceptance. Guarantee shall include all parts and labor. See Division 01, Guarantees, Warranties, Bonds, Service and Maintenance Contracts, for submittal form.

PART 2 – PRODUCTS

2.1   GENERAL PRODUCT REQUIREMENTS

A.   Equipment Design and Selection: All BAS equipment and accessories shall be designed and selected, for the intended use, in accordance with the scheduled capacities on the drawings and the requirements of this specification.

B.   Replacement of Existing Field Panels: Where existing field panels are considered obsolete/retired (building controllers, equipment controllers, and floor level network controllers), the BAS contractor shall include in his bid the cost to replace the existing obsolete/retired field panels with new field panels. The cost shall include all modifications to the graphics and programming resulting from this change. The obsolete/retired field panels are located in

<UMB to provide the panel ID and location for each panel in the project area to the engineer>

C. The BAS manufacturer and installer shall be Siemens Building Technologies. <u>No other manufacturers will be acceptable.</u>

2.2   SOFTWARE

A. General: Provide all necessary software to form a complete operating system as described in this specification. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description:

1. Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms:

a. Two (2) Position Control
b. Proportional Control
c. Proportional plus Integral Control
d. Proportional, Integral, plus Derivative Control
e. Automatic Control Loop Tuning

2. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one (1) hour period.
3. Heavy Equipment Delays: 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. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of controlled equipment, compare it with normal occupancy scheduling, and turn the preselected equipment on or off as necessary in a staggered/time-delayed manner to avoid excess electrical surge. The remainder of the equipment will not automatically start. The system will print out the assigned status of the equipment on the alarm printer. The system shall require a manual command to start any equipment.
5. 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.
6. The system shall be provided complete with 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
e. Add/delete/modify alarm reporting definition for points
f. Add/delete/modify control loops

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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

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

a.   Field Panel Programs shall be manufacturers' standard line program method.
b.   Inputs and outputs for any process shall not be restricted to a single DDC Controller. Each Controller shall be able to include data from 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).
c.   Provide the capability to backup and store system databases on the workstation hard disk. In addition, 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.
d.   Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

C.   Energy Management Applications: DDC Panels shall have the ability to perform any or all of the following energy management routines:

1.   Time of Day Scheduling
2.   Calendar Based Scheduling
3.   Holiday Scheduling
4.   Temporary Schedule Overrides
5.   Optimal Start
6.   Optimal Stop
7.   Optimal Stop
8.   Night Setback Control
9.   Peak Demand Limiting
10. Temperature Compensated Load Rolling
11. Variable frequency drive/CFM Control

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12.   Heating/Cooling Interlock
13.   Discharge Air Temperature Reset Based Optimized Reheat Coil Positions and Maximum Space Humidity Setpoint
14.   Hot Water Reset
15.   Chilled Water Reset

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

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

         a.   Any system-measured point data or status
         b.   Any calculated data
         c.   Any results from other processes
         d.   User-Defined Constants
         e.   Arithmetic functions (+,-,*,/, square root, exp, etc.)
         f.   Boolean logic operators (and, or, exclusive or, etc.)
         g.   On-delay/Off-delay/One-shot timers

     2.   Process Triggers: 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.   Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from other DDC panels on the local area network. In addition, a single process shall be able to issue commands to points in other DDC panels on the local area network.
     4.   Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer or pager.
     5.   Custom Process Documentation: The custom control programming feature shall be self-documenting. All interrelationships defined by this feature shall be documented via graphic flow charts and English language descriptors.

E.   Alarm Management: Alarm management shall be provided to monitor, print, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform

distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

1. Point Change Report Description: Alarm or point change reports shall include the point's English language description and the time and date of occurrence.
2. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three (3) priority levels shall be provided. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.
3. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PC's used for archiving alarm information.

    a. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

4. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a two hundred (200) character alarm message for each system point to more fully describe the alarm condition or direct operator response. Each stand-alone DDC panel shall be capable of storing a library of at least two hundred fifty (250) alarm messages. Each message may be assignable to any number of points in the panel.

F. Historical Data and Trend Analysis: A variety of Historical data collection utilities shall be provided to automatically sample, store, and display system data in the following ways.

1. Continuous Point Histories: Stand-alone DDC panels shall store Point History Files for analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of analog inputs at half hour intervals. Samples for points shall be stored for the past twenty four (24) hours to allow the user to immediately analyze equipment performance and problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten (10) status changes or commands for each point.
2. Control Loop Performance Trends: Stand-alone DDC panels shall also provide high resolution sampling capability with an operator-adjustable resolution of ten (10) to three hundred (300) seconds in one (1) second increments for verification of control loop performance.
3. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting

operator-specified performance data over extended periods of time. Sample intervals of one (1) minute to two (2) hours, in one (1) minute intervals, shall be provided. Each stand-alone DDC panel shall have a dedicated buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.

    4.   Data Storage and Archiving: Trend data shall be stored at the Stand-alone DDC panels and uploaded to hard disk storage (minimum 80 megabyte) when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. Trend data shall be available in disk file form for use in 3rd Party personal computer applications.

G.   Runtime Totalization: Stand-alone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.

    1.   The Totalization routine shall have a sampling resolution of <u>one (1)</u> minute or less.
    2.   The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

H.   Analog/Pulse Totalization: Stand-alone DDC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

    1.   Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons. etc.).
    2.   The Totalization routine shall have a sampling resolution of one (1) 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.   Event Totalization: Stand-alone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

    1.   The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
    2.   The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.3   STAND-ALONE DDC PANELS

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

B.   Building Controllers: Building controllers shall include the following:

1. Building Controllers shall be 32 bit, multi-tasking, multi-user, real-time 100 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

2. Each Building Controller shall have sufficient memory, a minimum of twenty four (24) megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.

3. Building Controller shall have an integral real-time clock.

4. Each Building Controller shall support firmware upgrades without the need to change hardware.

5. Each Building Controller shall support:

    a. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.

    b. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.

6. Spare Point Capacity. Each Building Controller shall have a minimum of 10 percent spare point capacity.

    a. 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 one spare of each implemented I/O type.

    b. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:

        1) Expansion modules
        2) Sensor/actuator
        3) Field wiring/tubing

7. Serial Communication: Building Controllers shall provide at least one EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals. A USB port shall alternatively be available to support local HMI tools connection.

8. I/O Status and Indication: Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated

intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.

9. Self-Diagnostics: Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

10. Power loss: In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of one hundred (100) hours.

11. Environment: Controller hardware shall be suitable for the anticipated ambient conditions as follows:

   a. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

   b. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

12. Immunity to power and noise.

   a. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

   b. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

   c. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

      1) RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V.
      2) Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
      3) Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power.
      4) Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).

   d. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:

      1) IEEE Standard 587 1980.
      2) UL 864 Supply Line Transients.
      3) Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11).

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13. Minimum Approved Building Controllers. BAS Contractors shall furnish Building Controllers as listed below. Providing an approved controller does not release the contractor from meeting all performance, software and hardware specifications for Building Controllers and system operations.

    a. Siemens Building Technologies Inc. – PXC Compact and PXC Modular Building Controllers.

14. Uninterrupted Power Source:

    a. Provide a UPS for each Stand Alone DDC Panel.

2.4   BUILDING AND APPLICATION SPECIFIC CONTROLLERS (ASC)

A. General: Provide building and application specific controllers to control each piece of equipment , including, but not limited to the following:

1. Each Building Controller shall be able to communicate with application specific controllers (ASCs) over the Secondary Network to control terminal equipment only.
2. The use of Secondary Network controllers with custom program applications to control AHU's, water systems, etc. is not acceptable.
3. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
4. Each ASC shall include all point inputs and outputs necessary to perform the specified control sequences. The ASC shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs utilized either for two-state, modulating floating, or proportional control, allowing for additional system flexibility.
5. Communication: Each controller shall perform its primary control function independent of other Secondary Network communication, or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.
6. Control Algorithms: The controller shall receive its real-time data from the Building Controller time clock to insure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.
7. Control Applications: Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's

exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

8.   Calibration: Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

   a.   Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary

   b.   Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

   c.   Calibration shall be accomplished by zeroing out the pressure sensor and holding damper at last known position until calibration is complete. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

9.   Memory: Memory requirements shall include the following requirements:

   a.   Provide each ASC 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 seventy two (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.

   b.   Upon replacement, new ASCs shall recover control function and site specific defaults automatically and resume normal operation.

