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BuildingName
The Description of the Project
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SPECIFICATION DIVISION 23

NUMBER SECTION DESCRIPTION

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)
SECTION 230905 - MECHANICAL SYSTEMS CONTROLS (HOSPITAL PROJECTS)

END OF CONTENTS TABLE

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)
SECTION 230905 - MECHANICAL SYSTEMS CONTROLS (HOSPITAL PROJECTS)

REVISION NOTES:

JULY 2026: REVISED TO REFLECT NEED TO PROVIDE NIST CERTIFICATION RECORD FOR CERTAIN APPLICATIONS.

APRIL 2026: REVISED TO REFLECT KODE INTEGRATION, ADDED SIEMENS AND DISTECH AS ACCEPTABLE ROUTER MANUFACTURERS, CLARIFIED TEMPERATURE SENSOR REQUIREMENTS, MODIFIED ACCEPTABLE GAS DETECTION MANUFACTURERS, ADDED LINK TO A KNOWLEDGE BASED ARTICLE AROUND UMH'S BMS ADDRESSING REQUIREMENTS UNDER SUBMITTALS SECTION.

JUNE 2025: REVISED TO REFLECT AL IP CONTROLLERS AND COMMUNICATION. MS/TP RESERVED FOR LIMITED APPLICATIONS WHERE IP IS NOT AVAILABLE. REVISED BMS ADDRESS TEMPLATE ACCESS LOCATION. REVISED SHOP DRAWING REQUIREMENTS. MISC CONTROLLER POWER REQUIREMENTS. CHANGE IN SENSOR REQUIREMENTS (REMOVAL OF LPI'S). FORMATTING CHANGES TO COMBINATION SENSORS (NOW INCLUDE MASTER OA SENSORS). REQUIREMENTS FOR INDICATION GAUGES FOR PRESSURE TRANSDUCERS. CHANGES TO CONTROL VALVE AND ACTUATOR REQUIREMENTS. ADDED LABELLING REQUIREMENTS AND ADDITIONAL DEMOLITION REQUIREMENTS. ADDED PANEL WIRING REQUIREMENTS. ADDED DDC PANEL HMI REQUIREMENTS. ADDED 3.8 CRITICAL ROOM TYPES.

JULY 2024: REMOVED ASI, ADDED DISTECH. REMOVED BIBB TABLE 1. EDITED HMI REQUIREMENTS TO REFLECT ALL IP. INCORPORATED NEED FOR DDC CONTROLLERS ON AIR TERMINAL UNITS PROVIDE DAMPER AND RHC VALVE POSITION TO THE BMS.

JUNE 2024: BALL STYLE CONTROL VALVES ARE NOW SPECIFIED TO BE NICKEL COATED BRASS OR STAINLESS STEEL CONSTRUCTION DUE TO WATER QUALITY ISSUES CASUING CORROSION AND FAILURE IN BALL VALVES WITH BRASS CONSTRUCTION. LTDE INSTALLATION REQUIREMENTS HAVE BEEN ADJUSTED TO MATCH MANUFACTURER RECOMMENDED INSTALLATION REQUIREMENTS.

MARCH 2024: UPDATED LINK UNDER 3.14. UPDATED IAQ MONITOR REQUIREMENTS UNDER SECTION 2.3. MODIIED 1.1.E FOR DESCRIPTION OF SIEMENS SERVER ARCHITECTURE.

JUNE 2023: MODIFIED AUTOMATIC CONTROL VALVE SECTION 2.14 AND DAMPER OPERATORS SECTION 2.16 TO INCLUDE ELECTRIC ACTUATION AS THE PREFERRED OPTION FOR NEW PROJECTS. REORGANIZED SECTION 2.14 TO SIMPLIFY VALVE REQUIREMENTS PER UM CONTROLS AD HOC SPECIFICATION SUBCOMMITTEE. CLARIFIED THERMISTOR REQUIREMENTS. REFORMATTED SECTIONS 2.5 THRU 2.11 TO ALIGN WITH CAMPUS SPEC FORMATTING, LITTLE IF ANY TECHNICAL CHANGES MADE. ADDED SECTIONS 3.3 THRU 3.6 TO ALIGN WITH CAMPUS.

FEBRUARY 2023: INCLUDES CHANGES ASSOCIATED WITH NEW SYSTEMS INTEGRATION SPEC 230924. CHANGED UMHHC TO UMH TO REFLECT BRANDING CHANGE. ADDED REFERENCE TO AND CONTACT INFO FOR FACILITIES APPLICATIONS AND SYSTEMS MONITORING GROUP. ADDED REQUIREMENTS FOR ALL IP DDC SOLUTIONS. MODIFIED DDC CONTROLLER REQUIREMENTS, INCLUDING ALARM AND TREND MANAGEMENT REQUIREMENTS. ADDED REQUIREMENT FOR MSCC TO PROVIDE LATEST FIRMWARE. MODIFIED DEMOLITION OF LEGACY DDC SYSTEM RESPONSIBILITIES. MODIFIED REQUIREMENT THAT MSCC CONFIGURE HMI'S.

MISC CHANGES TO INCORPORATE CAMPUS CHANGES TO 230900, INCLUDING EXPANDED ELECTRONIC ACTUATOR REQUIREMENTS, AND CONTROL LOOP TUNING REQUIREMENTS. ADDED GAS DETECTION, INCLUDING MRI O2 DEPLETION. ADDED OCC SENSORS FOR ORS. ADDED ROOM PRESSURE INDICATOR REQUIREMENTS. MINOR CHANGES TO SUBMITTAL AND WARRANTY REQUIREMENTS, INCLUDING NEW BMS ADDRESSING REQUIREMENTS.

MAY 2021: ADDED COV SETTING REQUIREMENTS, MODIFIED CONTROL DAMPER REQUIREMENTS.

AUGUST 2020: DELETED HONEYWELL AS ACCEPTABLE MSCC. UPDATED 3.14 TABLE 1 WITH UPDATED BACNET CONTROLLER PERFORMANCE.

JULY 2019: UPDATED UPS MODEL REQUIREMENTS.

MAY 2019: ADD COMBINATION ROOM TEMP AND HUMIDITY SENSOR. REVISE BALL VALVE ACTUATORS TO MODULATING TYPE.

JANUARY 2019: MODIFIED REQUIREMENTS FOR HMI'S. ADD CONDENSATION SENSOR, ALARM INDICATION STATION, OCCUPANCY COUNTER. PART 3: INDICATED THAT SETPOINTS ON DOCUMENTS ARE PRELIMINARY AND MUST BE FINALIZED WITH THE ENGINEER AND COMMISSIONING AUTHORITY PRIOR TO PROGRAMMING. ADDED SELF CALIBRATION DEVICE REQUIREMENTS.

JUNE 2018: REVISIONS TO SCOPE OF WORK, ADDED ONICON TO FLOWMETER MANUF, NEW UPS REQUIREMENTS AND INSTALLATIONS, REDEFINED ROOM PRESSURE MONITORS AS HMI'S, NEW HMI REQUIREMENTS AND INSTALLATIONS, PANEL IDENTIFICATION AND POINT DESCRIPTION ID REQUIREMENTS, CHANGES IN DEMOLITION SCOPE.

MAY 2017: REVISED SECTION TO ADD CONSTANT VOLUME VENTURI(CVV) FUME HOOD LAB AIRFLOW CONTROLS. VAV FUME HOOD LAB AIRFLOW CONTROLS, INCLUDING ALL OTHER MECHANICAL CONTROLS IN THE VAV FUME HOOD LAB, REMAINS IN MS230910. REFER TO DESIGN GUIDELINE 230030 FOR ADDITIONAL GUIDANCE. ADDITIONAL EDITS INCLUDE CLARIFICATION TO CONTROL DEMOLITION SCOPE, MISCELLANEOUS FLOW METER CLARIFICATIONS, HMI CLARIFICATIONS, CHANGE REFERENCE OF MCIT TO HITS, ADDITIONAL VAV CONTROLLER REQUIREMENTS, CHANGES TO DDC WIRING REQUIREMENTS, IDENTIFICATION LABELLING REQUIREMENTS, AND OTHER MISC EDITS

MAY 2015: NEW SECTION, SPECIFIC AND APPROPRIATE FOR HOSPITAL FUNDED PROJECTS ONLY

APRIL 2016: DEFINED THAT DDC HMI SHALL BE PROVIDED & INSTALLED BY MSCC, PROGRAMMED BY SI. MODIFIED SUBMITTAL REQUIREMENTS. FURTHER DEFINED DDC ARCHITECTURE. ADDED TSTAT AUX COMM PORT. MODIFIED HMI & DIFF PRESSURE TRANSMITTER REQUIREMENTS. MODIFIED BACNET NAMING REQUIREMENTS. ADDED INSTALLATION REQUIREMENTS.

EDITOR'S NOTE:

THESE SPECIFICATIONS MUST BE CUSTOMIZED APPROPRIATELY FOR EACH PROJECT. IN ADDITION TO THESE SPECIFICATIONS, THE PLANS ARE TO INCLUDE THE FOLLOWING, AS A MINIMUM:

- *TEMPERATURE CONTROL DIAGRAM / SCHEMATIC OF EACH SYSTEM (AIR HANDLING UNIT, CHILLED WATER, HOT WATER, AIR TERMINIALS, ETC.) INDICATING ALL CONTROL AND MONITORING INSTRUMENTS AND COMPONENTS. THE DIAGRAM SHOULD ALSO INCLUDE AN INPUT / OUTPUT SCHEDULE FOR THE DDC CONTROLLER AND SEQUENCE OF OPERATION. AUXILIARY CONTROL COMPONENTS SHALL BE INSTALLED IN AUXILIARY CONTROL PANELS (LOOP POWERED INDICATORS, E.P. RELAYS, P.E. SWITCHES, DIFFERENTIAL PRESSURE TRANSDUCERS, ETC.) SHALL BE SO INDICATED BY SOME METHOD. (I.E. ASTERISK)*

- *INDICATION OF ALL POINTS TO BE DISPLAYED ON THE HUMAN MACHINE INTERFACE (HMI) TOUCHSCREEN PANEL.*

- *LOCATIONS OF ALL DDC PANEL ARRAYS.*

- *PROVIDE TWO 20 AMP POWER CIRCUITS AT EACH DDC/AUXILIARY PANEL LOCATION. ONE CIRCUIT IS FOR THE DDC PANEL, THE OTHER IS FOR THE AUXILIARY PANEL. ELECTRICAL POWER REQUIREMENTS TO BE COORDINATED WITH ELECTRICAL DRAWINGS.*

- *WIRING DIAGRAMS FOR EACH SYSTEM TO SHOW INTENT OF AUTOMATIC OR INTERLOCKED OPERATION.*

- *SCHEDULES FOR DAMPERS, AIRFLOW MEASURING STATIONS, STATIC PRESSURE PROBE LOCATIONS, HUMIDITY RESET, TEMPERATURE RESET, DAY/NIGHT CONTROL ZONE, ETC.*

- *LOCATIONS OF ALL HITS DATA DROPS, SHOWN AT LOCATIONS FOR ALL IP CONTROLLERS.*

THE SCOPE OF THIS SPECIFICATION INCLUDES CONTROLS FOR ANY LAB ROOM WITHOUT VAV FUME HOODS WHICH INCLUDES HOODS WITH COMBINATION SASHES. IF A LAB ROOM INCLUDES THOSE HOOD TYPES, U-M MASTER SPEC 230910 MUST BE INCLUDED TO COVER ALL MECHANICAL CONTROLS IN THOSE ROOMS.

PART 1 - GENERAL

1.1 MECHANICAL CONTROL SYSTEM GENERAL REQUIREMENTS

A. This Section specifies mechanical systems controls applicable to all project controls except for labs with variable air volume (VAV) fume hoods, including combination (vertical/horizontal) sash fume hoods. Controls in rooms with VAV and combination sash hoods shall be in accordance with Section 230910.

B. The complete control system work shall be split between the Mechanical Systems Controls Contractor (MSCC), the Master Systems Integrator (MSI), UMH Facilities Applications and UMH's HITS department as described under section 1.4 "Scope of Work".

C. The Mechanical Systems Controls Contractor shall provide a fully integrated BACnet Mechanical Control System (MCS) incorporating electric, pneumatic, and direct digital control (DDC) components for the control and monitoring of heating, ventilating and air conditioning (HVAC) equipment and other related systems. Controllers shall natively use the most current ANSI/ASHRAE Standard 135 for communications and shall be BTL certified with BTL published PIC statements. Proprietary networks and protocols to one company or distributed by one company are prohibited.

D. All controllers to be used as an integral part of the proposed MCS must be contained on the vendor's "Acceptable BACnet Controllers" list (including BTL PIC statements) on file with the UMH Facility Planning and Development (FPD) office and included in Table 1 on BMS Network Architecture Detail on the contract documents. All pre-qualified MSCC shall periodically update their product documentation for approved products to reflect the most current product configurations and features. All new or different parts to be used on this project shall either be submitted and approved prior to bid or specifically included as an alternate on the bid form, in accordance with the alternate product requirements contained general conditions of these specifications. UMH reserves the right to reject any part not pre-approved which could result in bid disqualification. Any part that is installed that is not on the "Acceptable BACnet Controllers" list will be removed at the contractor's expense and replaced with the pre-approved controller needed to meet the requirements of these project documents.

E. University of Michigan Health (UMH) maintains an existing Vykon Niagara Supervisor BACnet Advanced Workstation (B-AWS), for local integration of BACnet Building Controllers (B-BC). This software is installed on application servers located in the HITS data center.

F. University of Michigan Health (UMH) maintains a cloud based integration platform, KODE OS, which provides system monitoring, alarming, scheduling, reporting and historical trend functions via graphical user interface.

G. The project shall provide a fully functional MCS comprised of BACnet Building Controllers (B-BC), advanced application controllers (B-AAC), application specific controllers (B-ASC) and Smart Sensors (B-SS), Smart Actuators (B-SA) and Operators Displays (B-OD). The MSCC shall configure, program and commission all controllers to provide the required functionality as defined in the sequence of operation located on the MCS drawings.

H. The MSCC will be responsible to configure B-BC's, B-AAC's and B-ASC's to serve BACnet data to BACnet Clients installed on the HITS network. Each B-BC shall be configured and programmed to expose all BACnet Objects associated with controllers supervised by the B-BC. The MSCC shall configure the B-BC's, B-AAC's and B-ASC's to utilize a Change of Value subscription within the Vykon Niagara Supervisor. Change of Value increments shall be set (tuned) to minimize HITS network traffic.

I. All MCS communication within the Vykon Niagara Supervisor requires the use of BACnet Broadcast Distribution Device configuration (BBMD). UMH maintains a BBMD server and will expand the BACnet Distribution Table (BDT) as needed for the project. Submit project requirements as detailed below to facilitate the BDT entries. Coordinate with UMH HITS to determine the proper server level setup for proper communication. The MSCC shall provide proper personnel skilled at BBMD and IT configuration to work with the UMH FPD personnel as needed.

1.2 DEFINITIONS

A. AWS: Advanced Workstation

B. BMS: Building Management System

C. BTL: BACnet Testing Labs http://www.bacnetinternational.net/btl/

D. B-AAC: BACnet Advanced Application Controller

E. B-ASC: BACnet Application Specific Controller

F. B-AWS: BACnet Advanced Workstation

G. B-OD: BACnet Operators Device

H. B-BC: BACnet Building Controller

I. B-SA: BACnet Smart Actuator

J. B-SS: BACnet Smart Sensor

K. BBMD: BACnet Broadcast Management Device

L. BDT: BACnet Distribution Table

M. DDC: Direct Digital Control

N. UMH Facilities Applications: UMH department responsible for maintaining the hospital's Building Management System application

O. UMH BAS Controls: UMH department responsible for maintaining the hospitals BMS hardware and devices

P. FLN: Field Level Network

Q. FPD: UMH Facilities Planning and Development department responsible for design & construction

R. HITS: Health Information Technology & Services

S. HMI: Human Machine Interface Panel

T. MSCC: Mechanical Systems Controls Contractor

U. MCS: Mechanical Control System

V. MSI: Master Systems Integrator

W. Systems Monitoring: UMH department responsible for operating the hospital's Building Management System

X. TC: Temperature Controls

Y. UMH: University of Michigan Health

Z. VFD: Variable Frequency Drive

1.3 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, Standard General and Supplementary General Conditions, Division 1 Specification Sections, and other applicable Specification Sections including the Related Sections listed below, apply to this Section.

B. Related Sections

1. Division 26: Electrical
2. 220523 Valves
3. 233600 Air Terminal Units
4. 230910 VAV Fume Hood Laboratory Air Flow Controls
5. 250000 Integrated Automation

1.4 SCOPE OF WORK

A. The complete control system work shall be split between the Mechanical Systems Controls Contractor, the Master Systems Integrator and UMH's HITS department as described below and under section 1.5 "Related Work by Others". As it relates to the extent of responsibility for work within this specification section, "provide" shall mean the identified party both furnishes and installs such item(s). "Furnish" shall mean the identified party furnishes the item for installation by others.

B. The Mechanical Systems Controls Contractor and the Master System Integrator shall be a direct Subcontractor to the Contractor.

C. Summary of work by the Mechanical Systems Controls Contractor shall include, but not be limited to:

1. Provide and install a native BACnet-based (latest version of ANSI/ ASHRAE 135) MCS consisting of programmable and application specific BACnet IP DDC controllers, electronic sensors, pneumatic actuators, electronic to pneumatic transducers, relays, switches, control panels, power supplies, twisted shielded pair (TSP)network cabling and all associated control wiring (excluding Ethernet network wiring) and low voltage conduit systems.
2. Provide and install control panels for all DDC controllers and an auxiliary control panel for all ancillary control devices (24VAC transformers, electric and pneumatic relays, EP switches, contactors, etc.)
3. Provide and install BACnet IP application specific controllers (B-ACS) or advanced application controllers (B-AAC) for terminal units (VAV, Dual Duct, Fan Coil Units etc.) including associated room temperature sensors, room temperature sensors with LED display, room temperature sensors with bias adjustment, and CO2 sensors.
4. Create BACnet object names and tags according to UMH's point naming standard outlined at in Section 3 – Execution.
5. MSCC shall provide and install primary network raceways, from panel to Telecomm Room, to permit communication to the existing Building Management System (BMS) server(s) via BACnet IP. UMH HITS shall provide primary network cabling.