10. Power Supply: The ASCs shall be powered from a 24 VAC source and shall function normally under an operating range of 18 VAC to 28 VAC, allowing for power source fluctuations and voltage drops. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 VAC power to the terminal units by utilizing:

   a.   The existing line voltage power trunk and installing separate isolation transformers for each controller.

   b.   Dedicated line voltage power source and isolation transformers at a central location and installing 24 VAC power trunk to supply multiple ASCs in the area.

11. Environment: The controllers shall function normally under ambient conditions of 32°F to 122°F (0°C to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

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12. Immunity to noise: Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

13. Manufacturer Installed Controls: Include the following:

    a. BAS manufacturer shall furnish ASC and actuator for factory mounting to equipment manufacturer.

    b. Cost of factory mounting shall be borne by equipment manufacturer.

    c. For each air terminal unit, equipment manufacturer shall provide and install flow-cross sensor, 24 VAC transformer, controls enclosure, SCR and factory install, wire and tube ASC controller and actuator.

    d. Fan powered VAV terminals shall be equipped with a fan speed controller and relay to change summer and winter speed set point.
    < Delete paragraph "d" if not included in the design>

B. Air Terminal Units: Air terminal units (ATU) shall include supply air terminal units with reheat, supply air terminal units without reheat, general exhaust air terminal units, and fume hood exhaust terminal units. Each ATU shall include the following requirements:

1. Each ASC for the air terminal box unit controllers shall support, but not be limited to, the control of the following configurations of air terminal boxes to address current requirements as described in the Execution portion of this specification, and for future expansion:

    a. Single Duct Only (Cooling Only, or Cooling with Reheat)

    b. Supply/Exhaust/Return Air Terminals with Airflow Tracking

2. Each ASC for the air terminal unit controllers shall support the following types of point inputs and outputs:

    a. Proportional Cooling Outputs

    b. Box and Baseboard Heating Outputs (Separate, Staged Proportional Outputs to Reheat Coil Valve and Radiation Valve, where both Radiation and Reheat are Provided)

3. The modes of operation supported by the air terminal unit controllers shall minimally include the following:

    a. Occupied Mode

    b. Unoccupied (Mode)

    c. Temporary Override Mode Via Pushbutton at Thermostats

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

5. Each air terminal unit controller shall be capable of communicating the following information to the building automation systems:

	Item	Readout (Units)	Adjustment
a.	Room Temperature (Actual)	Yes (°F)	
b.	Temperature Setpoint	Yes (°F)	Yes
c.	Occupied/Unoccupied		Yes

6.   Terminal Unit Controllers (TUC) shall be furnished by the BAS Contractor and sent to the manufacturer for factory installation onto air terminal units by the air terminal unit manufacturer.

    a.   The terminal unit manufacturer shall furnish and install a sheet metal enclosure for each DDC terminal unit controller.

2.5   TEMPERATURE SENSORS (DDC)

A.   General: Provide temperature sensors for controllers performing space temperature control. Sensors shall be wired thermistor type, with the following features:

1.   Accuracy: + .5°F.
2.   Operating Range: 35°F to 115°F.
3.   Set Point Adjustment Range: 55°F to 95°F.
4.   Calibration Adjustments: None required.
5.   Installation: Up to one hundred (100) ft. from controller.
6.   Auxiliary Communications Port: As required.
7.   Set Point Adjustment Dial: As required.
8.   Occupancy Override Switch: As required.
9.   Terminal Jack: As required.

B.   Set Point Modes: Provide the following set point modes:

1.   Independent Heating, Cooling.
2.   Night Setback-Heating.
3.   Night Setback-Cooling.

C.   Auxiliary Communication Port: Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

D.   Set Point Adjustment Dial: The set point adjustment dial shall allow for modification of the temperature by the building operators. Set point adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.

E. Override Switch: An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.

F. Room Temperature Sensors and Monitors: The following temperature sensors for space control and/or space monitoring where indicated on the drawings and as required for proper control for the project:

1. Room Temperature Control Sensor: Room sensor shall come with a wall plate suitable for surface mounting in the room. The local setpoint adjustment shall be capable of being locked out by the BAS. The sensors shall be wired to the TEC by a cable which transmits the temperature signal to BAS.

2. Duct Mounted Space Temperature Control: For duct mounted space temperature control provide a surface mounted duct thermistor for the space TRU TEC. Thermistor shall be 10,000 Ohm with a set point adjustment range of 55ºF to 95ºF and be accurate to within ± 5ºF at mid range. The sensors shall be suitable for mounting on either a round or rectangular ductwork with self drilling screws and a gasket. The sensors shall be wired to the TEC by a cable which transmits the temperature signal to BAS. Mount the thermistor where indicated on the drawings in the exhaust duct serving room. <Delete if not required for the Project>

3. Duct Mounted Supply Air Temperature Monitor: For each supply terminal unit serving a space, provide a duct mounted temperature sensor to monitor the supply and exhaust air temperature. The sensors shall provide an input for temperature monitoring range of 32ºF to 122ºF and be accurate to within ± 5ºF at mid range. The sensors shall be suitable for mounting on either a round or rectangular ductwork with self drilling screws and a gasket. The sensors shall be wired to the TEC by a cable which transmits the temperature signal to BAS.

4. Controlled Environment Room Temperature Monitor: For each controlled environment room provide a surface mounted temperature sensor to monitor the space temperature in the. The sensor shall provide an input for temperature monitoring range of 4ºC (39.2ºF) to 6ºC (42.8ºF) and be accurate to within ± 3ºF at mid range. The sensors shall be suitable for field mounting on the wall of the controlled environment room with self drilling screws and a gasket. The sensor shall be wired to the nearest TEC by a cable which transmits the temperature signal to BAS. <Delete if not required for the Project>

5. Space Temperature Monitor: In [the recycling center in the north building] and in [the switch gear rooms of both substations] provide a surface mounted temperature sensor to monitor the space temperature. The sensor shall provide an input for temperature monitoring range of 32ºF to 122ºF and be accurate to within ± 3ºF at mid-range. The sensors shall be mounted on the wall adjacent to the local control unit. The sensor shall be wired to the nearest TEC by a cable which transmits the temperature signal to BAS along with an alarm for low temperature/high temperature. <coordinate with UMB and Edit for the Project>

2.6   LABORATORY HOOD EXHAUST CONTROL (CONSTANT VOLUME)

A. General: The following type of air valves and components shall be required:

    1.   Constant volume fume hood exhaust (pressure independent), but all controllers
            shall be completely suitable for future resetting to be variable volume with only the
            addition of hood sash position or face velocity sensors.
    2.   The direct digital controller shall communicate to the building automation system
            through a two (2) way, optically isolated interface. This two (2) way interface shall
            allow commands to be sent to the controller, which shall in turn send status
            information back to the building automation system.
    3.   Provide necessary factory and/or field labor for complete calibration and
            adjustment of the airflow control components and shall be responsible for setting
            control setpoints, operating sequences and alarming systems contained within the
            airflow control centers to produce the overall system performance.
    4.   In conjunction with the system start-up, instruct the University's personnel in the
            proper operation of the airflow control system and participate in the commissioning
            process.
    5.   Ensure the proper operation of the airflow control system and calibrate the initial
            system installation. In addition, furnish all required service (labor and parts) during
            the guarantee period, as specified.

B. Laboratory Pressure Control System (LPCS) Equipment

    1.   The system configuration shall consist of the following components:

            a.   Hood exhaust air valve (DDC controlled, pressure independent)

    2.   Laboratory Air Valves

            a.   Supply air valve and general lab room exhaust valves shall be conventional
                    air terminal boxes as specified elsewhere in these specifications. The ATC
                    Contractor to provide DDC controllers.
            b.   An exhaust airflow control valve shall be supplied to control the exhaust
                    flow out of each laboratory fume hood and ducted biosafety cabinet. The
                    stainless steel constant volume, pressure independently controlled fume
                    hood/BSC control valves shall be as manufactured by one of the following:

                    1)   Enviro-Tec Model SSX
                    2)   Siemens FHET
                    3)   Tek-Air Pneumavalve

            c.   Fume hood/BSC control valve shall be pressure independent and use closed
                    loop control to regulate air volume via the DDC Controller provided under
                    this section.