6. MSCC shall provide and install secondary field level network data connection raceways between panels to permit communication to the existing Building Management System (BMS) server(s) via BACnet IP. UMH HITS shall provide secondary field level network cabling.
7. MSCC shall be responsible for final connection of DDC panels to the primary and field level networks (at the panel). UMH HITS shall provide and install the patch panel network connections in the Telecomm Rooms.
8. MSCC shall provide and install MS/TP communication trunk (cabling and raceways) for non-IP BACnet communication (i.e. SA's, SS's, packaged equipment controllers [chillers, VFDs, etc.] and room HMI's), when IP communication is not supported by the device.
9. For UM Utility's energy metering, install UM furnished data acquisition panel for utility metering. Provide Ethernet connection of Utility Meters to host computer. MSCC shall provide and install data connection raceway from panel to facility cable tray. Provide wiring from meters and transmitters to utility data acquisition panels. Provide communication wiring to utility data acquisition panels. Terminations inside panels by UM Utilities.
10. Engineering, submittals, as-built drawings, and operation and maintenance manuals.
11. Provide an auxiliary temperature control panel adjacent to each DDC panel. Provide additional auxiliary panels as required to house the required quantity of control components. Small control installations with limited future expansion may be allowed to forego an aux panel and install all devices in a single DDC panel- contact project engineer for approval. Auxiliary panels shall not be smaller than 24"x24" and shall have a 1' high by minimum 2' wide (but not less than panel width) contiguous clear area which can be used for future expansion. Provide all wiring between the DDC panel and the auxiliary panel(s).
12. Provide, install and configure all Human Machine Interfaces (HMI's), Room Pressure Monitors (RPM) and Room Pressure Indicators (RPI). Provide all wiring and accessories required to enable HMI/ RPM/ RPI to function as specified.
13. Provide and mount all airflow measuring station/ flow meter LCD readout panels on wall adjacent to DDC panels.
14. Provide & install all UPS's and required enclosures. Provide all interconnecting power wiring between the DDC panel power supply and the UPS panel receptacle.
15. Provide a 6"x 6" wiring trough extending over and between each DDC, auxiliary temperature control, and LPI panel. Provide 1" conduit from trough to cable tray, bonded to tray, for HITS network connection (coordinate routing with HITS).
16. Provide and install all DDC panel and device enclosures.
17. Provide pneumatic thermostats (where applicable), control valves, dampers, operators, meters, control air tubing, etc.
18. Provide pneumatic air main piping, PRV's and accessories.
19. Provide gauges, indicating devices, electric and electronic control accessories, and other control system devices.
20. Provide setup/ programming, calibration and start-up services of all DDC and non-DDC temperature control systems.
21. Configuration of all required alarming and point/object trending at the local DDC panel, as indicated by project documents.

22. Provide site supervision of temperature control work and coordination with related, pneumatic, electrical, fire alarm work and packaged controls.
23. Provide all control wiring and electrical components necessary for each system to permit automatic or interlocked operation, such as: air cooled condensing units, high level alarm circuits, damper end switches, fuel oil pumping/monitoring systems, chiller control/interface panels, boiler control/interface panels, early break contacts on disconnects to VSD's, cooling tower vibration switches, etc.
24. The MSCC shall be responsible for identifying the demolition/decommissioning scope on UMH's legacy Siemens, Honeywell, Johnson Controls, and/ or ASI DDC systems impacted by the project scope.
25. Configuration of all required alarming and point/object trending at the local DDC panel, as indicated by project documents.
26. Re-establish and validate existing DDC controller communication modified by the scope of work.
27. All other work and components required for complete and operational temperature control systems as specified herein, excluding work specified below in "Related Work by Others" section that is to be provided or furnished by the Systems Integrator.
28. Start-up, calibration, and checkout of sensors, transducers, thermostats, control valves, dampers/damper operators, meters, and all other components provided.
29. Commission all mechanical controls provided. Provide a detailed list of every control point installed to the project Commissioning Authority (CxA) and verify proper operation of each component prior to commissioning the controls with the CxA. Include, in checklist format, a detailed procedure to verify all aspects of the controls' Sequence of Operation.
30. Complete point-to-point verification and reporting for the CxA and MSI.
31. Coordination with Master Systems Integrator as well as UMH's HITS, Facilities Applications and Systems Monitoring groups.
32. Training of UMH personnel to familiarize operations staff with the configuration and operation of this project's MCS installations.

SPEC WRITER NOTES: FUME HOOD MONITORS ARE TYPICALLY NOT PROVIDED BY THE MSCC ON UMH PROJECTS, BUT ARE RATHER PROVIDED WITH THE FUME HOOD. FOR RARE OCCASIONS WHERE THE MSCC WILL PROVIDE THE FUME HOOD MONITOR, CHANGE THE FOLLOWING PARAGRAPH FROM HIDDEN TEXT.

33. Provide fume hood monitors except in rooms with VAV hoods, including combination sash fume hoods.
34. Provides controls for temporary heating/cooling/ventilation during construction, as required by the owner's construction manager.
35. Establish IP communication between all DDC devices and points and the UMH Vykon Niagara Supervisor, as indicated on the contract documents, for a complete and operational control system. Including:
    a. Re-establishing and validating existing DDC controller communication to the Vykon Niagara Supervisor, modified by the scope of work.

1.5 RELATED WORK BY OTHERS

A. A Master System Integrator (MSI) shall be contracted to coordinate all smart building system integration, including HVAC, Lighting, Metering, Generators, Fire, and third-party IoT devices.

B. BMS related work by the Master Systems Integrator (MSI):

1. Integration of all DDC devices and points into the UMH Vykon Niagara Supervisor, as indicated on the contract documents, for a complete and operational control system. Including:
   a. BACnet device and object discovery
   b. Re-establish and validate existing DDC controller communication/integration to the Vykon Niagara Supervisor, modified by the scope of work
   c. Provides system integration for temporary heating/cooling/ventilation during construction, as required by the owner's construction manager.
2. Coordinate with all subcontractors to ensure consistent integration process
3. Lead integration workshops and monthly coordination meetings
4. Validate and accept integration work performed by the MSCC or other contractors
5. Provide the graphical interface, dashboards, alarming and trending functions as defined by UMH.
6. See specification section 250000 Integrated Automation

C. BMS related work by UMH HITS:

1. Providing IP Layer 3 networking (primary and secondary field level network) for all peer-to-peer communication of DDC Building Controllers, utility acquisition panels and the front-end. The MSCC shall be responsible for coordinating implementation of the MCS on the HITS network without disruption.
2. HITS will verify network connectivity and establish a TCP connection between the BMS and the network drop termination.
3. HITS will provide all required patch cables for the connection between the initial data drop and the IP controller. MSCC shall be responsible for connecting all patch cables at respective IP devices (controllers, routers, UPS's, etc).

D. BMS related work by UM Utilities

1. Provide utility meter data acquisition panels. Panels installed and wired by MSCC. UM Utilities to terminate all I/O wiring and data connections, as well as start-up, configure and commission the panel.

E. BMS related work by UMH Facilities Applications:

1. Management of existing and assignment of new:
   a. IP addresses
   b. BACnet Device Instance and Network numbers
   c. BACnet Broadcast Management Device (BBMD) and Broadcast Distribution Table (BDT)
   d. MS/TP MAC Addresses
2. Validation that network devices meet the HITS "UDEW Process" to validate network security.
3. Confirmation of Telecommunication Rooms to extend network communications to IP devices.
4. Onboarding IP devices onto HITS network.

F. BMS related work by UMH Systems Monitoring:

1. Removal/ decommissioning of all graphics, alarms, trends on UMH's legacy BMS front ends (ie Honeywell EBI & JCI Metasys) related to points, devices & controllers that have been modified as part of the MSCC's work.
2. Validation of final integration services.

G. BMS related work by UMH BAS Controls:

1. Removal/ decommissioning of all legacy DDC panel databases (ie Honeywell EBI & JCI Metasys) related to points, devices & controllers that have been modified as part of the MSCC's work.

1.6 ACCEPTABLE MECHANICAL SYSTEMS CONTROLS CONTRACTORS

A. The following MSCCs are acceptable for the furnishing and installation of pneumatic, electric and DDC components as specified in this section:

1. Siemens Industry Inc.
2. Fontanesi & Kann (Distech Controls)

EDITOR: IN GENERAL, UMH DESIRES TO BID ALL WORK TO THE CONTRACTORS LISTED UNDER 1.6. HOWEVER, IN SPECIFIC INSTANCES, THERE MAY BE REASONS (I.E. MAINTAINING A SINGLE CONTROL SOLUTION IN CERTAIN CRITICAL SYSTEMS [CHILLER PLANTS, HEATING PLANTS, ETC] AND CERTAIN CRITICAL APPLICATIONS [PHARMACIES, ETC]) TO SOLE SOURCE WORK TO A SINGLE CONTROLS CONTRACTOR. WHEN THERE ARE REASONS TO SOLE SOURCE CONTROL WORK, THE AE SHALL CONTACT THE UM DESIGN MANAGER TO DETERMINE WHICH OF THE ABOVE CONTROLS INSTALLATION CONTRACTORS ARE TO BE LISTED AS ACCEPTABLE FOR THE SPECIFIC PROJECT.

1.7 QUALITY ASSURANCE

A. Manufacturers and Products: The products and manufacturers specified in this Section establish the standard of quality for the Work. Subject to compliance with all requirements, provide specified products from the manufacturers named in Part 2.

B. Reference Standards: Products in this section shall be built, tested, and installed in compliance with the specified quality assurance standards; latest editions, unless noted otherwise.

1. Electrical Standards: Provide electrical products that have been tested, listed and labeled by UL and comply with NEMA standards as well as NFPA 70 (National Electric Code).
2. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electrical control systems.
3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
4. Install all BMS components, panels, and wiring in compliance with NEC and all local electrical codes.
5. DDC devices shall use the latest version of ANSI/ASHRAE Standard 135 "BACnet- Building Automation and Control Networking Protocol" standard for communications and have passed BTL certification as available.

6. UL Compliance: DDC Controllers for this project shall comply with UL916 Standard for Energy Management Equipment. DDC Controllers associated with equipment utilized in a smoke control application shall also comply with UUKL-UL 864 "Standard for Control Units and Accessories for Fire Alarm Systems".
7. National Institute of Standards and Technology (NIST), NIST IR 6392 Annex B: Profiles of Standard BACnet Devices.
8. Electronics Industries Association (EIA)
   a. EIA-232: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
   b. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for Use in Balanced Digital Multi-Point System

1.8 COORDINATION

A. Coordinate with the Master Systems Integrator, as well as UMH's HITS, Systems Monitoring, and Facilities Applications groups as specified.

B. All correspondence with UMH Facilities Applications shall be via email directed to bmsIntegrationRequest@umich.edu.

C. All correspondence with Systems Monitoring shall be via email directed to HFAC-OPERATIONS-SYSTEMS-MONITORING-E4-LEADS@med.umich.edu.

D. All correspondence with the Master System Integrator or other UMH departments (ie HITS, Fac Apps, Systems, BAS Controls) involved in the project shall copy the respective owner's project manager (ie AEC).

E. Ensure installation of components is complementary to installation of similar components in other systems.

F. Coordinate installation of system components with installation of other mechanical system equipment.

G. Coordinate control wiring requirements with mechanical equipment manufacturers.

SPEC WRITER NOTES: FUME HOOD MONITORS ARE TYPICALLY NOT PROVIDED BY THE MSCC ON UMH PROJECTS, BUT ARE RATHER PROVIDED WITH THE FUME HOOD. FOR RARE OCCASIONS WHERE THE MSCC WILL PROVIDE THE FUME HOOD MONITOR, CHANGE THE FOLLOWING PARAGRAPH FROM HIDDEN TEXT.

H. Coordinate with laboratory equipment suppliers (constant flow fume hoods, etc.) regarding dimensions and mounting location for alarm monitors and assure proper accommodation is made for the installation of other devices related to laboratory airflow controls.

1.9 SUBMITTALS

A. Prior to submitting shop drawings to the AE of record, the MSCC shall request BMS address assignments from the UMH Facilities Application group, including:

1. IP addresses for new devices and the necessary IP addresses of other BACnet IP devices (for the BACnet Broadcast Distribution Table)

2. BACnet Device Instance and Network numbers
3. BACnet BBMD (when required) and BDT
4. Device/ controller MAC addresses

MSCC shall be responsible for following the "BMS Address Request Process" provided by UMH: https://michmed.service-now.com/sp?id=kb_article_view&sysparm_article=KB0033233. MSCC shall utilize the latest BMS Address Request Form included in this process to request IP and BACnet addresses for all devices.

B. Once BMS addressing has been assigned by UMH Facilities Applications, submit shop drawings to the project AE of record for their review and approval and to FPD Engineer. AE shop drawings shall reflect assigned BMS addressing.

C. No work shall be done until the final submittals are approved by project AE.

D. MSCC shall submit approved shop drawings to the Systems Integrator for coordination.

E. Shop drawings shall contain, as a minimum, the following:

1. UMH BMS Addressing Template pre-filled in with all project specific DDC devices needing BMS addressing assignments.
2. Schematic diagrams of all systems being controlled and/or monitored indicating all DDC points or BACnet objects, BACnet instance numbers, IP addresses, MAC addresses, object names/numbers (using UMH standard point naming conventions), sensors, relays, controllers, valves, dampers, complete control wiring schematics (including starter, VSD, DX system, etc. wiring diagrams), pneumatic tubing, DDC panel maps, etc. Each control device shall be uniquely labeled. Label each device with setting or adjustable range of control. Indicate all wiring, clearly differentiating between factory and field installed wiring. Wiring should be shown in schematics that detail contact states, relay references, etc.
3. Clearly indicate if DDC points are analog inputs (AI), analog outputs (AO), digital inputs (DI) or digital outputs (DO), universal inputs (UI) or universal outputs (UO).
4. Wiring of each point to the DDC panels, including terminal block numbers.
5. Layout of all auxiliary devices and panels, and wiring of relays, contacts, etc. Include terminal block numbers at all control panels, at all mechanical equipment, and at all control devices. Provide the design of and wiring diagrams for all safety interlocks for equipment (LTDE, fire alarm, high/low static etc.)
6. Complete Sequence of Operation for each system being controlled, including set points, etc. in written (text) format. Identify each piece of equipment that the sequence of operation applies to utilizing the equipment tags from the engineer's control diagrams.
7. Summary of all alarming & trending requirements, including alarm thresholds and delays, for all DDC points. Submittal shall clearly indicate which alarms/ trends are configured at the local DDC panel and which are configured at the Vykon Niagara front-end.

8. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications
9. Schematic network diagram of the complete DDC system layout, including all panels, peripheral devices and primary network and secondary field level network cable routing. Identify IP addresses of each controller and device along with IDF room and HITS network switch & port connections.
10. Floor plan drawing showing locations of field devices/instrumentation, transformer panels, control panels, UPS panels, RPMs, RPIs, HMIs, network equipment and BMS components.
11. Electrical power panel and circuit, including if source is emergency power, normal power, or UPS power, for all DDC panels and devices/ actuators.
12. Pneumatic compressed air supply equipment, risers, and major tubing runs.
13. Complete bill of materials to identify and quantify all devices and controllers. Bill of materials shall be included on flow diagrams for each system and on each panel layout showing panel components.
14. Protocol Implementation Conformance Statements (PICS) for all native BACnet controllers and BACnet IP routers.
15. Location/ identification of BBMD including configuration details.
16. Location, on a floor plan, of all HITS layer 3 network data connections needed for IP controllers. Show data jack locations and quantity.
17. Point Description Identification of all DDC points included in project, consistent with UMH requirements.
18. Change Of Value (COV) point parameters, consistent with UMH requirements.
19. Submit blank field check-out and commissioning test reports, customized for each panel or system, which will be filled out by the technician during start-up.
20. A schedule of all nameplates and associated wording.
21. An index of sheets for ease of access.
22. Wiring diagrams and locations of power supplies.
23. Additional submittal items required for any room designated as a lab:
    a. Equipment schedule for each room or zone, with the following information:
        1) Equipment tag, room served, occupied/unoccupied min., max., and offset CFM; lab subnet description, name, and network address; network and power trunk identifier.
        2) Model number of each control component.
        3) Function of each terminal airflow unit and control component

F. Submit, as a minimum, the following design data schedules indicating:

1. Airflow Measuring Probes:
    a. Device tag.
    b. Equipment served/function.
    c. Model number.
    d. Size, type, and location.

e. Station area in square feet.
f. Max/Min Range.
g. Magnehelic scale range.
h. Velocity pressure range.

2. Air and water pressure sensors:
   a. Device tag.
   b. Equipment served/function.
   c. Model number.
   d. Size, type, and location.
   e. Max/Min Range.
3. Control Dampers:
   a. Damper tag.
   b. Equipment served/function.
   c. Model number.
   d. Blade configuration and orientation.
   e. Size in width, height, and blade width.
   f. Pressure drop.
   g. Type of seals (blade and edge).
   h. Normal position.
   i. Size, quantity, type, and model number of actuators.
   j. Method of actuator mounting and actuation.
4. Control Valves:
   a. Valve tag.
   b. Equipment served/function.
   c. Valve flow rate (GPM).
   d. Line size.
   e. Specified valve pressure drop (ft. head).
   f. Valve size.
   g. Valve Cv.
   h. Actual valve pressure drop (ft. head).
   i. Valve normal position.
   j. Valve spring range.
   k. Valve shut-off rating (ft. head).
   l. Valve body pressure/temperature rating.
   m. Valve type/model number.
   n. Actuator type/model number.
5. DDC Controllers:
   a. Device tag.
   b. Equipment served/function.
   c. Model number and application code.
   d. Associated sensor location/tag.
   e. Size, control values, etc.

G. Submittal Requirements

1. Shop drawings shall be 8-1/2” x 11” and 11" x 17" size, in PDF format
2. All schematics and drawings shall be done on CAD. The electronic files shall be in the latest version of AutoCAD (or as noted otherwise)
3. Product data shall include description and complete engineering data for each control system component. Data sheets shall be organized behind sheet tabs. Each sheet tab shall indicate the category or component name (i.e. valves, dampers, relay & switches, thermostats, temperature transmitters, pressure transmitters, air flow stations, controllers, etc.).

4. Since many items are interrelated and should be checked concurrently, all of the MSCC's DDC related shop drawings shall be submitted at one time. No consideration will be given to partial submittals, except valve and damper submittals on approval only. Any partial submittals must be included in the complete submittal package.
5. All submitted PDF documents shall have electronic bookmarks setup to quickly and easily locate documents and submitted information. Bookmarks shall be set up as follows:
    a. Shop Drawings:
        1) Each major system (AHUs, Heating systems, Cooling systems, etc.) shall have a master bookmark programmed with all documentation for the system grouped in order under a single bookmark for that system. Subgroups under the main bookmark should be divided in a minimum of: flow diagram/bill of material, wiring detail, control sequence, point list.
        2) Each minor system (Air Terminals, FCUs, Plumbing systems, Electrical systems etc.) shall have a master bookmark programmed for the type of system with bookmarks under the master for each type of minor system. All documentation for the system shall be grouped in order under a single bookmark for equipment type but subgroups for flow diagrams, control sequences, point list etc. are not required.
    b. Device Data Sheets:
        1) Device Data Sheets shall have bookmarks organized in alpha numerical order by part number. Part numbers can and should be grouped by major category such as Valves, Dampers, Temperature sensors, Actuators, etc.
    c. Hyperlinks:
        1) Hyperlinks can be used to enhance the bookmark tools but are not an acceptable substitute for electronic bookmarks.
        2) If hyperlinks are used, they should be clearly identifiable as a hyperlink but using a different color text similar to how MS Office documents identify hyperlinks.

H. Project Record Documents

1. Submit Project Record Documents at the time of substantial completion.
2. Revise shop drawings to reflect actual installation and operating sequences and provide final electronic files in PDF.
3. PDFs shall contain the following files in the indicated format:
    a. As-built drawings in PDF format (separate file for each system’s related drawings/sheets).
    b. Sequences of operation in PDF. Provide separate files for each system’s sequence of operation.
    c. Product data and catalog specification sheets in PDF format (separate file for each product).
4. List of all BACnet IP and MSTP devices installed with their network IP addresses, BACnet Device Instance numbers and associated BACnet network numbers. MSCC shall be responsible for uploading the completed, as-builted BMS Addressing Template required under section 1.9.A upon project substantial completion.

5. All files shall be dated and shall contain the UMH project RTN number and UM AEC P100 number when applicable.
6. Electronic copy of the field panel database/ device configuration backup for all new devices installed.

I. Operation and Maintenance Manuals

1. The MSCC shall provide the specified number of copies of complete operation and maintenance instructions for all system components furnished.
2. Include hard copies of all Project Record Documents described above in paragraph G.
3. Indicate final set points, settings, and adjustments of all components.
4. Include project specific catalog cuts and data sheets indicating installation, operation, maintenance, repair, wiring diagrams, calibration, calibration tolerances, inspection period, cleaning methods and cleaning materials for all components.

J. Posted Operating Instructions

1. Provide panel related as-built documents in protective binder or clear plastic display envelope for each control panel. These instructions shall include such items as as-built control diagrams and sequences of operation, simplified narrative instructions and materials necessary to aid in the operation of the equipment at the local control panels.

1.10 DELIVERY, STORAGE AND HANDLING

A. Shipping and storage protection shall be provided by manufacturer to ensure that the interior and exterior of components are completely protected from damage, dirt or weather. Components shall be continuously covered with plastic or other durable means, until just prior to installation. Maintain protection after installation to protect against on-going construction activities.

1.11 WARRANTY

A. The Building Management System shall be guaranteed for a period of one year after final approval has been granted by the Owner and the project Architect/Engineer. The warranty shall be provided for a completely installed system, including all components, parts and assemblies. The warranty shall cover parts, materials and labor to correct any defects in materials and workmanship.

B. The MSCC shall initiate the warranty period by formally transmitting to the Owner commencement notification of the period for the system and devices accepted.

C. Provide 24 hour per day emergency service during warranty period. Provide phone number(s) where warranty service can be reached at all times. Respond on-site and make corrections within 12 hours of a warranty service call.

D. Provide and install any software or firmware revisions which are released by the DDC system manufacturer during the warranty period, at no additional cost to the Owner. Revisions that require updates at the central BMS server(s) will be coordinated with the SI at no additional cost to the Owner.

E. The MSCC shall provide programming modifications necessary to fine tune equipment sequences during the warranty period, consistent with achieving the sequence of operation and design intent, at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCT MANUFACTURERS

A. All pneumatic devices, valves, damper operators, EP relays, PE switches, low temperature detection thermostats, etc. shall be as manufactured by Honeywell, Johnson Controls or Siemens, unless noted otherwise in following sections. See "Products" for acceptable manufacturers for sensors, etc.

B. Acceptable DDC controllers and related software (unless noted otherwise in this specification):

1. Siemens Industry Inc.
2. Distech Controls

2.2 GENERAL DDC CONTROL ARCHITECTURE

A. All DDC controllers and routers shall provide BACnet IP routing to allow communication over UMH HITS's network (layer 3 IP) and between controllers. BACnet objects shall be routed from the new MCS installation to the existing central BMS server(s) that reside on the HITS network. The MSI will utilize these BACnet objects to generate system graphics at the existing BMS server(s).

B. All devices communicating across the UMH HITS layer 3 IP network shall be capable of supporting a minimum network speed of 100 MBPS.

C. The complete Mechanical Control System (MCS) shall consist of the following:

1. Data integration to UMH's existing Vykon Niagara Supervisor and operator workstations.
2. Peer-to-peer DDC controllers communicating with other controllers (where IP capable) and UMH's existing UMH Vykon Niagara Supervisor over the HITS layer 3 IP network.
3. MS/TP network for communication between controllers and/ or devices when IP communication is not supported by the device.
4. Sensors, transducers, thermostats, actuators, wiring, etc. directly wired to their respective DDC controller for a complete and operational MCS.
5. Networks that are not peer-to-peer are not allowed.

D. BACnet Broadcast Management shall be facilitated by one B-BC per IP Subnet and incorporate a BACnet Distribution Table. B-BC's that handle BBMD's and I/O functionality shall be properly sized to handle memory & processing requirements.

E. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Building Controllers, Advanced Application Specific Controllers, Application Specific Controllers, expansion modules and operator devices. The system shall be configured to correspond with the modular configuration of the site and to enable the progressive expansion of the site in this same modular manner.

F. Minimize onsite integration time by performing software programming and testing offline before integration onto the live system. Software development will not be permitted online at the project site.

G. MSCC shall develop the communications network architecture and overall system performance to have a maximum latency of 2 seconds from a state or value change at the controller to where the change is reflected on the BMS graphic screen.

H. System architectural design shall eliminate dependence upon any single device for control execution and alarm reporting. Each DDC controller shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies, reporting or alarm and trending function at other operational devices. Data collection that requires a single mechanism for user notification or viewing is strictly prohibited.

I. All controllers within a building shall be able to access any data from, or send control commands directly to, any other DDC controller or combination of controllers in the same building without dependence upon a central processing device (peer-to-peer).

J. UMH's HITS Layer 3 Network is the primary network communication means and will be required for communication between all Building Controllers (B-BC), B-AAC's and B-ASC's and the BMS B-AWS, via BACnet IP. The use of MS/TP communications for interconnecting the said IP capable devices is strictly prohibited. HITS shall provide and install the primary network, based on coordination with the MSCC.

K. For non-IP capable DDC controllers, the MSCC shall provide and install a secondary FLN. The secondary FLN shall utilize the Master-Slave/Token-Passing (MS/TP) protocol, as acknowledged by the ANSI/ASHRAE 135 standard, as necessary for communication to non-IP controllers. This secondary network shall be provided and installed by the MSCC. Proprietary RS-485 or equivalent links will not be considered unless otherwise noted. The MS/TP link shall operate at a 38.4 Kbps minimum and utilize no more than 2 repeaters in any instance. Multi-channel repeaters will not be permitted.

1. MS/TP data communications media shall be provided by a shielded twisted pair conductor.
2. MCSS shall provide required MS/TP repeaters, hubs, active links, gateways, etc. and associated power supplies as required to provide shared point and control information between 3rd-party equipment controllers and MCS.
3. Failure of any individual FLN installed BACnet controllers shall not cause the loss of communications between peer controllers.

4. UL864 controllers and devices installed for equipment utilized in a smoke control sequence shall not be on the same MS/TP network segment as non-UL864 controllers and devices. These devices shall be on their own MS/TP network segment.

L. All BACnet IP routers connected to the HITS network, whether integral to a controller or not, must support BACnet Broadcast Management Device (BBMD) service. Multi-casting or global broadcasting will not be permitted without the use of a BBMD.

M. The BACnet IP FLN shall allow shared point and control information between BACnet DDC controllers. All required cabling and associated power supplies shall be provided as required to provide shared point and control information between DDC controllers.

N. Failure of any individual FLN installed BACnet IP controllers shall not cause the loss of communications between peer controllers.

O. All data transmitted must be positively acknowledged as received or negatively acknowledged as not received. Negative acknowledgments shall cause a retransmission of the data. Network connected devices must send a "Heartbeat" message at a configurable time interval. Lack of a "Heartbeat" message after successive retries shall constitute a device failure and shall be recognized as such by the network and be reported as a network alarm at the BMS B-AWS.

P. Error recovery and communication initialization routines shall be resident in each network connected device.

Q. The MSCC shall provide an IP connected DDC controller in the same room as the equipment it serves, unless the contract documents explicitly direct otherwise. Designs that situate controllers in different rooms or on other floors than the equipment being served (ie remote I/O) shall not be allowed without special permission by FPD Engineer. IP connectivity to every DDC controller is required.

1. Exceptions to this are the use of MS/TP connected DDC controllers for equipment that functions as a system, ie chiller plants utilizing chillers and cooling towers shall utilize an IP connected controller in the chiller plant and a MSTP subnetwork to a secondary controller serving the cooling towers on the roof. MS/TP controllers are preferred to remote I/O modules for these types of applications. Use of remote I/O shall not be allowed without special permission by FPD engineer.

SPEC WRITER NOTES: INCLUDE THE FOLLOWING PARAGRAPH "R" FOR ALL INPATIENT I-2 FACILITIES, AMBULATORY SURGURY CENTERS AND ANY OTHER CRITICAL FACILITIES (IE DATA CENTERS, ETC). OTHERWISE DELETE PARAGRAPH "R" BELOW.

R. The MSCC shall provide a fault tolerant BMS architecture such that the loss of a single DDC controller does not inhibit the continued, automatic operation of that utility service (ie chilled water, heating hot water, airflow, etc). BMS architecture does not need to be fully redundant, but rather be capable of continuing to provide a partial capacity of the utility being produced. For example, do not control the entire facility chilled water plant (multiple chillers, pumps and towers) off a single DDC controller. Provide multiple (minimum of two) DDC controllers for all critical, major mechanical systems, including but not limited to:

1. Minimum of two (2) DDC controllers per chilled water plant (chillers, pumps, cooling towers, etc).
2. Minimum of two (2) DDC controllers per heating hot water plant (boilers, heat exchangers, pumps, etc).
3. A maximum of two (2) air handling units (AHU) on a single DDC controller. AHU's sharing a DDC controller shall not be designed as backup for one another, i.e. thru a header system or common SA or RA ductwork.
4. Air handling units (AHU) serving operating rooms (OR's) are required to utilize a dedicated DDC controller per AHU.

S. MCS designs utilizing DDC controllers that only manage centralized functions (ie alarming/ trending, scheduling, static pressure reset, supervisory control, etc) shall not be allowed. All programming identified as part of a systems sequence of operation shall reside within that systems DDC controller (ie static pressure reset for an air handling unit shall reside within the appropriate air handling unit's DDC controller).

T. Control loop software algorithms for each analog control loop shall reside on same controller as inputs and outputs required for that specific control loop.

2.3 GENERAL DDC CONTROLLER REQUIREMENTS

A. Stand-alone microprocessor board with ROM and fully custom programmable RAM, EPROM, and/or EEPROM memory, integral interface equipment and power surge protection. DDC controllers shall be connected directly to sensors, controlled devices and the communication network.

B. All DDC controllers shall use the latest version of ANSI/ASHRAE Standard 135 BACnet standard for communications, have passed BTL certification as available and be listed as compliant with UL916 Standard for Energy Management Equipment. DDC controllers used in smoke control applications must also be listed as compliant with UL864 Standard for Control Units and Accessories for Fire Alarm Systems.

C. Controllers shall be listed by BACnet Testing Laboratories (BTL) as conforming to the required standard device profile and support all of the minimum required BACnet Interoperability Building Blocks (BIBBs) associated with this device profile.

D. The "Present_Value" property of all analog output and binary output objects shall be writable so that UMH Systems Monitoring personnel have the capability to override all system outputs from the central BMS server(s).

E. Each DDC controller shall support firmware upgrades without the need to change hardware.

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

G. DDC controller types shall be one of three types, a BACnet Building Controller (B-BC), a BACnet Advanced Application Controller (B-AAC) or a BACnet Application Specific Controllers (B-ASC).

1. Building Controllers (B-BC) shall be used for all major mechanical equipment and/or systems (i.e. chilled water, heating hot water, large AHU's, etc.).
2. Advanced Application Specific Controllers (B-AAC) shall be used, as an extension of a B-BC's performance & capacity, for control of all medium and small mechanical systems and/or terminal equipment. In addition, all room types listed under section 3.8 "Critical Room Types" shall be provided with a B-AAC (or B-BC) controller; B-ASC controllers are not allowed to serve these room types.
3. Application Specific Controllers (B-ASC) shall only be allowed to be used on terminal equipment including VAV boxes, FCU's, etc, with the exception as noted above.

H. Provide and install the latest firmware on all controllers. This is defined as the latest version of firmware, as tested and recommended by the manufacturer, prior to project completion.

I. Alarm Management

1. Alarm management shall be provided within the controller software to monitor and direct alarm information to operator devices.
2. Each controller shall perform distributed, independent alarm analysis, minimize network traffic, and prevent alarms from being lost. At no time shall the controller's ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
3. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
4. Binary Alarms. Each binary alarm object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
5. Analog Alarms. Each analog alarm object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.
6. All alarm shall include the point's user-defined language description and the time and date of occurrence.
7. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print reports, be logged in the event log, generate custom messages, and display graphics.
8. The user shall be able to add a 200-character alarm message to each alarm point to more fully describe the alarm condition or direct operator response.
9. Operator-selected alarms shall be capable of initiating a trigger to an advanced annunciation, such as text, email, etc.
10. An alarm history log shall report the start of the alarm condition, acknowledgement by a user and return of the alarm to normal condition.
11. Controllers shall have enhanced alarming capabilities thru BACnet Event Enrollment Objects to allow BACnet integration of complex alarming and alarm management with the BMS frontend. Examples include:
    a. Alarms based on a deviation from setpoint

b. Alarms based on a sustained condition over time (ie time delay)
c. Alarm management that allows the capability for time delays or maintenance mode to allow alarms to be delayed during maintenance overrides.

J. Data Collection

1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
2. Building Controllers shall store point history data for selected analog and digital inputs and outputs.
3. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
4. Two methods of collection shall be allowed: either by up to four pre-defined time intervals or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided.
5. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
6. Trend data shall be stored at the controller and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in third-party personal computer applications.

K. BACnet Building Controller (B-BC):

1. Provide controllers conforming to the latest version of ANSI/ASHRAE 135 BACnet Building Controller (B-BC) standard device profile and support all of the minimum required BACnet Interoperability Building Blocks (BIBBs) associated with this device profile.
2. Controllers shall support Internet Protocol (IP) for communications to other BC's and the BMS front-end and MS/TP communication to B-AAC's and B-ASC's.
3. Controllers shall have a 32 bit processor with an EEPROM, flash driven operating system. They shall be multi-tasking, multi-user, real-time digital control processors and permit I/O expansion for control / monitoring of up to a minimum of 48 I/O. Controller size shall be sufficient to fully meet the requirements of this specification. Controllers shall be fully programmable while supporting standard energy management functions, including but not limited to:
   a. Alarm detection and reporting
   b. Automatic Daylight Saving Time switchover
   c. Calendar-based scheduling
   d. Closed loop PID control
   e. Duty cycling
   f. Economizer control
   g. Equipment scheduling, optimization and sequencing
   h. Event scheduling
   i. Historical trend collection
   j. Holiday scheduling
   k. Logical programming

l. Reset schedules
m. Night setback control
n. Peak Demand Limiting (PDL)
o. Start-Stop Time Optimization (SSTO)
p. Temperature-compensated duty cycling
q. Temporary schedule override

4. Provide controller with integral power switch. If an integral switch is not provided by the manufacturer, the MSCC shall provide a separate dedicated transformer and switch within each enclosure for each controller present.
5. The operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not.
6. Controllers shall provide local LED status indication for power, communications, status and each digital output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
7. All points associated with a given mechanical system (i.e., an air handling unit) will be controlled from a single Building Controller or point expansion panel(s) from the respective master. All expansion modules shall be located in the building controller enclosure or an attached enclosure. No points from a given mechanical system may be distributed among multiple panels - points must be run back to a single Building Controller dedicated to that mechanical system. Multiple mechanical systems shall be allowed on a single controller Closed-loop control must never depend upon network communications. All inputs, program sequences, and outputs for any single DDC control loop shall reside in the same Building Controller.
8. A variety of historical data collection utilities shall be provided for manual or automatic sampling, storing and displaying system point data.
   a. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
9. Building Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control. Provide capability to view or print trend and tuning reports.
      1) Loop tuning shall be capable of being initiated either locally at the Building Controller or from a network workstation. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
10. Provide controllers that, upon full system power recovery, all clocks shall be automatically synchronized, and all controlled equipment shall be automatically re-started based on correct clock time and sequence of operation.

11. Provide additional controllers or I/O modules if necessary in each DDC panel so that each panel has at least 20% spare universal I/O capacity for connection of future points. 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 expansion modules, sensors/actuators and/or field wiring/tubing.
12. Controllers shall provide at least one data communication port for operation of operator I/O devices such as portable laptop operator's terminals. 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.
13. Field bus adaptors may be used, as an extension of the B-BC, to facilitate communication between the B-BC and remote field devices (sensors, actuators). Adaptors shall be microprocessor based and utilize advanced diagnostics and configuration. Adaptor shall be housed in panel or junction box enclosure.
14. Provide a minimum of 72 battery backup hours for complete system RAM memory and clock, with automatic battery charger. The backup power source shall have sufficient capacity to maintain volatile memory in event of an AC power failure.