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    d.   All exhaust valves shall have pneumatic or electronic actuators, factory mounted to the valve body, to vary the position of the valve damper from its minimum to maximum flows. Constant Volume: Supply, General Exhaust and Fume Hood Exhaust Terminals shall fail in the last position.

    e.   Any electronic (hot wire, thermistor, etc.) airflow sensor exposed to exhaust airflow shall be UL listed under the UL 913 Class 1, Division 1 standard for intrinsically safe equipment used in hazardous locations.

3.   Fume Hood/BSC Low Flow Monitor

    a.   Fume hood face velocity sensors shall be furnished, installed and wired by the ATC Contractor, with dry contacts for alarm interface with the BAS.

    b.   Biosafety cabinet low flow sensor shall be furnished, installed and wired by the ATC Contractor with dry contacts for alarm interface with the BAS.

4.   Laboratory Make-Up Air and Exhaust Control Logic

    a.   Make-up and exhaust air control logic shall be provided to control the airflow balance of the laboratories. The control logic shall be valve mounted, complete with all integrated/interface hardware for BAS communications.

    b.   The control logic shall be of electronic design with analog signal inputs and outputs. The output signals shall control supply valves, fume hood valves, and general exhaust valves with signals linearly proportional to the desired supply or exhaust volumes.

    c.   The control logic shall maintain a constant adjustable offset between the sum of the room's total exhaust and the make-up/supply air volumes via the BAS. This offset shall be independent of the exhaust volume magnitude and represent the volume of air that will enter the room from the corridor or other room.

5.   Refer to the drawings and schedules to determine the hot water heating coil requirements, capacities and other characteristics. Hot water coils shall be furnished and installed by the mechanical contractor.

C.   System Start-Up and Training:

6.   System start-up shall be provided by a factory authorized representative of the LPCS manufacturer. Said start-up shall include setting of the fume hood face velocity and electronic verification of supply, general exhaust, and return airflows. The Balancing Contractor shall be responsible for final verification and reporting of all airflows.

7.   Furnish a minimum of forty (40) hours of University personnel training to provide an overview of the job specific airflow control components, calibration procedures in setting fume hood velocities, general procedures for verifying airflows of air valves, and general troubleshooting procedures.

2.7   FIELD DEVICES

   A.   Local Control Panels:

        1.   Controls, relays and switches for equipment located within the mechanical
                equipment rooms shall be mounted on enclosed control panels with hinge lock type
                door mounted adjacent to the system controlled.
        2.   Details of each panel shall be submitted for review prior to fabrication. Locations
                of each panel shall be convenient for adjustment and service. Manual switches shall
                be flush mounted on the hinged door.
        3.   Electrical devices within the panels shall be factory prewired to a numbered
                terminal strip. Wiring within the panel shall be in accordance with NEMA and UL
                Standards.

   B.   Temperature Sensors:
        1.   See temperature sensor specification in this section for requirements.

   C.   Humidity Sensors: <Delete if not required for the Project>

        1.   Sensors shall have minimum accuracy of ±3% RH over a range from 20-95% RH
                including hysteresis, linearity and repeatability.
        2.   Sensors shall be manufactured by Rotronic (F2 Series),, Contractor Instruments
                (Model 981/982-219), General Eastern (Model MRH-3-X), or equal.

   D.   Moisture Sensors:

        1.   Moisture Sensor: Provide DiversiTech Model WS-1 moisture sensors in A/C
                condensate drain pans in fan coil units and fan powered boxes.

   E.   Fan Status:

        1.   HVAC Fans: Verification of air flow for HVAC fans, which are wired from an
                electrical motor control center, shall be by a current sensor device unless indicated
                otherwise on the point schedule. Motor Start/Stop relay module shall provide either
                momentary or maintained switching action as appropriate for the motor being
                started. Relays shall be plugged in, interchangeable, mounted on a circuit board and
                wired to numbered terminal strips.
        2.   Terminal Unit Fans: Verification of air flow for fans, which are part of terminal
                heating and cooling units such as fan coil units, fan powered boxes, unit heaters,
                cabinet heaters, shall be by a current sensing device unless indicated otherwise on
                the point schedule.
        3.   Pneumatic Transducers: Electric to pneumatic transducers shall be housed in a
                control equipment cabinet. Transducers shall be compatible with the output of the
                digital system controller and the control pressure span of the pneumatic actuator.
                Transducer accuracy shall be at least ±2% of span and shall incorporate an integral
                potentiometer for position feedback to the digital system controller.

F.   BAS Energy Meters and Flow Meters: <Delete if not required for the Project>

    1.   The BAS System shall monitor and record output signals from energy meters and flow meters were indicated on the contract documents. See Division 26, Specification Section "Building Automation System – Energy Flow Meters" for meter types and requirements.

G.   Terminal Unit Control Valves: Terminal units include Supply Terminal Units, Fan Coil Units, Unit Heaters, Cabinet Heaters, Convectors and Chilled Beams:

    1.   Control Valves: All control valves shall be electronic type valves designed for quiet operation and 100% tight shut off against the system operating pressure. Valves concealed above suspended ceilings or in unit casings shall be packless type with bellows seals requiring no packing maintenance.

    2.   All control valves (1/2 inch to 1 inch) shall be globe type valves with bronze or forged brass body, NPT threaded ends, brass trim, type 303 stainless steel stem, metal to metal seat, ethylene propylene 'O' ring packing, ANSI Class 250, and selected to provide the scheduled gpm flow rate @ a maximum pressure drop of ten (10) feet. See equipment schedules for design flow rates.

    3.   Valve Fail Safe Position: Control valves fail safe position shall comply with the following:

        a.   Heating Valves Vivarium Areas – Fail Closed: Upon a loss of a signal or power control valves and actuators used as reheat valves for terminal units shall fail in the closed position.

        b.   Heating Valves Non Vivarium Areas – Fail Last Position: Upon a loss of a signal or power control valves and actuators used as reheat valves for terminal units shall fail in the last position.

        c.   Chilled Water Valves Non Vivarium Areas – Fail Last Position: Upon a loss of a signal or power control valves and actuators used as chilled water valves for fan coil/chilled beam terminal units shall fail in the last position.

    4.   Two-way valves shall have external spring adjustment with a self-sealing V-ring packing arranged to tighten the seal as the water pressure increases so that no manual adjustment is necessary.

    5.   Three-way valves shall be of the three-way mixing type designed for 100% tight shut-off and shall have full throttling plugs, renewable composition discs and seat rings. < Coordinate with UMB – Delete if not required>

    6.   Valves sequenced with other valves, or control devices, shall be equipped with pilot positioners or panel mounted positive positioning relays to insure proper control sequencing.

    7.   See Division 23, Specification Section "Valves for HVAC Piping Systems" for high performance Butterfly Valves.

    8.   Where pneumatic control systems are used provide pressure gauges on main air, branch air and pilot positioner output to each valve actuator. < Coordinate with UMB – Delete if not required>

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2.8   LABORATORY FUME HOOD CONTROLLER ASSEMBLY

A.   Fume Hood Controller Assembly: Where fume hoods are indicated on the construction documents provide a Siemens Fume Hood Controller Assembly for control of laboratory fume hoods as manufactured by Siemens. Power source shall be through a 24 Vac power trunk. The controller shall include the following components:

1.   Fume Hood Controller: The Fume Hood Controller shall consist of a control circuit board and metal enclosure. The controller circuit board shall be a snap in type circuit board mounted inside the enclosure. Provide all wiring terminations for input and output points, 24 Vac power, FLN trunk, and the Operator Display Panel. The controller shall maintain a constant face velocity as the fume hood sash is raised and lowered and includes the following:

a.   Communicates using BACnet MS/TP protocol for open communications on BACnet MS/TP networks.
b.   BTL listed as a B-ASC device.
c.   Programmable using PPCL.
d.   Plenum rated controller.
e.   Constant face velocity fume hood operation.
f.   Maintains programmed minimum exhaust flow.
g.   True exhaust flow measurement used to monitor safe operation and provide fine flow control.
h.   Modular components, easy to install and service.
i.   Program and calibration parameters are user defined or modified via the Laptop Terminal.
j.   PID closed loop control for all control devices.
k.   Electrically Erasable Programmable Read Only Memory (EEPROM) memory for setpoint and control parameters; no battery is needed.
l.   Supports multiple hood sash inputs.