L. BACnet Advanced Application Specific Controller (B-AAC):

1. Provide controllers conforming to the latest version of ANSI/ ASHRAE 135 BACnet Advanced Application Specific Controller (B-AAC) standard device profile and support all of the minimum required BACnet Interoperability Building Blocks (BIBBs) associated with this device profile.
2. Controllers shall support Internet Protocol (IP) for communications to other BC's/ AAC's/ ASC's and the BMS front-end.
3. Controller shall be a microprocessor-based, 32 bit, multi-tasking, real-time digital control processor capable of stand-alone operation for medium sized mechanical systems and/ or control of roof-top units, VAV terminal units, CAV terminal units, dual-duct terminal units, fan-coil units, heating and ventilating units, ventilating units, heat pump units, etc.
   a. If the hardware point requirements of any medium-sized system should exceed the I/O configuration of available B-AAC offerings, then a B-BC must be used. Control of one piece of mechanical equipment may not be performed by more than one controller.
4. Controllers shall be peer-to-peer devices with hand/off/auto switches for each digital output. Switch position shall be supervised in order to inform the system that automatic control has been overridden. Switches will only be required for non-terminal applications (not required for VAVs, CAV's and other above terminal devices). All inputs and outputs shall be of the universal type, allowing for additional system flexibility
5. Each controller shall support its own real-time operating system. Controllers without real-time clock functionality will only be permitted for use on terminal or unitary equipment such as VAV boxes, fan coil units and auxiliary monitoring and control.

6. Provide each controller with sufficient memory to accommodate point databases and operating programs. All databases and programs shall be stored in non-volatile EEPROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.
7. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) values for all applications. All PID values and biases shall be field adjustable by the user via operator terminals. Controllers that incorporate proportional and integral (PI) control algorithms only, without derivative (D) control algorithms, shall not be acceptable.
8. Controllers must be fully programmable. All programs shall be field-customized to meet the user's exact control strategy requirements. Controllers utilizing pre-packaged or canned programs shall not be acceptable.
9. All points used for a single mechanical system shall be connected to the same B-AAC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.
10. Provide spare additional I/O such that future use of spare capacity shall require providing only the field device, field wiring, point database definition and operational sequence programming changes as required. Additional point modules may be required to implement use of these spare points.
    a. Provide at least one (1) spare universal input and one (1) spare universal output or 15% spare I/O of the total capacity of each B-AAC whichever is greater.
    b. If B-AAC I/O is not universal then provide at least one (1) spare analog input, one (1) spare digital input, one (1) spare analog output and one (1) spare digital output or 15% spare I/O of the total capacity for each point type of each B-AAC whichever is greater.

M. BACnet Application Specific Controller (B-ASC):

1. Provide controllers conforming to the latest version of ANSI/ASHRAE 135 BACnet Application Specific Controller (B-ASC) standard device profile and support all of the minimum required BACnet Interoperability Building Blocks (BIBBs) associated with this device profile.
2. Controllers shall support Internet Protocol (IP) for communication to B-BC's, B-AAC's and other B-ASC's.
3. Controller shall be a microprocessor-based, 32 bit, multi-tasking, real-time digital control processor capable of stand-alone operation for control of mechanical terminal units, ie VAV terminal units, CAV terminal units, air terminal units, dual-duct terminal units, fan-coil units, heat pump units and roof-top units.
4. Each controller shall be capable of sharing point information with other B-BC, B-AAC, or B-ASC on a peer-to-peer basis via the BACnet IP network.

5. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. All inputs and outputs shall be of the universal type (outputs may be utilized either as modulating or two-state). Analog outputs shall be industry standard signals such as 24V floating control and 0-10VDC allowing for interface to a variety of modulating actuators.
6. Provide each controller with sufficient memory to accommodate point databases and operating and application programs. All databases and programs shall be stored in non-volatile EEPROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.
7. Each controller shall perform its primary control function independent of other DDC controller communications, or if communication is interrupted. Reversion to a fail-safe mode of operation during network interruption is not acceptable. Controller shall receive its real-time data from the Building Controller time clock to ensure network continuity.
8. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) values for all applications. All PID values and biases shall be field-adjustable by the user via operator terminals. Controllers that incorporate proportional and integral (PI) control algorithms only, without derivative (D) control algorithms, shall not be acceptable.
9. Controllers shall provide diagnostic LEDs for power, communications and processor status. The controller shall continually check the status of its processor and memory circuits
10. All points used for a single mechanical terminal unit shall be connected to a dedicated B-ASC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.
11. Controllers shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second. Controller shall store point history files for all analog & binary I/O's.

N. Controllers used for air terminal units (VAV's, CAV's, dual-duct mixing boxes):

1. Provide electronic damper operators compatible with the controller and the air terminal units provided. Actuator shall utilize a brushless DC operator, min 35 in-lbs of torque, floating control (unless noted otherwise).
2. Controllers shall have an internal differential pressure transducer(s) capable of utilizing the total and static pressure signals from the air terminal unit's velocity sensor. The differential pressure transmitter shall be capable of 5% accuracy, not to exceed a velocity pressure error of 0.023" w.c., for the flow range 0-5600 fpm. Associated velocity sensor shall be furnished by air terminal unit manufacturer.
3. Each controller shall have electronic outputs compatible with the electronically operated air terminal unit tempering coil control valve and perimeter radiation control valve where applicable.

4. All air terminal unit controllers shall integrate airflow damper command signal and reheat coil valve command signal to the BMS, as a percentage of full open (0% is closed, 100% is full open).
5. Provide a discharge air sensor, mounted on the discharge of the terminal box reheat coil and/ or the outlet of dual duct mixing boxes, interfaced with the controller.
6. DDC terminal controllers used in pressurized room applications shall not be permitted to modulate the terminal unit damper as part of a regular calibration cycle.
   MSCC shall provide alternate controllers, proportional actuators and/or auxiliary devices (ie an 'auto-zero' auxiliary device(s) which functions to temporarily disengaging the transducer from the air velocity sensor so that a 0 cfm air volume reading is forced without changing the damper position) when serving these spaces to prevent negatively affecting room pressurization.
7. If coordinated with mechanical contractor, controllers shall be furnished to the unit manufacturer for factory mounting; otherwise, controls shall be field installed.
8. MSCC shall provide controllers with metal enclosure, complete with conduit knockouts.

O. Provide wall-mounted space sensors for each controller performing space temperature control as indicated on floor plans. Sensor shall be thermistor, 55°F-85°F range, +/-0.18°F resolution and capable of being field calibrated. Provide sensor with auxiliary communications port to allow remote connection to VAV controller(s) with a laptop computer, to facilitate configuration and commissioning of controllers.

1. Space Sensors in private spaces (i.e. office, exam, patient room, etc.):
   a. Provide with digital temperature display
   b. High accuracy set point adjustment
   c. Flush mounted override button (only on systems where this function exists)
2. Space Sensors in public areas (i.e. corridors, waiting rooms, dining areas, etc.):
   a. Provide without digital LCD temperature display, no adjustment or override button.
3. Space Sensors where occupant safety is a concern (i.e. psych. patient areas):
   a. Install wall-mounted, blank-faced, stainless-steel temperature sensors with tamper-proof screws.
4. Space Sensors in areas subject to abuse (i.e. utility corridors, central sterile, OR's/ Procedure Rooms, etc.):
   a. Provide appropriate sensor per above with 2-piece crash guard, consisting of heavy gauge, bent stainless sheet steel securely anchored to wall on either side of sensor, consistent with guards used thru ought medical campus.
5. Zone Sensors shall not be located on perimeter walls. Where explicitly indicated on drawings to do so and/or in locations near exterior walls and/or subject to drafts, sensors shall have insulated mounting bases to prevent false room temperature readings.

P. BACnet IP Routers:

1. BACnet router between MS/TP and B/IP (BACnet over IP) as well as a BBMD (BACnet Broadcast Management Device) for transportation of BACnet broadcasts over an IP network with several subnets.
2. Router shall comply with latest version of ASHRAE Standard 135 for communications.
3. Routers shall be UL864 listed when connected to BACnet MS/TP network segments that contain UL864 listed devices being used in a smoke control application.
4. Device shall be capable of routing BACnet packets over layer 3 IP network and shall support both the router and BACnet Broadcast Management Device (BBMD) networking options. BBMD shall support registrations by Foreign Devices.
5. 24 VAC power supply required for router(s) shall be provided by the MSCC. Supply from UPS source at DDC controller panel.
6. Device shall be password protected with customizable password and security settings.
7. Acceptable Manufacturers: Loytec, Cimetrics, Siemens, Distech.

Q. Human Machine Interface (HMI) panel:

SPECIFICATION EDITOR: UMH DESIRES TO UTILIZE A LOCAL INTERFACE TO SIMPLY DISPLAY CRITICAL INFRASTRUCTURE POINTS (IE AHU DISCHARGE AIR TEMPERATURES, DIFFERENTIAL PRESSURE, SUPPLY & RETURN WATER TEMPERATURES, ETC) AT THE TEMPERATURE CONTROL PANEL TO PROVIDE A QUICK VISUAL ON THE STATUS OF A SYSTEM. OLDER INSTALLATIONS HAVE USED LOOP POWER INDICATORS IN COMBINATION WITH RTD SENSORS (SPECIFIED ELSEWHERE IN THIS SPEC). NEW INSTALLATIONS SHALL UTILIZE HUMAN MACHINE INTERFACE PANELS AS SPECIFIED BELOW.

1. The MSCC shall install a 15" TFT LCD industrial color touchscreen in the cover of the DDC control panel as identified in design documents. The HMI shall be custom configured by the MSCC to display controller status and DDC point values (i.e., AHU discharge temperature, differential pressure, supply & return temperatures, etc.) relevant to the equipment the DDC controller is controlling. Standard default view shall be a read only display.
2. HMI shall utilize IP thru the HITs network for management and configuration of the device.
3. HMI shall at a minimum satisfy BACnet Operator Device (OD) functionality as a local device.
4. HMI shall be suitable for operation in un-conditioned equipment room (32°F-122°F, 30%-90%RH).
5. Mount the HMI through the Auxiliary (Aux.) temperature control panel face, utilizing mounting bolts, with its center-line a nominal 60" A.F.F. Provide an additional Aux. panel for the HMI when insufficient room exists in the main Aux. panel.
6. Approved Manufacturers:
   a. Loytec LVIS-3ME15-G2 with mounting frame

R. Room Pressure Monitor (RPM)

1. RPM shall be capable of measuring the differential pressure between two adjacent spaces at all locations shown on the prints. Each room shall have its own controller capable of stand-alone operation. Each monitor shall be capable of both visual and audible alarms.

2. Room pressurization monitoring system shall consist of a differential pressure transducer, wall-mounted display, DDC controller, wall/ ceiling-pickups with stainless steel trim kits and tubing.
3. Supply voltage shall be 24V AC. Monitors shall be capable of wipe down cleaning.
4. Each monitor shall support up to four (4) individual screens.
5. Each monitor shall have the ability to zero and set up the transducer as well as configure the alarm delay from the local interface.
6. When used on rooms with anterooms, monitor shall be capable of monitoring up to (2) two separate rooms (i.e. Patient Room and Anteroom) with separate room pressure readings for each.
7. Provide a monitor with a full color TFT/ QVGA touchscreen interface, min. size of 7" corner to corner. Monitors with color touchscreen displays shall be flush mounted and user programmable. Home screen graphics shall indicate one of five (5) configurable room modes. Each mode will allow for customized color, verbiage and graphic. Monitor shall display relevant room values (pressure, temperature, humidity, airflow, status, etc.) as indicated on Contract Documents. Display shall provide a change of color for visual indication of alarm status: green for normal, orange for warning alarm (with notice on monitor to close door) and red for alarm. Monitor settings shall be accessed via password protected touch screen.
8. When used serving an Isolation Room or Protective Environment Room:
    a. Monitor mode (i.e. Normal Patient Room or Isolation/ Protective Environment Room) shall be set by the user (clinician) thru touchscreen password access.
    b. Shall be provided with a separate remote mounted monitor panel, located at the respective nurse's station- see drawings. Remote panel shall be flush mounted LCD screen, set to monitor and alarm (visual only) multiple RPM's. Panel shall be capable of indicating respective room's status (isolation/protective vs. normal patient room) and alarm.
9. Provide monitor with integrated room DDC controller, panel or valve mounted. Controller shall:
    a. Be non-proprietary and be fully configurable and commissionable thru the monitor touchscreen.
    b. Be native BACnet (MS/TP or IP), BTL listed high speed microprocessor based and integrated into the BMS.
    c. Comply with Part 1- "Quality Assurance".
    d. Be capable of direct connection to up to four (4) RPM's.
    e. NOT serve as the control for the space. All control shall reside within the MSCC's BMS. RPM DDC controller shall function as a pass-thru controller only.
10. Monitor shall generate a local visual alarm upon loss of room pressure after a time delay. Monitors used on patient spaces shall have their audible alarms silenced. See Contract Documents for alarm setpoints and time delay.
11. DDC interface: Device shall be integrated to the BMS front-end via BACnet MS/TP or IP.
12. Provide panel with Room Differential Pressure Transmitter, specified herein.

13. Provide NIST certified sensor, complete with document certifying NIST traceable compliance, for all Pharmacy (including Radiopharmaceutical) Compounding, General Pharmacy and Pharmacy Drug Storage applications. See section 3, "Calibration, Start-up and Commissioning" section.
14. Approved Manufacturers: Critical Room Control CRC-IRC-TM

S. Indoor Air Quality (IAQ) Monitor

1. IP smart sensor that utilizes Power over Ethernet (PoE) to monitor a room's indoor air quality. Provide with ethernet connectivity to hospital network.
2. Wi-Fi versions are not allowed.
3. Max dimensions: 4" square, 1.5" deep.
4. Operating environment: 41-113°F, 10-80% RH non-condensing.
5. Sensor requirements:
    a. Dust (PM2.5/PM10):0 to 1,000µg/m³ ±15µg/m³ or 15%
    b. TVOCs: 0 to 60ppm ±10%
    c. CO2: 400-5,000ppm ±75ppm or 10%
    d. Temperature: -40 to 125°C (-40 to +257°F) ±0.2°C
    e. Humidity: 0 to 100% ±2%
    f. Ambient light: 0.96 to 64,000lux
    g. Ambient noise sensor:
        1) Sensitivity: -26dBFS
        2) SNR (Signal to Noise Ratio): Typical 61dB (A-weighted, 20Hz~20kHz)
6. Sensor shall auto-calibrate for sustained accuracy.
7. Wall mount with bracket to allow unit to be anchored to the wall with screws.
8. Acceptable Manufacturers:
    a. Awair Omni
    b. Siemens

SPECIFICATION EDITOR: SYSTEMS (AHU'S CHILLER, ETC) THAT ARE FED FROM EMERGENCY POWER SOURCES SHALL HAVE THEIR ASSOCIATED DDC CONTROLLERS AND DDC DEVICES FED FROM THE SAME EMERGENCY POWER SOURCE. A/E TO INDICATE PROPER CIRCUITS ON DOCUMENTS.

T. Controller Power Supplies:

SPECIFICATION EDITOR: THE AE SHALL CLEARLY INDICATE SOURCE OF POWER FOR ALL DDC CONTROLS. POWER SOURCE (NORMAL VS EMERGENCY) & PRIORITY SHALL MEET OR EXCEED THAT OF THE EQUIPMENT BEING CONTROLLED.

1. Power to controllers and associated controlled devices shall be 24 VAC, provided by the MSCC. Power source (i.e. normal vs. emergency power & emergency power priority) shall match that of the equipment and/ or system being controlled.
2. Controllers powered from emergency power as well as non-emergency powered controllers serving critical front-end infrastructure (i.e. chiller plants, AHU's, etc.) shall be provided with UPS power. See UNINTERRUPTABLE POWER SUPPLIES (UPS) INSTALLATIONS under section 3 of this specification for UPS applications.
3. Provide each DDC panel with a line filter, surge suppressor, electrical disconnect, control fuse, and control transformer. All sized and provided by the MSCC.

4. Provide fully enclosed power supplies located inside control enclosures with external 24 Vac terminals, on/off control, equipment overcurrent protection, power indication, high/low voltage separation, and convenience 120VAC outlets.
5. Provide insulated, modular, feed-through, clamp-style terminal blocks suitable for rail-mounting with end plates and partitions for the termination of all field wiring in control enclosures. Field wiring to equipment with integral terminals and/or unitary equipment (i.e., VAV's, EF"s, etc.) shall not be required to have terminal blocks.

SPECIFICATION EDITOR: DESIGNER SHALL CLEARLY DELINEATE ON THE PROJECT DRAWINGS WHICH SPACES ARE LABORATORIES. UMH REQUIRES ALL LAB CONTROLS TO BE INTEGRATED TO THE KODE FRONT END DIRECTLY OVER THE HITS NETWORK. AE SHALL PROVIDE A HITS DATA DROP AT ALL LAB INTEGRATION LOCATIONS.

2.4 LABORATORY CONTROLS

A. Provide laboratory controls for any space designated as a laboratory and where indicated, except for rooms with VAV fume hoods and hoods with combination sashes. System shall include: temperature, pressure, and other sensors/transmitters; control valves; control, network, and power wiring; power supplies; routers, servers, and all other devices required for a complete system.

1. The system shall utilize conventional terminal air flow units for supply and general room exhaust and venturi style terminal air flow units for constant volume fume hoods and any other constant volume exhaust point. Refer to related section 233600.
2. Provide programming of all laboratory controls.
3. The system shall function to achieve the sequences of operation detailed on the drawings.
4. Each room or zone shall have a dedicated control system. Systems shall be independent and stand-alone from the Owner's BMS. Failures of the BMS system or network communications between the BMS and the system (cut communication cables, router or server failures, etc.) shall have no impact on individual laboratory control.
5. The system shall perform the following control functions:
   a. Pressurization Control: Control supply and auxiliary/general exhaust at a volumetric offset to maintain lab pressurization (positive, negative, or neutral). Controller shall maintain a constant offset (adjustable) between the sum of the room's total exhaust and the make-up/supply air volumes. This offset shall represent the volume of air that will transfer to or from the corridor or other adjacent rooms. Pressurization control shall consider networked devices, non-networked devices, and any number of constant volume devices.
   b. Lab Temperature Control: Regulate lab space temperature through a combination of supply air volumetric control and control of reheat coils and other auxiliary temperature control devices, in response to temperature sensor(s).
   c. Occupancy Control: Reset minimum volume settings and/or temperature control set points, based upon external signals from occupancy detectors, local over-ride buttons, and similar devices.

d. Constant volume fume hoods and other constant volume exhaust points (excluding general room exhaust): The self-actuated Constant Volume Venturi (CVV) Terminal Airflow Unit shall maintain a constant airflow set point.
e. Fume Hood Monitoring: Alarm unsafe condition at each fume hood.
f. Other control functions as indicated on the drawings.
g. Interface with the Owner's BMS thru BACnet IP.

BELOW PARAGRAPH INDICATES THAT POWER SUPPLIES SHOULD BE INSTALLED ABOVE DOORS TO LABS. DESIGNATE THE LOCATION OF THIS EQUIPMENT ON THE DRAWINGS. WORK WITH ELECTRICAL ENGINEER TO DESIGNATE THE RECEPTACLE PANEL CIRCUITS TO FEED LAB CONTROL POWER SUPPLIES. DEPENDING ON LOAD, MULTIPLE POWER SUPPLIES MAY BE FED FROM A SINGLE 120 VAC CIRCUIT.

B. Install power supplies secured to a wall and mounted above the doors to labs, unless indicated otherwise. Utilize receptacle panel circuits designated for powering lab control power supplies.

C. Provide power supplies for lab airflow controls in NEMA 1 metal enclosures, adequately ventilated to prevent overheating of the equipment, with exterior labeled "Laboratory Airflow Controls Power Supply", and listing the room numbers served. Maximum cabinet projection from wall shall be 8 inches. Label each secondary circuit inside the cabinet with the room number(s) served.

1. Control transformers shall be rated NEC Class 2 and shall meet all the requirements and recommendations of the laboratory airflow controls manufacturer.
2. No more than five pressurization zones shall be served from a single control transformer. No control transformer shall exceed 500 VA.
3. Each pressurization zone shall be powered by a dedicated (isolated) secondary circuit. Each secondary circuit shall include a disconnect switch, "power on" indicator, and be current limited with a slow blow fuse or circuit breaker.

D. Provide a disconnect switch, with shielded terminations, for line side power (one per control transformer). Locate inside the power supply enclosure.

SPEC WRITER NOTES: FUME HOOD MONITORS ARE TYPICALLY NOT PROVIDED BY THE MSCC ON UMH PROJECTS, BUT ARE RATHER PROVIDED WITH THE FUME HOOD. FOR RARE OCCASIONS WHERE THE MSCC WILL PROVIDE THE FUME HOOD MONITOR, CHANGE THE FOLLOWING PARAGRAPH FROM HIDDEN TEXT. CONSIDER IF OTHER LABORATORY EQUIPMENT WOULD BENEFIT FROM BEING EQUIPPED WITH A FUME HOOD MONITOR AND INDICATE THAT EQUIPMENT ACCORDINGLY. EXAMPLES: EXISTING FUME HOODS, BIO-SAFETY CABINETS.

E. Provide fume hood monitors for constant volume fume hoods and for other laboratory equipment where indicated.

1. Monitor shall include audible alarm, visual LED alarm, and a common (single) alarm silence button.
2. The fume hood monitor shall provide an alarm indication for the following conditions:
   a. Low fume hood face velocity as detected by:

1) Insufficient differential static pressure as detected by the TAU- CVV pressure switch (Phoenix CVV Terminal Air Flow Units).
2) Insufficient air volume, as detected by the air flow station (Siemens CVV Terminal Air Flow Units).
3) Sash raised above sash stop position.

b. When an alarm condition is detected, audible and visual alarm indicators shall activate. Pushing the alarm silence button shall mute the alarm for an adjustable time delay, initially set at 10 minutes. Alarm shall re-sound after the time delay, until alarm condition clears. Visual alarm shall remain lit until alarm conditions clears.

3. Sash position shall be sensed by using a vertical sash position sensor. The vertical sash sensor shall consist of a precision 10-turn potentiometer mechanically coupled to a constant tension spring reel. Resolution shall be +/- 1/2 inch or better. A stainless steel, burr and snag-free cable shall be attached to the spring reel. Expected lifetime based on manufacturer's tests shall be over 200,000 full height sash movements. Sash sensor shall be installed in a location on the fume hood easily accessible for service.
4. Fume hood monitor shall be suitable for surface mounting on the front of the fume hood.
5. Approved fume hood monitors:
   a. Phoenix FHM530 Controller (Provide for Phoenix CVV Terminal Air Flow Units)
   b. Siemens (Provide for Siemens CVV Terminal Air Flow Units)

2.5 TEMPERATURE SENSORS AND ACCESSORIES

A. Room, Duct, Outside Air and Liquid Immersion:

1. Temperature sensor assemblies shall match the requirements of the associated temperature controller and shall be based upon 10k or 20k thermistors. Transmitters should be provided as necessary to ensure temperature reading accuracy over extended sensor distance from controller or due to external electrical interference. When sensors are provided with transmitters, 4-20 mA transmitter output signals are preferred and specified herein, however sensors utilizing voltage signal transmitters (i.e. 0-10 VDC) are allowed if required by controller input requirements and sensor accuracy is not affected by sensor cable length. Accuracy shall be +/- 1/2°F over the entire range. Installations using thermistors shall be field calibrated for the full range, see section 3. 4-20mA or 0-10V transmitter designs shall conform to the calibrated spans noted below.
   a. Single point duct temperature sensor shall be rigid bulb type with stainless steel (SS) sheath, aluminum tip, and have a calibrated span of 20-120 deg. F or 30-250 deg. F for heating applications.

b. Averaging element duct mounted temperature sensor shall have a minimum 25 ft. long continuous element sensor along the entire length and have a calibrated span of 20-120 deg. F or 30-250 deg. F for heating applications. Provide sufficient sensor(s)/sensor lengths so that the elements are strung at 2-foot increments horizontally across the entire face of the coil. Provide additional sensors and wiring back to the DDC panel as needed to meet this requirement.

c. Rigid averaging element duct mounted temperature sensor shall have a brass case, bendable sheath, continuous element sensor along the entire length, and have a calibrated span of 20-120 deg.

d. Outside air sensor shall be designed to mount on a conduit, include an elbow type enclosure, sun shield, and have a calibrated span of -58-122 deg.

e. Liquid immersion temperature sensors shall have a probe with SS well, and weather tight enclosure. Sensor well length shall be 1/3 of the pipe diameter, minimum 2.5 inches. Transmitters for chilled water shall have a calibrated span of 20-120 deg. F or 30-250 deg. F for heating applications.

f. Only when specifically indicated, surface mount thermal-ribbon flexible sensor for pipe mounting shall have SS braid over lead wires, use pressure sensitive adhesive, must be properly insulated, and have a calibrated span of 30-250 deg. F.

g. Room temperature sensors (non-VAV) shall have a span of 20-120 deg. F, locking covers and when pneumatic, shall match the pneumatic thermostats used.

h. Adjustable room temperature sensors (non-VAV) shall have a digital temperature display, high accuracy set point slide, flush mounted override button, and a temperature range of 55-85 deg. F.

i. Provide NIST certified sensor, complete with document certifying NIST traceable compliance, for all Pharmacy (including Radiopharmaceutical) Compounding, General Pharmacy and Pharmacy Drug Storage applications. See section 3, “Calibration, Start-up and Commissioning” section.

j. Approved Manufacturers:
   1) TCS
   2) Siemens
   3) Honeywell
   4) Johnson Controls
   5) Minco
   6) Distech
   7) ACI (Automation Components Inc)

B. High Precision Liquid Immersion: (for temperature inputs used for BTU calculations and where noted)

1. Temperature transmitter with 100 ohm platinum RTD sensor and 4-20 mA 2-wire DC output. Zero and span shall be continuously adjustable. Sensor and transmitter shall be a matched assembly. Accuracy shall be +/- 0.1% of calibrated transmitter span, including combined effects of repeatability, hysteresis and linearity. Calibrated range shall be 20 to 120 deg. F. Both CHWS and CHWR sensor/transmitter assemblies shall have the same span and shall be factory calibrated as a matched pair.
2. Liquid immersion sensors shall have welded stainless steel thermowell. Transmitters shall be of the potted type or shall have a thermally isolated watertight enclosure. Length of sensor and thermowell shall be selected based on the diameter of the pipe to provide accurate, reliable and homogeneous sensing of the liquid temperature.
3. Approved Manufacturers:
   a. TCS
   b. Minco

2.6 HUMIDITY TRANSMITTERS AND ACCESSORIES

A. Room and Duct Type:

1. Sensor element shall be thin film capacitive type or bulk polymer resistance type, accuracy of +/- 2% RH, range of 0-100% RH with 4-20 mA 2-wire linear output. Factory calibrate for maximum accuracy at mid-range of normal operating humidity. All humidity sensors shall be resistant to chlorine and other cleaning agents.
2. Room Sensors shall have locking cover.
3. Duct Sensors shall have duct probe and mounting plate.
4. Provide NIST certified sensor, complete with document certifying NIST traceable compliance, for all Pharmacy (including Radiopharmaceutical) Compounding, General Pharmacy and Pharmacy Drug Storage applications. See section 3, “Calibration, Start-up and Commissioning” section.
5. Approved Manufacturers- Critical Applications (OR’s/ Procedure Rooms, AHU’s serving patient care, Central Sterile, animal research):
   a. Vaisala
6. Approved Manufacturers- Non-critical Applications:
   a. Siemens
   b. TCS
   c. General Eastern
   d. Vaisala
   e. Honeywell
   f. ACI (Automation Components Inc)
   g. Distech

2.7 COMBINATION TEMPERATURE AND HUMIDITY TRANSMITTERS AND ACCESSORIES:

A. Combination Room Temperature and Humidity Transmitter:

1. Single enclosure wall mounted room temperature and humidity sensor. Without display unless indicated otherwise on the contract documents. White casing/cover/fascia color. With service port to enable two-point calibration using either a PC or Vaisala HUMICAP Handheld Humidity and Temperature Meter HM70. Unit supply voltage 20-28 VDC.
2. Room temperature RTD shall be 100 ohm platinum sensor with 4-20 mA loop powered 2-wire output transmitter, 23-131°F temperature range, accuracy of +/- .54°F between 86-104°F.
3. Room humidity sensor shall have a 4-20 mA loop powered 2-wire output transmitter, humidity range of 0-90 percent RH, accuracy of +/- 1.7 percent RH at temperature range of 50-104°F, stability in typical HVAC applications of +/- 0.5 percent RH/year.
4. Provide with certificate of calibration.
5. Approved Manufacturers:
   a. Vaisala HMW92 Series

B. Outside Air Master Temperature and Humidity Sensors - Dual System:

1. Single point outside air temperature RTD shall be 1000-ohm thin film platinum resistor sensor with 4-20 mA 2-wire output transmitter with solar shield.
2. Outside air humidity sensor shall be thin film alumina substrate capacitance signal generating sensor with 4-20 mA 2-wire output transmitter with 0-100% relative humidity range within +/- 1% RH.
3. Sensor shall be wall mounted for exterior use. All mounting brackets and support material shall be stainless steel.
4. Approved Manufacturers:
   a. Vaisala

C. Outside Air Wet Bulb Temperature Sensors:

1. Single point outside air temperature RTD shall be 1000-ohm thin film platinum resistor sensor with 4-20 mA 2-wire output transmitter
2. Humidity sensor shall be thin film alumina substrate capacitance signal generating sensor with 4-20 mA 2-wire output transmitter with 0-100% relative humidity range within +/- 2% RH.
3. Calculated output should be in the form of wet bulb temperature.
4. Sensor shall be wall mounted for exterior use. All mounting brackets and support material shall be stainless steel.
5. Provide sensor with naturally ventilated solar radiation and precipitation shield. Shield shall be provided by the sensor manufacturer and be specific for the sensor being provided.
6. Approved Manufacturers:
   a. Vaisala

2.8 VIVARIUM TEMPERATURE AND HUMIDITY TRANSMITTERS AND ACCESSORIES

A. Vivarium Temperature and Humidity Transmitters for Wet Service:

1. Room temperature RTD shall be 100 ohm platinum sensor with 4-20 mA 2-wire output transmitter. Transmitter shall be waterproof or shall be remote mounted.
2. Room humidity sensor shall have a 4-20 mA 2-wire output transmitter, 0-100% relative humidity range, accuracy of +/- 2% RH, shall be waterproof, and shall be resistant to chlorine and other cleaning agents.

3. Combination T & H units shall comply with the above, but shall be mounted in a single enclosure.
4. All vivarium sensors shall have rust proof and waterproof covers and be protected by a stainless steel "U"-shaped guard firmly attached to the wall.
5. Approved Manufacturers:
   a. Vaisala (combination temp. and humidity)
   b. TCS (temp. only)
   c. Siemens(temp. only)

2.9 PRESSURE TRANSMITTERS AND ACCESSORIES

A. Air Differential Pressure Transmitter:

1. Variable capacitance type with ranges not exceeding 150% of maximum expected input. Transducer shall have zero and span adjustment. Output shall be 2-wire 4-20 mA with 24 VDC input.
2. Safe over pressure rating shall be minimum 5 times the range.
3. Temperature compensated with thermal error of not greater than 0.04% of full scale in temperature range of 40 to 100 deg. F.
4. Accuracy shall be 1% of full scale.
5. Approved Manufacturers:
   a. Air Monitor
   b. Setra
   c. Modus
   d. Ashcroft

B. Air Static Pressure Sensors- Duct, Area, Outside Air:

1. For use with Air Differential Pressure Transmitter
2. Duct mounted sensors shall be easily removable for cleaning, have multiple sensing ports, and fabricated of aluminum, copper, or SS. Sensors used in outdoor or condensing environments shall not be copper.
3. Wall or ceiling (area) mounted sensors shall be shielded, suitable for surface or flush mounting, complete with multiple sensing ports, contain a pressure impulse suppression chamber, and fabricated of aluminum, paintable steel, or SS as required.
4. Outside air mounted sensors shall be shielded, complete with multiple sensing ports, maintain sensing accuracy regardless of wind flow direction or pattern, and fabricated of aluminum or SS.
5. Accuracy shall be 1% of actual pressure value.
6. Provide a companion 4" Magnehelic gauge, mounted at auxiliary panel, of appropriate span for each sensor. Gauges shall be graduated in inches W.C. Provide a phenolic identification tag for each gauge.
7. Approved Manufacturers:
   a. Air Monitor
   b. Siemens
   c. Dwyer
   d. Honeywell

C. Airflow Sensors:

SPECIFICATION EDITOR: UMH'S PREFERENCE IS TO USE AND AIRFLOW MEASUREMENT STATION INTEGRATED INTO THE FAN BELL HOUSING. IF USED, THIS DETAIL SHOULD BE REFLECTED IN THE FAN SPECFICATION.

1. Airflow Traverse Probe Type:

a. For use with Air Differential Pressure Transmitter
b. Provide where indicated amplified signal airflow traverse probe(s) or airflow stations, complete with straighteners when required, capable of continuously monitoring the fan or duct capacities (air volumes) it serves.
c. Each airflow array shall contain multiple total and static pressure sensors positioned at the center of equal and symmetrical cross-sectional areas, and interconnected by their respective averaging manifolds.
d. Sensors shall not protrude beyond the surface of the array, nor shall be adversely affected by particle contamination normally present in building airflow systems.
e. The airflow array shall be fabricated of galvanized steel or aluminum of adequate gauge to withstand the velocities to be encountered and with all required mounting brackets, plates, gaskets, and flanges.
f. Accuracy shall be a minimum of 3 percent of actual airflow over the designed range of flow.
g. Provide a companion 4" Magnehelic gauge, mounted at auxiliary panel, of appropriate span for each sensor array. Gauges shall be graduated in CFM for airflow measurement. Provide a phenolic identification tag for each gauge.
h. Approved Manufacturers:
    1) Air Monitor
    2) Tek-Aire
    3) Dietrich-Standard
    4) Ramsey Air

2. Thermal Dispersion Type:
a. Sensors: Thermal mass flow, temperature and pressure compensating type.
b. Each sensor shall have an accuracy of +/-2% of reading over the entire operating airflow range. Each temperature sensor shall have an accuracy of +/-0.15 degree F (+/-0.07 degree C) over the entire operating temperature range. Each sensor assembly shall be calibrated to standards of the National Institute of Standards and Technology (NIST).
c. The combined accuracy of all components that make up the air measuring device shall meet the performance requirements specified above throughout the measurement range.
d. Multiple sensor circuits shall be equally weighted and averaged by the sensor multiplexing unit and communicate digitally to the control transmitter.
e. The operating temperature range for the sensor assembly shall be -20 degree F to 160 degree F (-29 degree C to 71 degree C). The operating humidity range for the sensor assembly shall be 0-99% RH (non-condensing).
f. The number of sensors for each probe array shall be:

Duct or Plenum Area (sq.ft)	Total # of Sensors /Location
<2	4
2 to <4	6
4 to <8	8
8 to <16	12
> = 16	16

g. Fan Inlet Sensor Probe Assemblies shall either be contoured, low profile sensor housings mounted on the fan inlet bell to reduce pressure drop and effect on fan performance or shall be a face mount probe and bracket spanning the fan bell opening. Designs mounted in the throat of the fan bell are not allowed. The operating airflow range shall be 0 to 10,000 fpm.

h. Duct/ Plenum mounted assemblies shall utilize bead-in-glass sensors/ elements housed in an anodized aluminum tube, suitable for duct/ plenum mounting. The operating airflow range shall be 0 to 5,000 fpm.

i. Accessories: Include probe mounted transmitter junction box, connecting cables, transmitter and system electronic enclosure with a velocity profiler with digital display. Display shall display total airflow for each air handling unit as a whole, regardless of number of fans. Provide analog (4-20mA, 0-10VDC) transmitter outputs for interface with DDC BMS.

j. Approved Manufacturers:
   1) Fan Inlet Assemblies: Ebtron GOLD Series
   2) Duct/ Plenum Assemblies: Ebtron GOLD Series, Air Monitor "Electra-flo"

D. Room Differential Pressure Transmitter

1. Provide room differential pressure transmitter and wall/ ceiling-shielded static air probes with trim kits and tubing.
2. Transducer accuracy shall be minimum ±0.4% full scale including the effects of linearity, hysteresis and repeatability. The transducer shall be dead-ended and not allow air to pass from controlled space to reference. Transducer sensing diaphragm shall be non-metallic, silicon-based. The transducer max change shall be ≤0.25% per year. Provide with bidirectional range of +/- 0.10 in wc. Each transducer shall be digitally compensated using an application specific integrated circuit (ASIC). The transducer shall have an integral LED power/status indicator. The room pressure transducer shall be factory calibrated with NIST traceable standards. Span and zero shall be individually adjustable. Implied pressure measurement systems utilizing thermal hot wire or thermal mass air velocity measurement are not acceptable.
3. Provide with aluminum or stainless-steel flush mounted, shielded static air probes, complete with pressure impulse suppression chamber and airflow shielding. Probe shall be capable of sensing static pressure within 1% of actual pressure value while being subjected to airflow at 1,000 FPM. Air Monitor model "SAP" or CRC "RST".
4. When used with RPMs, or as shown on contract documents, provide with door contact switch(es) for all doors into room. See construction documents for details.
   a. Powered sliding doors shall utilize a relay in the door actuator as proof of door status, coordinate with door hardware.

b. Hinged doors shall utilize a concealed, hermetically sealed magnetic reed switch, field mounted in the top of the door frame and correspondingly in the top of the door. Contact housing color shall match door frame. Contacts shall be UL listed, GE Sentrol Industrial series or CRC Solutions door contact.