2.   Offboard Air Module: The Offboard Air Module shall contain the air velocity sensor (a specialized differential pressure transducer), V/F conversion circuitry and solenoid for auto-zero function and advanced digital signal processing to produce a highly accurate reading of even the noisiest flow signals. The auto-zero solenoid shall be connected to the air velocity pressure transducer's inlet ports to enable automatic periodic re-calibration. This re-calibration ensures accurate, drift-free airflow measurement. Automatic re-calibration of the differential pressure transducers occurs upon system power-up and when airflows are stable with frequency selectable from one (1) to six (6) times a day.

3.   Operator Display Panel II: The Operator Display Panel shall provide the fume hood user with the face velocity readout, operating status of the hood, alarm horn, alarm silence and an emergency purge function and include the following:

a. Continuous display of hood operating parameters using a large alpha-numeric display.

b. Colored hood status lights for normal (green), marginal (yellow), and alarm (red) conditions. Purge push-button for activation of emergency operation mode. Alarm horn for high and low face velocity and emergency purge indication.

c. Easy to install and connect to the controller via a single cable and telephone type connectors.

d. "Greenleaf" turns red to indicate unsustainable operation, such as keeping sash open when not in use. Animated graphics to encourage safe use.

e. Communicates using BACnet MS/TP protocol for open communications on BACnet MS/TP networks.

f. BTL listed as a B-ASC device.

g. Programmable using PPCL.

h. Auto-discovery and Auto-addressing over entire MS/TP network. (WCIS 4.0 or later)

i. RJ-11 type connectors to provide termination to the Fume Hood Controller and for the Portable Operator's Terminal.

4. Power Module and Cable: Siemens Product Number AQM2200.

5. Sash Sensor Kits (Vertical/ Horizontal): Siemens Product Number 149-269.

6. Airflow Measurement and Control Options:

a. [Application 6740] [Application 6741]

2.9 UNINTERRUPTIBLE POWER SUPPLIES (UPS)

A. All Building Automation System field panels and application specific controllers shall be provided with Uninterruptible Power Supplies (UPS). Provide a single UPS, if possible, at each central field panel location, sized for total load of connected equipment. Provide external battery cabinets, if required to meet load requirements.

B. Provide constant on line 1500 kVA minimum UPS with Ethernet card to feed back to IP based UMB monitoring system APC Model # SMX1500RM2UNC, 120V 1.5 kVA UPS and a UPS bypass Eaton hot swap Model # MBP-115 or approved equal for seamless serving. When a larger UPS is required, increase the kVA capacity as needed. Line interactive UPS's will not be acceptable.

PART 3 – EXECUTION

3.1 GENERAL REQUIREMENTS

A. The sequences listed hereinafter describe the general intent of the automatic temperature control systems. Provide all devices, equipment, and wiring as required to perform the sequences described herein.

B. Unless otherwise noted, size all automatic control valves for a maximum of ten (10) foot water pressure drop at the maximum design flow rate.

C. See plans for location of all room thermostats, control panels, dampers, valves, and equipment; where such devices are not indicated, however required by the sequences, they shall be provided and located in the field as directed by the A/E and UMB.

D. Room Sensors: Room sensors shall be mounted as follows:

   1.   Wall Mounting Height: Wall mount sensor with the centerline @ forty eight (48) inches AFF and to the right of the room light switch with a two (2) inch space between the devices.

   2.   Duct Mounted: When the space sensor cannot ben wall mounted provide a duct mounted temperature sensor located in the rooms general exhaust duct. <Coordinate with UMB> <Delete if not required>

E. Current Sensors: All motors serving HVAC fans and pumps shall be provided with a current sensor for "on/off" status to the BAS.

F. Moisture Sensors: All terminal A/C units shall be provided with moisture sensors in the unit's condensate drain pan for "high water" alarm. When high water level is detected, the sensor shall send an alarm to the BAS and shut off the unit. The BAS alarm shall also remotely notify the client via [email], [or text] [or all three (3)] types of notification methods. <engineer coordinate with UMB and edit for project>

G. Terminal Unit Fan Status: All fans serving fan coil units, cabinet heaters, and unit heaters shall be provided with current sensors for "on/off" status to the BAS.

H. All temperature, pressure, air flow, water flow and time set points shall be fully adjustable from the Central Control and Monitoring System (CCMS).

I. Provide all hardware, software, devices, equipment and wiring as required to interface with the CCMS.

J. Refer to input/output summary schedule for additional control items not described in the sequences. The input/output summary schedule list the minimum requirements, provide all required points for complete operation of the system. <Delete if not required for the Project>

K. Where indicated on the drawings, the variable frequency drives (VFD) for secondary pumps shall be soft started at minimum speed and increased to operating speed by the CCMS. <Delete if not required for the Project>

L. The control manufacturer shall prepare and submit for approval a composite control and interlock wiring diagram depicting the control system that will be provided.

M. All two (2) position control valves used to isolate equipment and/or sections of hydronic piping systems shall be fitted with an end switch to indicate proof of opening and closure. The end switch shall be internal or external to the valve actuator. <Delete if not required for the Project>

N. After each Room Air Terminal Unit (RATU) has been field set at its design operating position, the BAS Contractor shall revise the program logic of each RATU so that future RATU calibration is scheduled during the unoccupied mode.

O. The BAS Contractor shall be responsible for ensuring that the room numbers assigned to all control components such as RATU'S, Thermostats etc. in the program logic are the actual room numbers used in the building prior to the system being turned over to UMB.

3.2   SEQUENCE OF OPERATION – AIR TERMINAL UNITS (CV, VAV)

A. Room Pressurization: Room pressurization shall comply with the following: <Coordinate with UMB and Edit for Project>

    1. Positive Pressure: For positively pressurized spaces the exhaust terminal unit (GETU, FHETU) shall track the supply terminal unit using a preset cfm differential to maintain the required room pressurization. Where multiple supply terminal units are served by a single exhaust terminal unit, the exhaust terminal unit shall track the total of all corresponding supply units air volume (cfm) using a preset cfm differential to maintain the required room pressurization.
    2. Negative Pressure: For negatively pressurized spaces the supply terminal unit shall track the exhaust terminal unit (GETU, FHETU) using a preset cfm differential to maintain the required room pressurization. Where multiple exhaust terminal units, such as general exhaust and fume hood terminals, are served by a single supply terminal unit, the supply terminal unit shall track the total of all corresponding exhaust units air volume (cfm) using a preset cfm differential to maintain the required room pressurization.

B. Supply and Exhaust Air Terminal Unit Controls: <Edit for Project >

    1. Supply Terminal Reheat Units: The pressure independent [constant volume] [variable volume] supply terminal reheat units (STU) shall be controlled by an application specific DDC controller using electric actuation. [For supply terminal units serving Laboratory, Animal and/or Vivarium areas provide an auto zero module for periodic calibration of the controller's air velocity transducer. The

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calibration of the controller shall be programmed for the unoccupied mode.] The space served by each STU shall be controlled in occupied and unoccupied modes as follows:

1) Occupied: The STU supplies a [constant volume] [variable volume] of supply air to the space. The controller monitors the air velocity sensor and modulates the supply air damper to maintain the supply air volume at the occupied set point. The controller monitors the room temperature sensor and modulates the reheat valve to maintain the space temperature at set point.

2) Unoccupied: The STU is controlled using the unoccupied temperature and volume set point. The controller may reset to the occupied mode for a predetermined time period upon a signal from the control system.

2. Exhaust Terminal Units: The pressure independent [constant volume] [variable volume] exhaust terminal units (ETU) shall be controlled by an application specific DDC controller using electric actuation. [For exhaust terminal units serving Laboratory, Animal and/or Vivarium areas provide an auto zero module for periodic calibration of the controller's air velocity transducer. The calibration of the controller shall be programmed for the unoccupied mode.] The space served by the ETU shall be controlled in occupied and unoccupied modes as follows:

1) Occupied: The ETU exhausts a [constant volume] [variable volume] of air from the space. The controller monitors the air velocity sensor and modulates the exhaust air damper to maintain the exhaust air volume at the occupied set point.

2) Unoccupied: The ETU is controlled using the unoccupied volume set point. The controller may reset to the occupied mode for a predetermined time period upon a signal from the control system.