5. Acceptable Room Differential Pressure Transmitter Manufacturers:
   a. Ashcroft CXLdp
   b. CRC-DPT

E. Steam/Liquid Differential Pressure Transmitters: (flow only)

1. Each differential pressure transmitter shall be selected and calibrated for operations between 0 and 125% of the normal differential pressure and up to 150-psig line pressure. The calibration point shall be rounded upward to the nearest 10 inches WC (for spans less than 200" WC) or to the nearest 5 psi for larger spans. Calibration date shall be included on an embossed tag attached to each transmitter.
2. The accuracy, including linearity, hysteresis and repeatability, of the transducer for measuring differential pressure shall be better than 0.25% of the span stated above throughout a minimum of a 6:1 turndown. Turndown ratio shall be based on the actual flow span.
3. The transmitter shall not be damaged by pressures of up to 500 psig on either side of the transducer and all wetted parts shall be inert in the presence of up to a 40% concentration of ethylene or polypropylene glycol in water.
4. Provide a drain valve for each side of the pressure chamber. Furnish and install mounting brackets appropriate for the installation location.
5. Span and zero shall be individually adjustable.
6. Shall be 2-wire and 4-20mA output.
7. Approved manufacturers:
   a. Tobar
   b. ITT Barton
   c. Dietrich - Standard
   d. ABB
   e. Siemens
   f. Rosemont/Fischer
   g. Honeywell

F. Steam/Liquid Differential Pressure Transmitters: (pressure only)

1. Each differential pressure transmitter shall be selected and calibrated for operations between 0 and 200% of the normal differential pressure. The calibration point shall be rounded upward to the nearest 10 inches WC (for spans less than 200" WC) or to the nearest 5 psi for larger spans. Calibration date shall be included on an embossed tag attached to each transducer. Adjust output signal span to 150% of the differential pressure setpoint determined by the water balancer or the maximum differential pressure expected at the point of measurement.

2. The accuracy, including linearity, hysteresis and repeatability, of the transmitter for measuring differential pressure shall be better than 2% of the span stated above throughout a minimum of a 4:1 turndown. Turndown ratio shall be based on the actual differential span.
3. The transmitter shall not be damaged by pressures of up to 500 psig on either side of the transducer and all wetted parts shall be inert in the presence of up to a 40% concentration of ethylene or polypropylene glycol in water.
4. Provide a drain valve for each side of the pressure chamber. Furnish and install mounting brackets appropriate for the installation location.
5. Span and zero shall be individually adjustable.
6. Shall be 2-wire and 4-20 mA output.
7. Approved manufacturers:
   a. Tobar
   b. ITT Barton
   c. Dietrich - Standard
   d. ABB
   e. Siemens

G. Steam/Liquid Pressure Transmitters: (pressure only)

1. The pressure transmitter shall be selected and calibrated for 150% of the normal operating pressure at the location of installation. Calibration date shall be included on an embossed tag attached to each transmitter.
2. The accuracy, including linearity, hysteresis and repeatability, of the transmitter for measuring differential pressure shall be better than 2% of the span stated above throughout a minimum of a 10:1 turndown.
3. The transmitter shall not be damaged by pressures of up to twice its range. All wetted parts shall be inert in the presence of up to a 40% concentration of ethylene or polypropylene glycol in water.
4. Provide an isolation valve and pressure gauge on the inlet of each pressure transmitter.
5. Shall be 2-wire and 4-20 mA output.
6. Approved manufacturers:
   a. ABB
   b. Siemens
   c. Kele
   d. Setra
   e. Dwyer
   f. ACI

H. Steam/Liquid Flow Sensors: (differential pressure type)

1. Uni-directional sensors shall be of the venturi type or velocity pressure type. They shall be constructed of stainless steel, sized to the system's range of flow, and have an accuracy of 0.5%.
2. Bi-directional sensors shall be of the velocity pressure type. They shall be constructed of stainless steel, sized to the system's range of flow, and have an accuracy of 0.5%.
3. Approved Manufacturers
   a. Preso
   b. Gerand
   c. Dietrich-Standard (Annubar Diamond II)

I. Indication Gauges for Steam/Liquid Pressure Transducers:

1. Each transducer shall come with an indicating gauge that reads in GPM for flow measurement or inches WC / PSI / PSIG for pressure sensing. The gauge shall be analog differential pressure type piped in parallel to the transducer.
2. The analog pressure gauge shall be selected and calibrated for the same span as the transducer it serves.
3. The accuracy, including linearity, hysteresis and repeatability, of the gauge for measuring differential pressure shall be better than 3% of the span stated above throughout its span. Calibration data shall be included on an embossed tag attached to each gauge.
4. The gauge shall not be damaged by pressures of up to 500 psig on either side of the gauge and all wetted parts shall be inert in the presence of up to 40% concentration of ethylene or polypropylene glycol in water.
5. Scale shall be a minimum of 4.5" diameter. Furnish and install two bleed fittings for each gauge and mounting brackets appropriate for the installation location.
6. Gauges shall be field mounted. Provide a phenolic identification tag for each gauge and indicator.
7. Approved manufacturers:
   a. Beckman
   b. Moore
   c. Testoterm
   d. Dwyer
   e. Transducer manufacturer's gauge

J. Three Valve Manifolds for Steam/Liquid Pressure Transmitter:

1. Provide a three-valve manifold for each transducer. Pressures of up to 500 psig shall not damage the manifold. All wetted parts shall be inert in the presence of up to a 40% concentration of ethylene or polypropylene glycol in water.
2. The manifold shall be designed for direct mounting on the transducer it serves and utilizes two quarter turn valves to provide zeroing, blocking and normal service modes.
3. Approved Manufacturers:
   a. D/A Manufacturing

EDITOR: CONTACT THE FPD DEPARTMENT VIA THE U-M DESIGN MANAGER FOR INSTRUCTIONS ON TYPE OF FLOW METER TO USE FOR STEAM, CONDENSATE, CHILLED WATER, AND HEATING HOT WATER. MAG FLOW METERS ARE GENERALLY PREFERRED.

2.10 FLOW METERS AND ACCESSORIES

A. Liquid Electro-Magnetic Flowmeters:

1. The meter system shall consist of a primary flow sensor and transmitter. The flow sensor shall be equipped with 150-lb. flanges. The meter system shall be installed with all necessary grounding components and gaskets per manufacturer's instructions. The meter shall be capable of bi-directional operation. The meter shall be sized appropriately for the range of flow for the system. The electrodes shall be SS or Hasteloy C. The transmitter shall be provided with a remote mounting bracket, cable, integral LCD display, NEMA 4X housing, shall indicate flow rate and totalized flow, shall have an isolated 2-wire 4-20 mA linear output flow rate signal, and shall have a pulsed output signal for totalization. The transmitter shall be capable of being field calibrated and reprogrammed from the outside housing via magnetic probe or security protected integral keypad menu switching. Unit electronics shall have noise immunity. The primary flow sensor and transmitter shall be mounted in accessible locations. Unit shall have the capability to maintain flow total in non-volatile memory. The flowmeter and transmitter as a unit shall have the following minimum characteristics:
   a. Flowmeter Liner:
      1) Heating hot water, domestic hot water, and other water systems operating at or above 110°F: Teflon
      2) Chilled water, domestic cold water, and other water systems operating below 110°F: Polyurethane
      3) Steam condensate: Teflon to 300°F, Ceramic over 300°F, and as suitable for the expected fluid conditions.
   b. Accuracy:
      1) At 1 to 33 feet per second velocity: ±0.5% of rate.
      2) At 0.3 feet per second velocity: ±2% of rate.
   c. Each unit shall be factory calibrated for the specified flow and shall be calibrated in both directions if the application is bi-directional. Calibration shall be a minimum of three point. Specific performance test data shall be furnished with the meter.
   d. Each meter shall provide two analog 4-20 mA signals or a single 4-20 mA signal and a digital contact closure on reverse flow.
   e. Meters for steam condensate shall be capable of sensing with condensate conductivity down to 6 µS/cm.
2. Provide a phenolic tag for each transmitter to identify service and meter ID number (i.e. SECONDARY CHILLED WATER FLOW, FM-1, etc.).
3. Approved Manufacturers (Water)
   a. ABB
   b. Siemens
   c. EMCO
   d. Rosemount
   e. Krohne
   f. Onicon
4. Approved Manufacturers (Steam Condensate)
   a. Rosemount
   b. Krohne
   c. ABB

B. Steam (Vapor) Flowmeters (Vortex-Shedding Type):

1. The meter system shall consist of a primary flow sensor and transmitter. The flow sensor body and wetted parts shall be SS, and shall be flanged and suitable for the service rating. The meter shall be installed with all necessary grounding components and gaskets per manufacturer's instructions. The transmitter shall be provided with a remote mounting bracket and cable, integral LCD display, NEMA 4X housing, shall indicate flow rate and totalized flow, shall have an isolated 2-wire 4-20 mA linear output flow signal and a pulsed output signal for totalization. The transmitter shall be capable of being field calibrated and reprogrammed from the outside housing via magnetic probe or security protected integral keypad menu switching. Unit electronics shall have noise immunity. Unit shall have the capability to maintain flow total in non-volatile memory. The primary flow sensor and transmitter shall be mounted in accessible locations. The flowmeter shall be provided with a 1-year warranty and application non-degradation performance guarantee. The flowmeter and transmitter as a unit shall have the following minimum characteristics:
   a. Temperature range shall be -40 to +750°F.
   b. Accuracy shall be 1.0% of rate and 0.1% of full scale.
   c. Repeatability shall be 0.15% of flow rate.
   d. Each meter shall be factory calibrated for the specified flow range prior to shipment and specific performance test data shall be furnished with the meter.
   e. Meter range shall accommodate the minimum and maximum expected flow for the steam pressure at the installed location.
   f. Meter shall be equipped with a temperature and pressure compensation feature.
2. Provide a phenolic tag for each transmitter to identify service and Meter ID number (i.e. MEDIUM PRESSURE STEAM FLOW - LSI BUILDING, etc.).
3. Approved Manufacturers
   a. Rosemount
   b. Krohne
   c. ABB

C. Steam (Vapor) Flow Meters (Differential-Pressure Type)

1. The meter system shall consist of a differential pressure primary flow element, a differential pressure transmitter (or transmitters), and a flow monitor/computer. The flow sensor body and wetted parts shall be SS, and shall be equipped with 150-lb. flanges. The transmitter(s) and flow computer shall be provided with a remote mounting bracket and cable, integral LCD display, and NEMA 4X housing. Flow computer shall indicate flow rate and totalized flow, shall have an isolated 2-wire 4-20 mA linear output flow signal and a pulsed output signal for totalization. Unit electronics shall have noise immunity. The transmitter shall be capable of being field calibrated and reprogrammed from the outside housing via magnetic probe or security protected integral keypad menu switching. Unit shall have the capability to maintain flow total in non-volatile memory. The flowmeter and transmitter as a unit shall have the following minimum characteristics:
   a. Temperature range shall be -40 to +750°F.

b. Accuracy shall be 1.0% of rate or better and 0.1% of full scale.
c. Repeatability shall be 0.15% of flow rate.
d. Each meter shall be factory calibrated for the specified flow range prior to shipment and specific performance test data shall be furnished with the meter.
e. Meter range shall accommodate the minimum and maximum expected flow for the steam pressure at the installed location.
f. Meter shall be equipped with a temperature and pressure compensation feature.
g. V-cone horizontal pilot lines shall be pitched back to steam lines and shall not trap condensate.

2. Provide a phenolic tag for each meter to identify service and Meter ID number (i.e. MEDIUM PRESSURE STEAM FLOW – LSI BUILDING, FM-1 etc.).
3. Approved Manufacturers
   a. McCrometer (V-cone-style meter)
   b. Preso (Venturi-style meter)
   c. Gerand Engineering (Venturi-style meter)

TWO METHODS OF CALCULATING ENERGY CONSUMPTION (BTUS), WITH THE RESPECTIVE EQUIPMENT REQUIRED, ARE SPECIFIED BELOW: (1) BY THE DDC SYSTEM OR (2) BY A "BTU METER". D.2 IS USED WHEN UTILITY (REVENUE) BILLING OF A SYSTEM IS PLANNED. D.1 IS USED WHEN ENERGY CONSUMPTION IS COLLECTED FOR INFORMATIONAL PURPOSES ONLY. ASSURE THE CONTROL DRAWINGS INDICATE WHICH METHOD, IF ANY, IS TO BE USED FOR EACH SYSTEM.

D. BTU Metering

1. (BTU determination via virtual point) When the control drawings describe BTU or BTU/hr trending, provide the following for each point described:
   a. One (1) liquid flowmeter unit with transmitter as specified elsewhere in this section.
   b. Two (2) high-precision matched temperature sensor assemblies with transmitters as specified elsewhere in this section. Sensor with SS well shall be installed in each respective supply and return pipe as shown on project drawings.
   c. These devices shall be wired to a local DDC panel. Calculations for instantaneous and totalized load shall be incorporated into the panel control code, and the necessary virtual points shall be created to allow remote monitoring and trending via the DDC system.
2. When a BTU meter is indicated on the control drawings, provide all the requirements described above for BTU virtual points, and additionally provide a Flow/BTU computer. Flow/BTU computer shall be programmable for various flow meter types including linear, square law, or multi-point linearization data interpretation:
   a. Inputs shall include 4-20ma flow from flow meter, and 4-20ma from two temperature sensors.
   b. Flow and temperature inputs shall be simultaneously connected to this computer and looped to the local DDC panel.

c. Flow/BTU computer shall operate in an environment of 0 to 50 C, shall include a keypad for data input and retrieval, and an EEPROM/nonvolatile RAM. Unit shall calculate and provide:
   1) Two 4-20ma analog outputs indicating btu, mass or volume flow rate, temperature 1, temperature 2, delta temperature, pressure, density, and peak demand.
   2) One isolated pulse output indicating btu, mass or volume total.
   3) Two NC/NO relay outputs assignable to trip according to various rate, total, temperature or pressure readings. Programmable as latching or non-latching, or as pulsed output of a total.

d. Outputs shall be stored in a battery backed data logger, selectable for continuous or periodic log modes.

e. Unit shall have a real time clock and shall date stamp logged data. Unit shall have an RS-232 port and shall be capable of setup from a laptop computer. The supplier shall set up and verify BTU measurement and shall train U of M personnel in all aspects of BTU computer setup and operation.

f. Computer shall calculate and display heat, mass or Volume flow rate, resettable total, non-resettable total, temperature input 1, temperature input 2, delta temperature, density, pressure, peak demand, and time/date stamp.

g. Provide a phenolic tag for each transmitter and flow computer (as applicable) to identify service and ID number (e.g. CHILLED WATER BTU METER – LSI BUILDING, etc.).

h. Mount Flow/BTU computer in a NEMA 4 enclosure: Minimum size 16” (H) x 14” (W) x 8” (D), hinged cover, pad-lockable latch, and stainless steel hinge. Provide cutout in enclosure face and mount computer in face. Where multiple computers are supplied, they may be mounted in a common enclosure.

i. Approved Manufacturers and Models for Flow/BTU Computer:
   1) Kessler-Ellis Supertrol II with MS816 enclosure.

2.11 MISCELLANEOUS DEVICES

A. Alarm Indication Station

1. Alarm indicating station with red alarm LED, alarm horn, horn momentary silence switch, adjustable alarm delay and alarm repeat time, and alarm status relay.
   a. Supply Voltage: 24 VAC @ 100 mA or 24 VDC @ 34 mA.
   b. Alarm Time Delay: None, or 1 to 31 seconds in one-second increments, or 10 to 310 seconds in 10-second increments.
   c. Alarm Horn: Continuous or pulsed tone, 70 db minimum.
   d. Alarm Repeat Time: None, or 1 to 7 minutes in one-minute increments, or 10 to 70 minutes in 10-minute increments.
   e. Alarm Relay: SPDT, 0.5A @ 24 VAC, 1.0A @ 30 VDC, follows horn or lamp action, selectable.
   f. Connections: Screw terminals, 22 – 14 AWG wires.
   g. Mounting: Brushed stainless steel plate mountable to standard single junction box, with two screws provided.
2. Accepted Manufacturer:
   a. Kele Model RAD-1.

B. Carbon Dioxide Sensors:

1. Carbon dioxide sensing cell shall consist of a non-dispersive infrared carbon dioxide gas cell that uses a pulsed source and has no free air optical path. Output shall be linearized 4-20 mA for use with 24 VDC input. The unit shall be specifically designed for the wall or duct application specified. Duct aspiration boxes shall be by the manufacturer. Unit shall have span adjustment. The unit shall have no moving parts.
2. Minimum requirements:
   a. Range: 0-2,000 ppm
   b. Accuracy: 3 % of full scale
   c. Repeatability: 1% of full scale
   d. Power Consumption: less than 3 watts
   e. Zero Drift at Constant Temp.: 100 ppm per 24 hrs(random not cumulative)
   f. Max. allowable Drift in 1 year: 20 ppm
3. Unit shall not require calibration for a period of 1 year or more.
4. Approved Manufacturers:
   a. Valtronics
   b. Telaire

C. Carbon Monoxide and Combustible Gas Sensors:

1. Sensors shall be a micro-processor-based system for continuous monitoring and use catalytic, electro-chemical, diffusion cell, or solid-state type sensing. Output shall be linearized 4-20 mA for use with 24 VDC input with green LED normal operation indicator. Unit shall provide a SPDT pilot duty low voltage alarm contact with an adjustable set point. The unit mounting shall be wall, duct aspiration, or ceiling to suit application. The unit shall specifically designed for the application and shall be explosion proof, as required. Unit shall have single point set point and span adjustment. The unit shall have no moving parts. Units mounted outdoors shall be waterproof and rustproof.
2. Minimum requirements:
   a. Range: as required for application; ppm, %, % L.E.L.
   b. Accuracy: 3-5% of full scale
   c. Repeatability: 1% of full scale
   d. Power Consumption: 5 watts or less
   e. Relay contact rating: 5 amp at 24 VDC, 150 VA max. inductive
   f. Zero Drift at Constant Temp.: 0 per 24 hrs (random not cumulative)
   g. Max. allowable Drift in 1 year: 1% of full scale.
3. Approved Manufacturers:
   a. Draegar
   b. Vulcain

D. Gas Detection System:

1. Each system shall be complete package with remote or local space sensors, detection instruments, alarm contacts, local indication of current measured value for each sensor and status indicator lights for power and status of each sensor. Devices not requiring remote mounting shall be housed in metal control panel. Status indicators shall be mounted on panel faceplate.