3. Fume Hood Exhaust Terminal Units: The pressure independent fume hood exhaust terminal units (FHETU) shall be controlled by an application specific DDC controller using electric actuation. This sequence shall be for constant volume fume hoods that incorporate an integral hood bypass. Provide an auto zero module for periodic calibration of the controller's air velocity transducer. The calibration of the controller shall be programmed for the unoccupied mode. The fume hood served by the FHETU shall be controlled in occupied and unoccupied modes as follows:

1) Occupied: The FHETU exhausts a constant volume of air from the space through the fume hood. The controller monitors the air velocity sensor and modulates the exhaust air damper to maintain the exhaust air volume at the occupied set point.

2) Unoccupied: The FHETU is controlled using the volume set point. The controller may reset to the occupied mode for a pre-determined time period upon a signal from the control system.

4.   Animal/Vivarium Rooms - Supply Terminal Units with Reheat and Humidity: The pressure independent constant volume terminal reheat unit (STU), the reheat valve and the humidifier shall be controlled by an application specific DDC controller using electric actuation. Provide an auto zero module for periodic calibration of the controller's air velocity transducer. The calibration of the controller shall be programmed for the unoccupied mode. The space served by the STU, the Reheat Valve and the Humidifier shall be controlled in occupied and unoccupied modes as follows:

   1)   Occupied: The STU supplies a constant volume of supply air to the space. The controller monitors the air velocity sensor and modulates the supply air damper to maintain the supply air volume at the occupied set point. The controller monitors the room temperature sensor and modulates the reheat valve to maintain the space temperature at set point. The controller monitors the room relative humidity sensor and modulates the humidifier valve to maintain the space relative humidity at set point.

   2)   Unoccupied: The STU is controlled using the unoccupied volume and temperature set points. The controller may reset to the occupied mode for a predetermined time period upon a signal from the control system. The controller monitors the room relative humidity sensor and modulates the humidifier valve to maintain the space relative humidity at set point.

   3)   Safeties: Certain conditions of temperature and/or relative humidity set point change could cause either the temperature or humidity control loop to be held constant while the other loop operates. This takes place when allowing both loops to operate simultaneously may lead to high or low relative humidity levels. Discharge humidistat closes the humidifier valve when discharge humidity exceeds 85% relative humidity. When the air volume falls below a low limit, the humidity control valve will close to prevent condensation in the duct.

3.3   SEQUENCE OF OPERATION – SUPPLY TERMINAL UNITS AND SUPPLEMENTAL COOLING EQUIPMENT

   A.   STU and Supplemental DX A/C Unit Control: The pressure independent constant volume supply terminal reheat unit (STU), the reheat valve are controlled by an application specific DDC controller using electric actuation, and the supplemental A/C unit is controlled by its unit controller through the BAS system in occupied and unoccupied modes to maintain 75ºF occupied / 72ºF unoccupied conditions as follows:

   1.   Occupied Mode: The STU shall maintain the minimum occupied air flow volume to provide room pressurization and make up air for the exhaust systems. When the space temperature, as measured by the space sensor, rises above the room occupied cooling set point of 75ºF (adjustable) by 3 degrees, the Building Automation System (BAS) shall enable the controller in each supplemental A/C unit. The unit controller shall monitor the return air temperature through a unit mounted return air temperature sensor and energize and cycle the unit fan and compressor through the

unit controller to maintain the occupied return air temperature set point of 75ºF (adjustable). The supplemental A/C unit controller shall monitor all unit refrigeration and safety set points and controls. If the supplemental A/C unit fails to operate properly when energized by the BAS, the unit controller shall shut down the unit and send an alarm signal to the BAS. The unit controller shall permit return air temperature set point adjustment by the BAS. When the space temperature drops below the occupied space temperature set point of 75ºF, as measured by the space sensor, the supplemental A/C unit shall be de-energized. When the space temperature, as measured by the space sensor, drops below the occupied room set point of 75ºF (adjustable) the BAS shall modulate the STU reheat coil control valve open to maintain the space temperature set point. Adjustments of the BAS space sensor shall automatically reset the set point of the supplemental A/C unit, through the units mounted controller to maintain the dead band between the room sensor set point and the unit set point.

     2.   Unoccupied Mode: In the unoccupied mode the supplemental A/C unit(s) shall be de-energized. The STU shall maintain the minimum air flow volume to provide room pressurization and make up air for the exhaust systems. When the space temperature, as measured by the space sensor, drops below the unoccupied room set point of 72ºF (adjustable) by more than 3 degrees, the BAS shall modulate the STU reheat coil control valve open to maintain the space temperature set point. When the space temperature, as measured by the space sensor, rises above the unoccupied room set point of 72ºF (adjustable) by more than 3 degrees, the BAS shall close the STU reheat coil control valve. The supplemental A/C unit shall remain off until the space temperature rises 6 degrees above the unoccupied set point then the BAS shall enable the supplemental A/C unit. On a fall in temperature to the unoccupied room set point of 72ºF the BAS shall disable the supplemental A/C unit.

B.   STU and Supplemental Cooling Only Fan Coil Unit Control: The pressure independent constant volume supply terminal reheat unit (STU), the reheat valve, and supplemental cooling only fan coil unit are controlled by an application specific DDC controller using electric actuation through the BAS system in occupied and unoccupied modes to maintain 75ºF occupied / 72ºF unoccupied conditions as follows:

     1.   Occupied Mode: The STU shall maintain the minimum occupied air flow volume to provide room pressurization and make up air for the exhaust systems. When the space temperature, as measured by the space sensor, rises above the room occupied cooling set point of 75ºF (adjustable) by 3 degrees, the Building Automation System (BAS) shall enable the controller in each supplemental FCU. The FCU controller shall monitor the return air temperature through a unit mounted return air temperature sensor and energize and cycle the unit fan and modulate the units cooling coil valve to maintain the occupied return air temperature set point of 75ºF (adjustable). If the supplemental FCU fails to operate properly when energized by the BAS, the unit controller shall shut down the unit, close the cooling coil control valve, and send an alarm signal to the BAS. When the space temperature drops

below the occupied space temperature set point of 75ºF, as measured by the space sensor, the supplemental FCU shall be de-energized and the cooling coil control valve shall close. When the space temperature, as measured by the space sensor, drops below the occupied room set point of 75ºF (adjustable) the BAS shall modulate the STU reheat coil control valve open to maintain the space temperature set point. Adjustments of the BAS space sensor shall automatically reset the set point of the A/C unit, through the units mounted controller to maintain the dead band between the room sensor set point and the unit set point.

2.   Unoccupied Mode: In the unoccupied mode the supplemental FCU shall be de-energized. The STU shall maintain the minimum unoccupied air flow volume to provide room pressurization and make up air for the exhaust systems. When the space temperature, as measured by the space sensor, drops below the unoccupied room set point of 72ºF (adjustable) by more than 3 degrees, the BAS shall modulate the STU reheat coil control valve open to maintain the space temperature set point. When the space temperature, as measured by the space sensor, rises above the unoccupied room set point of 72ºF (adjustable) by more than 3 degrees, the BAS shall close the STU reheat coil control valve. The supplemental FCU shall remain off until the space temperature rises 6 degrees above the unoccupied set point then the BAS shall enable the supplemental FCU, energize the supply fan, and open the cooling coil valve. On a fall in temperature to the unoccupied room set point of 72ºF the BAS shall disable the supplemental FCU and close the cooling coil valve.

3.4   SEQUENCE OF OPERATION – TERMINAL HEATING EQUIPMENT
        < Edit for Project or Delete if not required>

A.   Finned Tube Radiation: (Zoned by Building Exposure): On a decrease in outside air temperature below 50ºF (adjustable) each zone control valve is commanded open. On an increase in outside air temperature above 55ºF (adjustable), each zone control valve is commanded closed. Temperature control is through the buildings heating system which regulates the water temperature.

B.   Cabinet Heaters: When the space thermostat (remote or unit mounted) senses a decrease in temperature below its set point of 68ºF (adjustable) the two position heating valve shall be commanded open. When a strap on aquastat, located on the hot water supply pipe serving the unit senses the hot water supply temperature of 180ºF (adjustable) the unit fan shall be energized an shall run continuously to maintain the space set point. On a rise in space temperature above the set point the reverse shall occur.

C.   Unit Heaters - Mechanical Equipment Rooms: When the space thermostat (remote or unit mounted) senses a decrease in temperature below its set point of 60ºF (adjustable) the two position heating valve shall be commanded open. When a strap on aquastat, located on the hot water supply pipe serving the unit senses the hot water supply temperature of 180ºF (adjustable) the unit fan shall be energized an shall run continuously to maintain the space set point. On a rise in space temperature above the set point the reverse shall occur.

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D.   Convectors: When the space thermostat (remote or unit mounted) senses a decrease in temperature below its set point of 68ºF (adjustable) the two position heating valve shall be commanded open maintain the space set point. On a rise in space temperature above the set point the reverse shall occur.

3.5   SEQUENCE OF OPERATION – SELF CONTAINED A/C UNITS

A.   Water Cooled A/C Unit: <Engineer to Edit for Project Requirements>

<Engineer to coordinate requirements with UMB and edit for project requirements or delete if not required>

1.   The Building Automation System (BAS) shall send enable/disable signal to the A/C Unit, [Drycooler] [& Pump Package].
2.   The unit shall be controlled by the factory furnished and installed microprocessor controls. The unit controls shall enable/disable cooling at the A/C unit by energizing the unit's compressor to maintain space temperature set point as sensed by space temperature sensor.
3.   On a call for cooling if the unit compressor fails to start an alarm shall be transmitted to the BAS through the BAC NET IP BMS Card and the unit shall be de-energized.
4.   On a call for cooling if the unit compressor starts but the unit fan fails to start an alarm shall be transmitted to the BAS through the BAC NET IP BMS Card and the unit shall be de-energized.
5.   When water cooled units and/or fan coil units have auxiliary drain pans provide a moisture sensor connected to the BAS. When moisture is detected, the sensor shall send an alarm to the BAS and de-energize the unit.
6.   Provide BAC NET IP BMS Communication Software to interface with the water cooled A/C unit controls.
7.   The following points are included with the A/C Unit microprocessor controller. BAS shall provide BAC NET IP BMS communication software to allow for BAS monitoring. Listed points are based on Stultz manufactured equipment. Points 'a' through 'm' and 'p' and 'q' shall be alarmed and trended by the BAS:

a.   Unit on/off —Digital Output
b.   Compressor running Module1 —Digital Output
c.   Fan running Module1 —Digital Output
d.   Compressor low pressure alarm Module1 —Digital Input
e.   Compressor high pressure alarm Module1 —Digital Input
f.   Air flow alarm Module1 —Digital Input
g.   Water detector alarm Module1 (condensate pan) —Digital Input
h.   Room temperature to high alarm —Digital Input
i.   Room temperature to low alarm —Digital Input
j.   Supply temperature to high alarm —Digital Input
k.   Supply temperature to low alarm —Digital Input

      l.   Water temperature to high alarm —Digital Input (Process Cooling Water)
      m.   Water temperature to low alarm —Digital Input (Process Cooling Water)
      n.   Set point space temperature —Analog Input
      o.   Set point supply air temperature —Analog Input
      p.   Return air temperature —Analog Input
      q.   Supply air temperature —Analog Input

8. For systems requiring Humidity Control include the additional points indicated below. BAS shall provide BAC IP BMS communication software to allow for BAS monitoring. Points 'a' through 'e' shall be alarmed and trended by the BAS:

      a.   Humidity Sensor
      b.   Humidifier Active
      c.   Humidifier Failure Alarm
      d.   Room Humidity to High
      e.   Room Humidity to Low

9. For systems requiring auxiliary drain pans the following point shall be alarmed through the BAS:

      a.   Auxiliary Drain Pan Water Detector Alarm — Digital Input

B. Dry Cooler and Pump Package: <Edit for Project or Delete if not required>

1. The Building Automation System (BAS) shall send enable/disable signal to the A/C Unit, Drycooler & Pump Package.
2. Building Automation System ("BAS") shall enable/disable cooling at the A/C unit by energizing the unit's compressors in stages to maintain space temperature set point as sensed by space temperature sensor.
3. Whenever the A/C unit is enabled for cooling, the BAS shall also enable the associated drycooler. The drycooler will in turn initiate the associated pump package. If the status feedback for flow via the drycooler's flow switch is not established within a predetermined period of time (adjustable), the BAS shall disable the A/C unit/Drycooler/Pump package and send a critical alarm to the BAS Operator's Workstation.
4. In addition to the points included with the A/C Unit, the BAS shall also include the points indicated below. BAS shall provide BAC NET IP BMS communication software to allow for BAS monitoring. Points 'a' through 'e' shall be alarmed and trended by the BAS:

      a.   Drycooler Enable/Disable—Digital Output
      b.   Drycooler Status (via flow switch)—Digital Input
      c.   Supply Water Temperature — Analog Output
      d.   Return Water Temperature — Analog Output
      e.   Pump Status —Digital Input

3.6   SEQUENCE OF OPERATION – EXHAUST FANS

A.   Exhaust Fan Control – Lead / Lag Fans:

    1.   The [BAS] [CCMS] shall select one of the exhaust fans as the lead fan on a monthly basis. After the fan's isolation damper end switch has proven that the damper has opened the lead fan shall be energized.

    2.   The exhaust fan status shall be as determined by a current transducer. If the lead fan fails to energize its isolation damper shall close and a current transducer shall transmit an alarm signal the [BAS] [CCMS]. The [BAS] [CCMS] shall signal the lag fan isolation damper to open and after the damper has opened the lag fan shall be energized to run continuously.

B.   Hot Laboratory Exhaust System:

    1.   The [BAS] [CCMS] shall select one of the exhaust fans as the lead fan on a monthly basis. After the fan's isolation damper end switch has proven that the damper has opened the lead fan shall be energized.

    2.   The exhaust fan status shall be determined by a current transducer. If the lead fan fails to energize, its isolation damper shall close and a current transducer shall transmit an alarm signal the [BAS] [CCMS]. The [BAS] [CCMS] shall signal the lag fan isolation damper to open, and after the damper has opened, the lag fan shall be energized to run continuously.

    3.   Upon the loss of normal electrical power as monitored by the [BAS] [CCMS] the hot lab exhaust system shall remain in operation. The fans serving this system are served with emergency power.

C.   Fume Hood Exhaust Fan:

    1.   The fume hood fan shall be energized through the [BAS] [CCMS] and run continuously. If the fan fails to energize a current sensor shall transmit an alarm to the [BAS] [CCMS].

3.7   LIGHTING CONTROL <Delete if not required>

A.   Low voltage lighting control system interface.

    1.   The [BAS] [CCMS] shall provide electronic interface to the lighting control system and provide override commands and scheduling capability to the [BAS] [CCMS] operators located at the Operations Centers and [Vivarium Management Office].

    2.   The [BAS] [CCMS] shall provide control zones as shown on the Input/Output Summary.

    3.   All low voltage lighting control and dimming control primary equipment shall be provided and installed by the electrical contractor.

3.8   SYSTEM INPUT/OUTPUT POINT SUMMARY

A. Description: For points not listed below and for software association, see sequence of operation. Points shall be able to integrate to trends and totalizations, as applicable. Additional points not specifically called for herein but required to perform the sequences as specified shall be provided at no additional cost to the Owner. Points labeled with * shall be trended.

B. Input/Output Point Summary:
          <mark>\<Engineer to edit Summary for Project Requirements ></mark>
1. Air Handling Unit:

    a. Analog Inputs Measured:
        1) Space Temperature *
        2) Supply Air Temperature - Discharge *
        3) Supply Air Temperature – Cooling Coil *
        4) Supply Air Temperature – Mixed Air *
        5) Supply Air Flow – CFM *
        6) Filter – Pressure Drop *
        7) Static Pressure Sensor *

    b. Analog Inputs Calculated:
        1) Damper Position – Supply, Return & Outside Air *
        2) Per cent (%) Flow – Supply, Return & Outside Air *

    c. Digital Outputs:
        1) On – Off *
        2) Alarms – Temp, Flow and Pressure *

    d. Digital Input:
        1) Current Sensor – Fan Status *

    e. Analog Outputs:
        1) Damper Control – Supply, Return & Outside Air *
        2) VFD *
        3) Space Set Point Adjustment *

    f. System Features:
        1) Alarm *
        2) Proof *
        3) Trend *
        4) LAN device for VFD to BAS

2. Return Air Fan:

    a. Analog Inputs - Measured:
        1) Return Air Temperature *
        2) Return Air Flow – CFM *

          3)   Return Air – RH

    b.   Analog Inputs Calculated:
        1)   Damper Position – Relief Air *
        2)   Per cent (%) Flow – Relief Air *

    c.   Digital Output:
        1)   On – Off *
        2)   Alarms – Temp, Flow *

    d.   Digital Input:
        1)   Current Sensor – Fan Status*

    e.   Analog Output:
        1)   Damper Control – Relief Air *
        2)   VFD

    f.   System Features:
        1)   Alarm *
        2)   Proof *
        3)   Trend *
        4)   LAN device for VFD to BAS