2. Units shall be provided with local alarm horn & light with horn silence pushbutton, unless indicated otherwise.
3. Sensor life shall be a minimum of one year.
4. Units shall have adjustable setpoints and self-test diagnostics.
   a. Gas to be Detected: Oxygen (O2)
   b. Warning Setpoint: 20 %
   c. Alarm Setpoint: 19.5 %
   d. Alarm Relays: 3 Amps, 120 VAC (1 Warning relay, 1 Alarm relay and 1 Fault)
   e. Range: 0-25% O2
   f. Remote Sensor: Electrochemical O2 Sensor
5. Provide phenolic plastic signs, minimum 1/2" high white engraved letters on red background at each light/horn location. Signs shall read "Do Not Enter -Oxygen Deficient Atmosphere".
6. Approved Manufacturers:
   a. Honeywell Analytics
   b. MSA
   c. Drager
   d. Toxalert
   e. MDA Scientific
   f. Enmet

E. Gas Detection System – MRI Oxygen Depletion:

1. Provide pumped sample oxygen depletion monitor for each MRI room. Systems shall be complete packages with sample tubing, end-of-line filters, monitors, alarm contacts, local indication of current measured value for sensor and status indicator lights for power and status of sensors. Devices shall be housed in metal control panels. Status indicators shall be mounted on panel faceplate.
2. Units shall be provided with local alarm horn & light with horn silence pushbutton.
3. Sensor life shall be a minimum of one year.
4. Units shall have adjustable setpoints and self-test diagnostics.
   a. Gas to be Detected: Oxygen (O2)
   b. Warning Setpoint: 20 %
   c. Alarm Setpoint: 19.5 %
   d. Alarm Relays: 3 Amps, 120 VAC (1 Warning relay, 1 Alarm relay and 1 Fault)
   e. Range: 0-25% O2
   f. Remote Sensor: Electrochemical O2 Sensor
   g. Installation: Pumped remote sample. Sample tubing to penetrate ceiling above MRI unit through wave-guide. Provide non-metallic end-of-line filter.
5. Approved Manufacturers:
   a. Honeywell Analytics Midas
   b. MSA
   c. Critical Environment Technologies
   d. Enmet

F. Condensation Sensor - Pipe Mounting Type

1. Sensor with built-in relay contact that opens upon detection of condensation, for sensing condensation when mounted on bare pipe.
   a. Supply voltage: 24 VAC/VDC ±10%

b. Power consumption: Maximum 1.6 VA
c. Relays contacts: rated 1 amp @ 24 VAC/VDC
d. Operating temperature: -20… +50°C
e. Display: LED (visible without removing cover), green – power supply ok, red – condensation sensed, contact open.
f. With pipe mounting bracket.

G. Current Sensing Relays

1. Provide current sensors with donut transformers capable of monitoring AC current, maximum input current ranges from 20 to 300 amp, peak, with digital output signals having adjustable high and low current trips. An LED shall provide visual indication and shall not bleed through.
   a. Provide special current sensing relays designed to monitor belt breakage, when indicated or described in the Sequence of Operation.
2. Approved Manufacturer:
   a. Neilsen Kuljian
   b. Veris Industries
   c. ACI (Automation Components Inc)

H. Electronic to Pneumatic Transducers

1. Provide transducers to convert electronic signals from the DDC controller analog output modules to linear proportional pneumatic signals for all DDC controlled modulating pneumatic devices. The transducer shall be a panel-mounted device, with hand/auto switch, override dial for manual override control, and a 0-30 psig output gauge. Supply voltage shall be 19-26 VAC. Control signal shall be 0-10 VDC or 4-20 mA. Output accuracy shall be 1/4 psig at 75 Deg. F, producing a 0-15 psig pneumatic signal. Output repeatability shall be .05 psig maximum. Transducers shall be high capacity non-bleed devices with a minimum output capacity of 500 SCIM, except special circumstances that require a constant bleed controller with branch exhaust on signal loss.
2. Approved Manufacturers:
   a. Non-bleed Type:
      1) Siemens
      2) ACI - PXP
   b. Bleed Type:
      1) ACI – PXP

I. Liquid Detectors

1. Liquid detectors shall utilize microchip technology for detection of conductive liquids through one of the following types of sensors: gold-plated probes, self-adhesive sensor tape with copper electrodes and durable cotton cover, or rope type sensor. Detectors shall be selected based on the best use for the application. Power requirement shall be 11-27 VAC or VDC and have a green LED normal operation indicator. Unit shall have a SPDT pilot duty low voltage alarm contact. Unit shall be waterproof and rustproof. A red LED shall indicate the presence of liquid. Unit shall have an adjustable set point.
2. Approved Manufacturers- Spot Detectors:
   a. DiversiTech "Wet Switch"
   b. Water Alert
3. Approved Manufacturers- Rope or Ribbon Detectors

a. RLE Technologies
b. Water Alert
c. Kele

J. Loop-Powered Indicators:

1. Where indicated, analog sensors (i.e., temperature, humidity, CO2, CO, etc.) shall be provided with a Loop-Powered Indicator (LPI) mounted on a separate dedicated LPI panel, except those sensors that are provided with a local display. Local displays shall be mounted at the DDC panel array.
2. Indicator shall be designed to display any 4-20 mA transmitter signal directly in the engineering unit of the measured media. The display shall be powered directly by the measured 4-20 mA signal without requiring an additional power supply. Indicator shall not impose impedance on the current loop beyond the capability of the transmitter.
3. Display shall have minimum 5/16" LCD digits, with 3-1/2 digit capability selectable decimal point and selectable scale. Accuracy of indication shall be 0.1% of scale.
4. Indicator shall be provided with a lettered plate indicating appropriate engineering units.
5. Approved Manufacturer:
   a. R. E. Technologies, Inc. (Kele Assoc.)

K. Occupancy Sensors (Operating Rooms):

1. Sensors shall be from the same manufacturer as being provided with the building lighting control system, see division 26 specifications.
2. Occupancy sensors shall operate with combination ultrasonic and passive infrared technologies and shall be ceiling mounted.
3. Occupancy sensors shall have visible LED to indicate occupant detection.
4. Occupancy sensors shall contain an isolated relay with normally open, normally closed, and common outputs.
5. Approved Manufacturers:
   a. Cooper Controls (Eaton)
   b. Hubbell
   c. Legrand WattStopper
   d. Leviton
   e. Lutron
   f. Sensor Switch
   g. Tork Tekmar

L. Occupancy Counters (People Counters)

1. Dual Sensor - Differential Thermal Imaging Counter
   a. General
      1) Provide combination BACnet-MS/TP and Analog Output counting devices for Dynamic Ventilation Reset Controls to be mounting where indicated on the plans and controlling ventilation to occupied zones as populations vary, in compliance with the Ventilation Rate Procedure in ASHRAE 62.1-2013 and 2016.
   b. Counters shall provide data on net zone populations to dynamically calculate the ASHRAE Standard 62.1 Ventilation Rate.

1) Each counter shall consist of a center-top door frame mounted counter, using a dual thermopile differential thermal imaging counters, an integral microprocessor-based design capable of providing net population data to the controls network for use in ventilation reset based on accurately measured real- time zone populations.
2) Counter with steel enclosure shall have an overall size of: 6.12L x 2.94W x 1.36H inches and weigh approx. 0.25 lbs.
3) Counters shall have an environmental operating range of no less than 65° F to 85° F and 5% – 95% RH, non-condensing.

c. Population Counter Design and Counting Performance
1) Counter shall be mounted to provide zone entry and exit data to the network for maintenance of a net zone population value to less than ±5% of actual or ±3 people, whichever is larger.
2) Counter design shall be optimized for single entry/exit interior doors, ≤ 42 x ≤ 96 in.
3) Small deviations or accumulation in counts shall be adjusted when "population reset interval" is selected during configuration and set up. Upon activation, the total net population in memory shall be 'zeroed' based on the user-determined reset period selected or every 24 hours during a predetermined non-occupied period.
4) Power, Connectivity and Communications
a) The BACnet / analog combination counters shall be capable of communicating with other devices using an RS-485 standard interface and BACnet-MS/TP protocol, implemented as a Master node.
b) Communication speed shall be field-selectable by dip switch between 9.6, 19.2, 38.4 and 76.9 kBaud.
c) The counter-network communications shall be capable of field configuration and setup using a simple dip- switch interface.
d) A simultaneous 0-10 VDC scalable and protected analog output shall also be available to provide net counts.
e) All counters shall be powered with individual 24 VAC transformers (22.8V to 26.4V under load) @1.2 V-A nominal.

2. The manufacturer's authorized representative shall review and approve counter position placement for each location indicated on the plans.
3. Accepted Manufacturer:
a. EBTRON, Inc. Model CENSUS - C100, Single-entry interior door occupancy counter.

M. Pressure to Electronic Transducers

1. Provide transducers to convert linear proportional pressure signals to interface with the Siemens analog input modules. The transducer shall be a panel-mounted device, with input pressure snubber, as required, and gauge. Supply voltage shall be 19-26 VAC. Control signal shall be 4-20 mA. Accuracy shall be 1 percent full scale. Thermal effect shall be less than 1 percent full scale on zero and less than 1 percent of reading on span. Transducer shall have elastomer seals and SS wetted parts.
2. Approved Manufacturers:
   a. Siemens
   b. Setra
   c. Modus
   d. ACI
   e. Dwyer

N. Room Differential Pressure Indicating Gauges

1. Dial (4" dia.) in metal case, diaphragm actuated, black figures on white background, front recalibration adjustment, center zero scale with scale range of 0.05-0-0.2" WC with 0.005 minor divisions, suitable for surface or flush mounting. Accuracy +/- 2% of full scale. With plastic gauge mounting plate for flush mounting and space pressure sensor consisting of pressure port, barbed tubing connection, and sensor plastic mounting plate suitable for mounting on a standard electrical junction box.
2. Approved Manufacturers:
   a. Dwyer "Magnehelic" 2000-00N with A-465 pressure sensor and A-464 flush mounting plate (provide A-368 mounting bracket for surface mount applications)

AE TO CONSIDER THE USE OF LOCAL, ROOM DIFFERENTAL PRESSURE INDICATORS AS SPECIFIED BELOW ON PRESSURIZED ROOMS THAT DO NOT NEED TO BE INTEGRATED BACK TO THE HOSPITAL BMS. SEE DESIGN GUIDELINE 5.16: UMHS - REQUIREMENTS FOR PRESSURE SENSITIVE ROOMS AND REVIEW WITH FPD ENGINEER.

O. Room Pressure Indicator (RPI)

1. Provide local room differential pressure indicator and wall/ ceiling-shielded static air probes with trim kits and tubing. RPI's provide local indication only and do not interface with the Building Management System.
2. Indicator accuracy shall be minimum ±0.5% full scale including the effects of linearity, hysteresis and repeatability.
3. Provide with Room Differential Pressure Transmitter, specified herein.
4. The indicator shall have an integral LED light indicating room pressure status – "Green" Normal, "Red" Alarm.
5. Provide with aluminum or stainless steel flush mounted, shielded static air probe, complete with pressure impulse suppression chamber and airflow shielding. Probe shall be capable of sensing static pressure within 1% of actual pressure value while being subjected to airflow at 1,000 FPM. Air Monitor model "SAP" or CRC "RST".
6. Acceptable Room Pressure Indicator Manufacturers:
   a. Setra Lite
   b. CRC Alpha

2.12 ELECTRIC COMPONENTS

A. Components shall be Honeywell, Johnson, or Siemens, unless listed otherwise.

B. Low temperature detection thermostats shall be duct type, fixed 5 deg. F differential, range 30 to 60 deg. F. Sensing element shall have a 20-foot long capillary tube responding to the lowest temperature sensed along any 12 inches of bulb length. Switch shall be SPDT 120 VAC, UL listed, rated for 10 amps at 120 VAC full load. Unit shall be manually reset. Provide one thermostat for every 20 square feet of coil surface.

C. High temperature detection thermostats shall be two-position type, range and element shall be suitable for the service, single or double pole, normally open or normally closed as required. Set point shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load. Unit shall be manually reset.

D. Immersion electric thermostats shall be two-position type, range and element shall be suitable for the service, single or double pole, normally open or normally closed as required, with stainless steel separable well. Set point shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load.

E. Remote-bulb electric thermostats shall be two-position type, range and element shall be suitable for the service, single or double pole, normally open or normally closed as required, with stainless steel separable well as required. Set point shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load.

F. Wall-mounted electric thermostats shall be two-position type, range and element shall be suitable for the service, single or double pole, normally open or normally closed as required. Set point shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load.

G. Strap-on electric thermostats shall be two-position type, range and element shall be suitable for the service, single or double pole, normally open or normally closed as required. Set point shall be adjustable over the full range. Switch shall be UL listed, rated for 10 amps at 120 VAC full load.

H. Differential Pressure Switches:

1. Shall provide electrical switching action upon a sensed pressure differential increase between two points. Sensitivity shall be suitable for the application. Set point shall be adjustable over the full range of the device. Switching action shall SPDT. Electrical switch rating shall be 10 amps at 120 VAC, minimum.
2. Pressure rating of switch and connecting tubing:
   a. Fan - Rated for 12 inches WC.
   b. Pump – Maximum deadhead system pressure.
3. Switches used for safety shutdown applications shall be of the manual reset type.
4. Approved Manufacturers:
   a. Honeywell
   b. Siemens
   c. Dwyer

d. Cleveland Airflow

I. Limit Switches:

1. Limit switches shall be oil tight type with appropriate operator to provide required function.
2. Approved Manufacturers:
   a. Honeywell
   b. Siemens
   c. Allen-Bradley
   d. GE
   e. Square D

J. Control Relays and Contactors:

1. Relays shall be a minimum DPDT, of proper coil voltage, with neon indicator light, and of sufficient rating for specified purpose. Relay base shall be of the screwed terminal type.
2. Contactors shall be definite purpose type, have adequate number of poles, of proper coil voltage, and of sufficient rating for specified purpose. Contactors used for DDC interface control shall contain a Hand-Off-Auto switch.
3. Approved Manufacturers:
   a. Dayton
   b. Siemens
   c. Allen-Bradley
   d. GE
   e. Square D
   f. Functional Devices- RIB
   g. IDEC
   h. Omron

K. Selector Switches:

1. Switches shall be multiple position type, oil-tight, watertight, dust-tight, have the adequate number of contact blocks, capable of additional contact blocks, and of sufficient rating for specified purpose. Nomenclature plate shall be provided with appropriate wording, units, etc.
2. Approved Manufacturers:
   a. Dayton
   b. Siemens
   c. Allen-Bradley
   d. GE
   e. Square D

L. Push Buttons and Pilot Lights:

1. Push button switches and pilot lights shall be, oil-tight, watertight, dust-tight, have the adequate number of contact blocks, capable of additional contact blocks, and of sufficient rating for specified purpose. Nomenclature plate shall be provided with appropriate wording, units, etc.
2. Pilot lights shall be neon or LED, push-to-test type with replaceable lens. Lens shall be of the appropriate color for application served.
3. Approved Manufacturers:
   a. Dayton
   b. Siemens
   c. Allen-Bradley

d. GE
e. Square D

M. Fuse Holder/Disconnects:

1. Fuse holder/disconnects shall be provided for all control circuits inside auxiliary control panels, and shall be of appropriate size/type for service.
2. Approved Manufacturers:
   a. Little Fuse
   b. Dayton
   c. Buss
   d. GE

N. Terminal Blocks:

1. Terminal blocks shall be modular, barrier type, direct mount, single pole, and snap together to any required number of poles. Units shall be rated for 300 volts, 20 amp., handle wire sizes from 22-12 AWG, and have a marking strip for identification.
2. Approved Manufacturers:
   a. Cooper-Bussman
   b. Weidmuller
   c. Kele
   d. Buss
   e. GE

O. Toggle Switches:

1. A toggle switch shall be provided for every auxiliary and local control panel that utilizes a 120 VAC power source as a means to turn off the power to that panel and shall be of appropriate size/type for service. Toggle switches shall be rated 120/277 volts, 20 amps, SPDT, specification grade, extra-heavy duty, back and side wired, with brown handles.
2. Approved Manufacturers:
   a. Leviton
   b. Pass & Seymor
   c. Hubbell
   d. Arrow Hart
   e. Bryant

2.13 ELECTRICAL ACCESSORIES

A. Wiring and Conduit

1. The MSCC shall provide all DDC and related control wiring, conduit, wiring troughs and J-hook cable hanging system. Wire and cable shall be pulled from device or control point to the DDC, auxiliary, or UPS and run between DDC, auxiliary or UPS with 6'-0" spare coiled at the panel. All wire and cable shall be labeled and tagged at each end, 4 inches down from the point at which the wire enters the cabinet with the corresponding point number and I/O tag. Labels shall be thermal printed type designed specifically for wiring identification.
2. All wiring carrying voltages greater than 24 volts shall be run in conduit.
3. All wiring carrying voltages 24 volts nominal or less shall be run as follows:

a. Wiring routed in shafts, walls, below grade, and in any concealed or inaccessible space, or above ceilings requiring the use of a tool to access or held in place by clips or similar devices: run wiring in conduit.
b. Wiring routed in exposed locations such as mechanical and electrical rooms or in rooms without ceilings (i.e. exposed to deck above): run in conduit.
c. Network wiring: run in conduit to nearest cable tray.
d. Wiring above accessible lay-in ceiling areas: Utilize J-hook hangers and/ or utilize facility cable tray.
    1) Provide UL Listed zinc electro-plated steel or plastic J-hooks, sky blue color, plenum use approved, with minimum 1-inch wide cable support area, rated for the cable type being supported. Provide with integral cable retainer strap to provide containment of cables within the hanger.
    2) Install J-hooks with J-hook bottoms a minimum of 10 feet A.F.F. and no less than 2 feet above the ceiling.
    3) Space hangers at maximum 5 foot intervals, with additional hangers located a maximum of 3 feet from both sides of any change in direction. Wiring shall not sag more than 12 inches between J-hooks. Install wiring and J-hooks in a neat and workman-like manner, routed parallel or perpendicular to the building column lines.
    4) Install to protect wire from damage and to allow for wire replacement. Do not exceed 50 % of the wire capacity specified by the J-hook manufacturer (first installation), or route control wiring in non-control-wiring J-hooks.
e. Wiring to wall mounted devices such as room sensors, switches, and similar devices:
    1) NEW CONSTRUCTION: Route wiring in wall in minimum 1/2 inch conduit. Stub conduit up/down into accessible ceiling space, terminating conduit with a 90 degree bend and a strain relief to prevent wire damage. Install wall box for device mounting.
    2) RETROFIT (EXISTING WALL CONSTRUCTION): Route wiring in wall, no conduit is required. Install wall box for device mounting.
f. Wiring to perimeter radiation valves and similar control devices requiring wiring to be routed in walls: Route wiring in wall in minimum 1/2 inch conduit. Stub conduit up/down into accessible ceiling space, terminating conduit with a 90 degree bend and a strain relief to prevent wire damage. Provide maximum 12 inch long flexible metal conduit for the final connection to the device.