3.   AHU - Condensing Units:

    a.   Analog Binary Input:
        1)   Status *

    b.   Digital Output:
        1)   On – Off *
        2)   Alarm *

    c.   System Features:
        1)   Alarm*
        2)   Proof *

4.   Split System A/C Unit:

    a.   Analog Binary Input:
        1)   Status *

    b.   Digital Output:
        1)   On – Off *
        2)   Alarm *

    c.   System Features:

            1)   Alarm *
            2)   Proof *

5.   Laboratory Supply Air and Exhaust Terminals: (CV)

    a.   Analog Inputs Measured:
        1)   Space Temperature *
        2)   Supply Air Temperature *
        3)   Supply Air Flow – CFM *
        4)   Exhaust Air Flow – CFM *
        5)   [Terminal Humidifier]
        6)   [Space RH]*
        7)   Exhaust to Track Supply or Supply to Track Exhaust
                for Room Pressurization *
        8)   Differential Pressure Monitors (DPM)

    b.   Analog Inputs Calculated:
        1)   Differential Flow *
        2)   Valve Position *
        3)   Damper Position – Supply & Exhaust *
        4)   Per cent (%) Flow – Supply & Exhaust *

    c.   Digital Outputs:
        1)   Auto - Zero Module
        2)   [Fin Tube Radiation Valve] *
        3)   [Alarms – Temp, Flow and Pressure]

    d.   Analog Outputs:
        1)   Damper Control – Supply & Exhaust *
        2)   Reheat Valve Control *
        3)   Space Set Point Adjustment *
        4)   [Fin Tube Radiation Valve] *
        5)   [Humidifier Output]

    e.   System Features - Programs:
        1)   Alarm Instruction *
        2)   Occupied/Unoccupied
        3)   Trend *

6.   Laboratory Supply Air and Laboratory Exhaust Terminals: (VAV)

    a.   Analog Inputs Measured:
        1)   Space Temperature *
        2)   Supply Air Temperature *
        3)   Supply Air Flow – CFM *
        4)   Exhaust Air Flow – CFM *

        5)   Terminal Humidifier – When Required
        6)   Space RH – When Required *
        7)   Supply Air Flow Min/Max Cooling and Heating *
        8)   Exhaust Air Flow Min/Max *
        9)   Exhaust to Track Supply or Supply to Track Exhaust for Room Pressurization *
        10)   Differential Pressure Monitors (DPM)

    b.   Analog Inputs Calculated:
        1)   Differential Flow*
        2)   Valve Position *
        3)   Damper Position – Supply & Exhaust *
        4)   Per cent (%) Flow – Supply & Exhaust *

    c.   Digital Outputs:
        1)   Auto - Zero Module
        2)   [Fin Tube Radiation] *
        3)   [Alarms – Temp, Flow and Pressure]

    d.   Analog Outputs:
        1)   Damper Control – Supply & Exhaust *
        2)   Reheat Valve Control *
        3)   Space Set Point Adjustment *
        4)   [Fin Tube Radiation Valve] *

    e.   System Features - Programs:
        1)   Alarm Instruction
        2)   Occupied/Unoccupied
        3)   Trend *

7.   Office Environment – Supply and Exhaust Air Terminals: (CV)

    a.   Analog Inputs - Measured:
        1)   Space Temperature *
        2)   Supply Air Temperature *
        3)   Supply Air Flow – CFM *
        4)   Exhaust Air Flow – CFM *

    b.   Analog Inputs Calculated:
        1)   Differential Flow *
        2)   Valve Position *
        3)   Damper Position – Supply & Exhaust *
        4)   Per cent (%) Flow – Supply & Exhaust *

    c.   Digital Outputs:
        1)   [Fin Tube Radiation Valve] *

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2)   [Alarms – Temp, Flow and Pressure]

d.   Analog Outputs:
1)   Damper Control *
2)   Reheat Valve Control *
3)   Space Set Point Adjustment *
4)   [Fin Tube Radiation Valve] *

e.   System Features - Programs:
1)   Night Setback
2)   Occupied/Unoccupied
3)   Trend *

8.   Office Environment – Supply and Exhaust Air Terminals: (VAV)

a.   Analog Inputs - Measured:
1)   Space Temperature *
2)   Supply Air Temperature *
3)   Supply Air Flow – CFM *
4)   Exhaust Air Flow – CFM *
5)   Supply Air Flow Min/Max Cooling and Heating *
6)   Exhaust Air Flow Min/Max *
7)   Exhaust to Track Supply or Supply to Track Exhaust for Room Pressurization *

b.   Analog Inputs Calculated:
1)   Differential Flow *
2)   Valve Position *
3)   Damper Position – Supply & Exhaust *
4)   Per cent (%) Flow – Supply & Exhaust *

c.   Digital Outputs:
1)   [Fin Tube Radiation Valve] *
2)   [Alarms – Temp, Flow and Pressure]

d.   Analog Outputs:
1)   Damper Control *
2)   Reheat Valve Control *
3)   Space Set Point Adjustment *
4)   [Fin Tube Radiation Valve] *

e.   System Features - Programs:
1)   Night Setback
2)   Occupied/Unoccupied
3)   Trend *

9.   Laboratory Fume Hoods (LFH):

    a.   Analog Inputs Measured:
        1)   Fume Hood Controller Air Flow – CFM *
        2)   Fume Hood Safety Monitor Air Flow – FPM *

    b.   Analog Inputs Calculated:
        1)   Damper Position – Exhaust *
        2)   [Sash Height]

    c.   Analog Binary Input:
        1)   Safety Monitor – Status Alarm

    d.   Digital Outputs:
        1)   Auto - Zero Module

    e.   Analog Outputs:
        1)   Damper Control – Supply & Exhaust

    f.   System Features - Programs:
        1)   Fume Hood Controller – High Analog Alarm
        2)   Fume Hood Controller – Low Analog Alarm
        3)   Fume Hood Safety Monitor – Low Analog Alarm
        4)   Trend *

10.   [General Exhaust Fans], [Hot Lab Exhaust Fans], [Fume Hood Exhaust Fans]:

    a.   Analog Inputs - Measured:
        1)   Air Flow CFM *

    b.   Analog Binary Input:
        1)   Current Relay *

    c.   Digital Output:
        1)   On – Off *

    d.   Digital Input:
        1)   Current Sensor for Fan Status*

    e.   Analog Output:
        1)   VFD

    f.   System Features:
        1)   Alarm *
        2)   Proof *
        3)   LAN device for VFD to BAS

          4)   Trend *

11.   [ATC Isolation Dampers:]

    a.   Analog Binary Input:
          1)   Status

    b.   Digital Output:
          1)   On – Off

    c.   System Features:
          1)   Alarm *
          2)   Proof *

12.   [Filter Housing Assembly:]

    a.   Analog Measured:
          1)   Duct Pressure

    b.   Digital Output:
          1)   Pressure Differential Across Each Filter
          2)   Duct DP Sensor to BAS

    c.   System Features:
          1)   Graphics and Programming

13.   [Fan Coil Units], [Unit Heaters], [Cabinet Heaters]:

    a.   Analog Inputs Measured:
          1)   Space Temperature *

    b.   Analog Inputs Calculated:
          1)   Valve Position *

    c.   Digital Output:
          1)   On – Off *
          2)   Heating Valve *

    d.   Digital Input:
          1)   Current Sensor for Fan Status*
          2)   <u>Drain Pan Moisture Sensor*</u>

    e.   Analog Outputs:
          1)   Reheat Valve Control *
          2)   FCU Space Set Point Adjustment *

    f.   System Features:

1)   Proof *
2)   Trend

14.   [Fan Powered Box:]

     a.   Analog Inputs - Measured:
         1)   Space Temperature *
         2)   Supply Air Temperature *
         3)   Supply Air Flow – CFM *

     b.   Analog Inputs Calculated:
         1)   Heating Valve Position *
         2)   Cooling Valve Position *
         3)   Damper Position – Return & Ventilation *

     c.   Digital Outputs:
         1)   [Fin Tube Radiation Valve] *
         2)   [Alarms – Temp and Flow]

     d.   Digital Input:
         1)   Current Sensor for Fan Status*
         2)   Drain Pan Moisture Sensor*

     e.   Analog Outputs:
         1)   Damper Control *
         2)   Reheat Valve Control *
         3)   Cooling Valve Control *
         4)   Space Set Point Adjustment *
         5)   [Fin Tube Radiation Valve] *

     f.   System Features - Programs:
         1)   Night Setback
         2)   Occupied/Unoccupied
         3)   Trend *

15.   [Convectors]:

     a.   Analog Inputs Measured:
         1)   Space Temperature *

     b.   Analog Inputs Calculated:
         1)   Valve Position *

     c.   Digital Output:
         1)   Heating Valve *

  d. Digital Input:
    1) Current Sensor for Fan status *

  e. Analog Outputs:
    1) Heating Valve Control *
    2) Space Set Point Adjustment *

  f. System Features:
    1) Trend *

16. [Chilled Beams]

  a. Analog Inputs Measured:
    1) Space Temperature *

  b. Analog Inputs Calculated:
    1) Valve Position *

  c. Digital Output:
    1) Heating Valve *

  d. Analog Outputs:
    1) Heat Valve Control *
    2) Space Set Point Adjustment *

  e. System Features:
    1) Trend *

17. [Walk In Cold Rooms:]

  a. Analog Inputs - Measured:
    1) Space Temperature

  b. Analog Binary Input:
    1) Status

  c. System Features:
    1) Alarm – High Binary Alarm
    2) Alarm – High/Low Temp Alarm

18. [Server Rooms:]

  a. Analog Inputs - Measured:
    1) Space Temperature
    2) Compressor status
    3) RH

  b. System Features:
    1) Alarm – High Analog Alarm
    2) Compressor Failure
    3) Safety Trip
    4) Com Error
    5) General Alarm
    6) Water Alarm
    7) Trend
    8) Alarm Instruction
    9) MODBUS interface if applicable

19. System Features (Typical for '1' through '14' above):

  a. General:
    1) Color Graphics
    2) DDC Control
    3) Programming
    4) Trend

  b. For points related to supplemental A/C equipment see points list specified elsewhere.
  c. For points related to HVAC Systems coordinate with UMB and insert as directed.

C. BAS Networking and Point Identification: BAS contractor shall use the UMB Standard BAS Networking and Point Identification information and naming conventions for all project required networking and points. Include these requirements in the BAS Submittal. Contact UMB Building Automation Manager for additional requirements.

3.9 EMERGENCY POWER <Engineer to Edit for Project>

A. BAS Emergency Power Requirements:

1. Connect the following BAS equipment to the building emergency power system as indicated on the contract drawings:

  a. Building Level Network by UPS.
  b. Floor Level Control Network and STU, ETU, FHET Power.
  c. UPS Devices.

2. All tie-ins to the emergency power system will be accomplished through a non-switching UPS with "micro pods" to allow for servicing the UPS without interrupting the downstream components
3. BAS contractor shall coordinate the power requirements for this equipment with the electrical contractor.

3.10   AIR TERMINAL UNITS

    A.   Air terminal units shall be furnished and installed by the sheet metal contractor. All control components and wiring shall be furnished and be installed by the BAS contractor.

    B.   Reheat control valves shall be furnished by the BAS contractor and installed by the mechanical contractor. All control components and wiring shall be furnished and be installed by the BAS contractor.

    C.   Furnish, terminate and connect all cables as required.

3.11   LABORATORY AIRFLOW CONTROL VALVES <Engineer to Edit for Project>

    A.   Laboratory airflow control valves shall be provided by the BAS contractor and installed in the ductwork by the sheet metal contractor. All control components and wiring shall be installed by the BAS contractor.

    B.   [Install 20 psi clean, pneumatic supply air to all airflow control valves if pneumatic.]

    C.   Furnish, terminate and connect all cables as required.

3.12   FUME HOOD CONTROLLER ASSEMBLY

    A.   BACnet Fume Hood Controller: The enclosure may be mounted directly on the exterior of the fume hood or remotely on the laboratory wall or ceiling.

    B.   Operator Display Panel II: The Operator Display Panel shall be field mounted on the fume hood where indicated on the fume hood submittal and shall fit over any unused hood electrical box or over predrilled holes.

3.13   PROJECT MANAGEMENT <Engineer to Edit for Project>

    A.   The Contractor shall designate a project manager for the Building Automation System who will be responsible for the following:

        1.   Construct and maintain BAS project schedule.
        2.   On-site coordination of BAS requirements with all applicable trades and subcontractors.
        3.   Authorized to accept and execute orders or instructions for the BAS from the University's Representative.
        4.   Attend project meetings as necessary to avoid conflicts and delays.
        5.   Make necessary field decisions relating to this scope of work.
        6.   [BL-3 Lab Special Provisions.]

a.   All penetrations of piping and wiring through walls, ceilings, and floors of the BL-3 suite shall be sealed and caulked. Seal inside the thermostat back boxes, and at wiring/tubing entry points with Silicone sealant material.

3.14   GRAPHICS AND PROGRAMING
<Engineer to Edit the Control Name: Siemens, Johnson Control, Delta Coordinate with UMB>

A.   Graphics: For campus renovation projects, the BAS Contractor shall provide a graphics package as follows:

1.   Existing Graphics: Where graphics exist in the Siemens System for the project, the BAS contractor shall either modify the existing graphics or replace the existing graphics with new graphics indicating the architectural changes to the project area and the locations of air terminal units or HVAC equipment and BAS sensors.

2.   New Graphics: Where the Siemens System does not include graphics for the project, the BAS contractor shall provide a new graphics package for the project area indicating the architectural changes to the project area and the locations of air terminal units or HVAC equipment and BAS sensors.

3.   New Graphics Background: Where new backgrounds are created by the BAS contractor these backgrounds must reside on and be compatible the Siemens Front End System and software. The BAS contractor can either create the background or utilize a CAD dwg file from the consultant or UMB as the background.

4.   BAS Sensors: Where BAS Sensors are installed in HVAC Systems show the sensor locations on the mechanical graphics diagrams and the floor plan graphics. The locations on the mechanical graphics diagram shall include the nearest room number as a location reference. Identify each sensor by sensor type, floor number and numerical number. Types of sensors include but may not limited to the following:

   a.   Hydronic Systems: Differential pressure sensors in hydronic piping systems. (DPS – 2 – 1, 2…)

   b.   Air Systems: Static pressure sensors in air distribution systems. (SPS – 1 – 1, 2…)

B.   Programing: For campus renovation projects, the BAS Contractor shall provide the required programing as follows:

1.   Existing Programing: Where programing exists in the Siemens System for the existing air terminal units or HVAC equipment that is either relocated, or removed and replaced, the existing building automation system programming shall be either modified or deleted, and a new program written by the BAS contractor to identify the air terminal units with the rooms they serve as part of the ATC work for the project.

2.   New Programing: Where programing does not exist in the Siemens System for the existing air terminal units or HVAC equipment that is either relocated, or removed and replaced, the BAS contractor shall provide new programming to identify the

air terminal units with the rooms they serve as part of the ATC work for the project. The new programing must reside on and be compatible the Siemens Front End System and software.

   3. Miscellaneous: Programming modifications shall also include the occupied and unoccupied modes of control for each terminal unit or lead/lag operation for HVAC equipment.

3.15   TESTING AND ADJUSTMENT

A. Furnish labor, material, instruments, supplies, and services and bear costs for the accomplishment of all tests herein specified. Correct defects appearing under test, and repeat the tests until no defects are observed. Leave the equipment clean and ready for use.

B. Perform other tests that may be required by the State Building Code, Fire Code, or Underwriter's Laboratory.

C. Furnish necessary testing apparatus, make temporary connections, and perform testing operations required at no additional cost to the University.

D. Upon completion of the project:

   1. Completely adjust, ready for use, thermostats, controllers, DDC panels, transducers, valves, damper operators, relays, etc., provided under this Section.
   2. Load and debug software and related data base provided for under this Contract.

3.16   START UP AND COMMISSIONING

A. Start Up: Comply with the following:

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

   2. Provide any recommendation for system modification in writing to the University. Do not make any system modification, including operating parameters and control settings, without prior approval of University's Representative.

B. Commissioning: See Division 23, Specification Section "Commissioning HVAC Systems" for requirements. Schedule a time and date with the UMB Commissioning representative through the UMB-PM.

END OF SECTION 230900