4. Conduits shall be sized on a maximum fill of 40% capacity.
5. Existing conduits shall be allowed to be reused keeping with the maximum fill requirement of 40%.
6. Five separate conduit systems shall be provided:
    a. DO/DI and 120 VAC control wiring.
    b. AO/AI wiring (may also contain DI wiring if rated as Class II teflon jacketed twisted pair)
    c. Pneumatic tubing.
    d. Network (primary and secondary FLN) cables.

e. 24VAC (note exception under terminal air unit Wiring Requirements)
Exception: DO's, DI's, AI's, and AO's (including pneumatic tubing) installed between VSD's and DDC panels may share the same conduit.

7. All new junction boxes and couplings on conduit containing DDC related wiring or pneumatic tubing shall be painted sky blue color. Alternative: Allied Tube True Color® EMT, color blue, may be used in lieu of painted fittings and junction boxes.
8. All exposed DDC wiring shall utilize a sky blue insulation outer jacket color.
9. Data transmission cabling and equipment grounding procedures shall meet the latest FCC guidelines for electromagnetic field generation.
10. All control wiring sizes and types shall meet the equipment manufacturer's recommendations.
11. All control wiring shall have insulation rated for 300 volts minimum, and be installed per NEC requirements. Exposed wiring running in return plenums, air handling devices, and where required by code shall be plenum rated.
12. Wiring requirements for controllers on air terminal units:
    a. Provide all necessary 24 VAC transformers, 24 VAC power distribution wiring, etc. to controllers for a complete operating system. Transformers shall have primary and secondary fuse protection and shall be mounted in an electrical closet, auxiliary panel or other suitable accessible location with disconnecting means. Provide a pilot light for each transformer, to indicate the presence of load power.
    b. Terminal fittings or insulating bushings shall be used to protect wiring associated with controllers at enclosures, junction boxes, etc.

B. Provide all necessary 24 VAC transformers, 24 VAC power distribution wiring, etc. for a complete operating system. Transformers shall have primary and secondary fuse protection and shall be mounted in an electrical closet, auxiliary panel or other suitable accessible location with disconnecting means. Provide a pilot light for each transformer, to indicate the presence of load power.

C. Provide conduit and wiring to power all 120 VAC control accessories such as flow meters, BTU meters, data acquisition panels and actuators. Feed this power from an auxiliary control panel, with a separate disconnect and fuse for each device, located in the auxiliary panel.

D. For air terminal controllers, provide 120 VAC conduit and wiring between electrical panels and controller power supply transformers. Power for terminal controllers shall be from a dedicated 20A power circuit, as shown on construction documents (CD's). In general, only one circuit shall be allowed per electrical closet, unless otherwise directed by project engineer.

1. For renovation work, MSCC shall utilize existing dedicated circuit when available and either utilize existing transformer if adequate or provide new transformer(s). When an existing dedicated circuit is not available, provide new per above and as shown on construction documents. When not shown on CD's, request proper circuiting by project engineer.

SPECIFICATION EDITOR: THE AE SHALL CLEARLY INDICATE SOURCE OF POWER FOR ALL DDC CONTROLS. POWER SOURCE (NORMAL VS EMERGENCY) & PRIORITY SHALL MEET OR EXCEED THAT OF THE EQUIPMENT BEING CONTROLLED.

E. Power source (i.e. normal vs. emergency power & emergency power priority) to all controllers and associated controlled devices shall be of the same or higher priority than that of the equipment and/ or system being controlled.

2.14 AUTOMATIC CONTROL VALVES AND ACTUATORS

A. General:

1. Operators shall be electric unless specifically noted otherwise on the drawings and schedules.
2. Unless indicated otherwise on the control drawings, provide the control valve body style (globe, ball, butterfly, etc.) indicated for each application (hydronic, steam, etc.) noted below.
3. Except where otherwise noted, valve bodies 2 inches IPS and smaller shall be single seated bronze, and shall have screwed end connections. Valve bodies 2-1/2 inches IPS and larger shall be cast iron and shall have flanged end connections. Valve stem packing shall be PTFE or EPDM, spring loaded, self-adjusting. Packless construction is acceptable. Valve linkage shall have an adjustment for valve lift. Valve shall have rising stem, renewable seat and disc, repackable under pressure
4. Valve rangeability shall be no less than 50:1 for valve $C_v \leq 1$, no less than 100:1 for valve $C_v > 1$.
5. When indicated, provide separate SPDT limit switches which actuate at the full open and full closed valve position.
6. Electric actuators contained within air handling unit enclosures (and thereby subjected to maintenance power washing as part of regular PMs) shall be NEMA 4X or IP66 rated or shall be provided with weatherproof NEMA 4X stainless steel enclosures that have removable covers with clasps or machine screws (no sheet metal screws) and that do not require removing fasteners.
7. All electrically actuated control valves installed in locations exposed to outdoor conditions shall be provided with NEMA 4/4X weather resistant housings and thermostatically controlled heaters for climates that reach below freezing.

B. High Performance Butterfly Valves

1. May be used for hydronic applications, when approved, for valves 5" and larger.
2. High performance butterfly valves shall comply with Related Section 220523 Valves.
3. Approved Manufacturers
   a. Per Related Section 220523 Valves

STEAM CONTROL VALVES: REVISE THE VALVE PRESSURE DROP SPECIFIED BELOW TO THAT APPROPRIATE FOR YOUR PROJECT. FOR EXAMPLE, FOR LOCATIONS CLOSE TO THE CENTRAL POWER PLANT, A PRESSURE DROP HIGHER THAN THE INDICATED 4 PSIG WOULD BE APPROPRIATE. ALSO NOTE THAT THE BELOW VALVE SIZING CRITERIA ASSUMES THAT THE STEAM PRESSURE REQUIREMENT FOR THE EQUIPMENT SERVED BY THE CONTROL VALVE IS 1 PSI OR LESS. ALWAYS VERIFY THE EQUIPMENT PRESSURE REQUIREMENT AND MODIFY THE BELOW ACCORDINGLY.

C. Hydronic Control Valves

1. General Valve Requirements
   a. Maximum pressure drop across any hydronic system valve at maximum flow and valve size shall be as indicated.
   b. When not indicated, valves shall be sized for a pressure drop of 3 psig for chilled water and 4 psig for hot water based on the maximum flow rate scheduled for the device controlled.
   c. Two-way valves shall have equal percentage characteristics for heating and cooling applications, either linear or equal percentage for other applications as appropriate, linear for three-way valves.
   d. 2 year unconditional warranty, parts and labor. 5 year unconditional parts warranty.

2. Globe Style Valves (May be used for sizes 1" and larger).
   a. Bodies and trim shall be rated for service pressures through 125 psig at 250 deg. F, globe style.
   b. Hydronic system valves shall have replaceable plugs and seats of SAE 72 brass or AISI 300 series stainless steel, selected for maximum lift under application conditions.
   c. Shall provide safe and reliable operation in water or in up to 50% glycol/water solutions, at fluid temperatures between 35°F and 212°F and static pressures up to 300 psi.
   d. Bronze body with female NPT end connections.
   e. Differential pressure rating (valve operating): 30 PSID maximum.
   f. Provide valves with the flow coefficient indicated, or if not indicated, subject to engineer's approval, with a Cv appropriate for good control and considering the system differential pressure available.
   g. Approved Manufacturers
      1) Siemens
      2) Honeywell
      3) Johnson

ALTHOUGH AVAILABLE UP TO 4", BALL VALVES SHOULD TYPICALLY ONLY BE USED FOR SMALL CONTROL VALVE APPLICATIONS, E.G. VAV BOXES, FAN COILS. THIS SPECIFICATION IS ONLY FOR BALL VALVES UP TO 3/4" DIAMETER.

3. Ball Style Control Valves
   a. Control Valve Body: Quarter turn ball valves, 2-way and 3-way configuration as indicated, for 2 position or modulating service, with the following features:
      1) 1/2" or 3/4" valve size.
      2) Nickel coated brass or stainless steel body with female NPT end connections.
      3) Stainless steel or chrome plated brass ball, with reinforced EPDM or PTFE O-ring seals.
      4) Blow-out proof stainless steel or chrome plated brass stem with double O-ring EPDM or PTFE seals.
      5) Shall provide safe and reliable operation in water or in up to 50% glycol/water solutions, at fluid temperatures between 35°F and 212°F and static pressures up to 300 psi.

6) Ball and stem seals shall be formulated to prevent degradation by typical water treatment chemicals and Chloramines.
7) Minimum close-off rating: 200 PSI.
8) Differential pressure rating (valve operating): 30 PSID maximum.
9) Downstream leakage: maximum of 0.01% of design flow at rated close-off differential pressure.
10) 0 – 90 degree angle of rotation.
11) Valves for modulating service shall be equipped with a characterized ball (glass filled polymer flow insert) that provides an equal percentage flow characteristic.
12) Valves for two position control shall be reduced port type as required for the appropriate valve Cv.
13) Provide valves with the flow coefficient indicated, or if not indicated, subject to engineer's approval, with a Cv appropriate for good control and considering the system differential pressure available.

b. Approved Manufacturers:
1) Johnson Controls
2) Belimo

D. Steam Control Valves

1. Globe Style.
a. Bodies and trim shall be rated for scheduled saturated steam service pressures. Steam valve replaceable plugs and seats shall be stainless steel, hardened to not less than 500 Brinnel.
b. Valves shall have modified linear characteristics and shall be sized based on a 10 psig inlet pressure and a maximum drop of 8 psig.
c. 2 year unconditional warranty, parts and labor. 5 year unconditional parts warranty.
d. Approved Manufacturers
1) Siemens
2) Honeywell
3) Johnson

E. Control Valve Actuators

EDITOR: WHENEVER POSSIBLE, THE USE OF ELECTRIC ACTUATION FOR CONTROL VALVES IS PERFERRED. PNEUMATIC ACTUATION MAY ONLY BE CONSIDERED FOR PARTIAL RETROFITS OF EXISTING SYSTEMS WITH PNEUMATIC CONTROLS. CONSULT WITH THE UM DESIGN TEAM IF PNEUMATIC CONTROLS ARE REQUIRED. CONTROL VALVES LOCATED IN AN UNCONDITIONED ENVIRONMENT SHOULD BE ELECTRIC.

NOTE THAT MOST ELECTRIC BUTTERFLY VALVE ACTUATORS ARE NOT AVAILABLE WITH A SPRING RETURN OPTION WITHOUT THE ADDITION OF A BATTERY OR CAPACITOR TO DRIVE THE ACTUATOR TO ITS FAILSAFE POSITION. CAREFUL CONSIDERATION SHOULD BE GIVEN TO THE APPLICATION OF THIS TYPE OF CONTROL VALVE BEFORE USE.

WHEN THE USE OF ELECTRIC ACTUATORS IS PLANNED, THE METHOD OF GETTING POWER TO THOSE ACTUATORS MUST BE CONSIDERED. READ THE BELOW SPEC SECTION CAREFULLY AND NOTE THE SIZE RANGE FOR VARIOUS ACTUATOR VOLTAGES. THE CONTROLS CONTRACTOR SHALL NOT RUN POWER WIRING ABOVE 120V. THEREFORE:

FOR 120V ACTUATORS, POWER TO SUCH ACTUATORS IS THE RESPONSIBILITY OF THE CONTROLS CONTRACTOR AND IS TO BE ROUTED FROM THE DDC AUXILARY PANEL (SEE SECTION 2.5). IF YOUR PROJECT HAS A LARGE NUMBER OF 120V ACTUATORS, THE STANDARD (2) 20 AMP CURCUITS RUN TO THE DDC AUX PANEL MAY NOT BE ENOUGH. DETERMINE THE TOTAL AMPERAGE OF SUCH ACTUATORS AND DIRECT THE ELECTRICAL DESIGNER TO DESIGNATE ADDITIONAL 120V CIRCUITS TO THE DDC AUX PANEL, IF REQUIRED.

1. Except as noted otherwise, actuators shall be electric.
2. Provide actuator manufactured by the respective control valve manufacturer and factory assembled with the valve body.
3. Ball Style Control Valve Actuators
    a. Actuator shall include a manually operated hand wheel/ lever for manual override of the valve position.
    b. Modulating Actuators (0-10V or 4-20mA)
        1) UL listed electronic rotary actuator designed for operation with the ball type control valve, with the following features:
        2) The actuator shall be of the same manufacturer as the valve body and shall be integrally mounted to the valve at the factory.
        3) For direct coupling to the valve shaft without the use of linkages, use an ISO-style mounting pad.
        4) Minimum cycle life: 60,000 full strokes at maximum rated torque.
        5) Torque: as required for smooth positioning and closure of the valve against a maximum differential pressure of 30 PSI and to provide close-off up to 200 PSI.
        6) Motor runtime to rotate the valve ball 90°: 90 seconds maximum, 20 seconds minimum.
        7) Spring return runtime to rotate the valve ball 90°: 90 seconds maximum, 20 seconds minimum.
        8) For use with a 24VAC power supply with the ability to operate off the same power supply required for the temperature controller.
        9) For use with 0-10Vdc output proportional plus integral room controllers, fully compatible with the specified temperature controller. Unless indicated otherwise on the control drawings:
            a) Heating coil (non-vivarium applications): Normally open spring return actuation.
            b) Heating Coil(vivarium applications): Normally closed spring return actuation.
            c) Cooling coil: Normally closed spring return actuation.
        10) Electronic stall detection/overload protection. Actuator shall sense that maximum rotational position has been reached even when control signal is still applied and stop rotating prior to actuator damage.
        11) Rotation mechanically limited by adjustable integral limit stops.
        12) Mechanical range adjustment.
        13) Valve position indicator.

14) Actuator/actuator housing: Brushless DC motor design, NEMA type 1 or 2 enclosure, die-cast aluminum alloy or UL 94 listed plastic housing, lubricated gears, with a thermal barrier to prevent condensation on the actuator parts when used for chilled water applications. It shall be possible to rotate the actuator to any of four rotational angles in 90° increments, relative to the valve body.
15) Ambient temperature operating range: -20°F and 120°F.
16) Maximum actuator noise level, running or spring return: 40 dBA.

c. Floating Point Actuators
1) Shall only be used for VAV box applications
2) 24 VAC 3-position floating control, 7/32" (5.5 mm) stroke minimum, direct-coupled to valve bodies without the use of tools, with sufficient power to prevent valves from lifting off their seats. With visual position indication, manual override knob, UL-listed for plenum installations.
3) The actuators shall be fail-safe open for perimeter heating applications.
4) The actuators shall be fail-in-place for reheat control valves.

4. Butterfly Valve Actuators
a. Electric Actuators
1) Actuators shall utilize split capacitor, reversible electric motor driving a compound epicyclic gear, thermal overload protected, factory tested, factory lubricated, localized mechanical position indicator readable at 25 feet, 0-90 degree reversible operation, bolt directly to valve top plate.
2) Housing shall be weatherproof and suitable for outdoor location (NEMA 4X or IP66 rated).
3) Provide thermostatically controlled heater for prevention of condensation at low temperatures.
4) Provide auxiliary limit switches to confirm open/closed valve position.
5) For modulating valves, provide 0-10 VDC or 4-20 mA feedback signal for valve position.
6) Actuator voltage shall be 120 VAC. 120V actuators shall be fed out of the DDC auxiliary panel with a separate disconnect and fuse. Disconnect and fuse to be located in the DDC auxiliary panel.
7) In all cases the MSCC shall provide the required control wiring to the actuators.
8) Actuator ambient temperature range shall be -20 deg. F to +140 deg. F.
9) Actuator shall include a manually operated hand wheel for manual override of the valve position.

b. Pneumatic Actuators

1) Pneumatic actuators shall be pneumatic rotary type with rack and pinion to provide constant output torque rated for at least 125 percent, pilot positioner with gauges, spring return, adjustable travel stops, factory tested, factory lubricated, self-draining body, integral pneumatic parting,
2) Actuators shall have localized mechanical position indicator readable at 25 feet, 0-90 deg. reversible operation, capable of operating in any valve mounting position.
3) Actuators shall be capable of being mounted in line or transverse to pipeline, and bolt directly to valve top plate.
4) Valves shall be actuated with 60-psig air and 3-15 psig pilot service. Valves used for isolation do not require pilot positioners. Actuator shall include a manually operated hand wheel for manual override.
5) Provide speed control valves for On/Off (2-position) actuators for adjustment of actuator speed

5. Globe Valve Actuators
   a. Valves shall spring return to normal position as indicated.
   b. Select with sufficient close-off power for system pressure, pump shut off head, highest operating torque, and torque requirements of valves that may stick because of infrequent use.
   c. Select to provide smooth proportioning control under operating conditions normal to the system.
   d. Electric Actuators
      1) All actuators shall have visual position indication.
      2) Actuator shall be electric motor driving, microprocessor signal controlled.
      3) Modulating valves shall be positive positioning, responding to a 0-10VDC, 2-10VDC or 4-20mA signal.
      4) Power: All actuators shall be 24VAC power and less than 100VA draw. Power shall be via Class 2 wiring.
      ~~5)~~ Fail Safe: Valves actuators shall position the valve in a fail-safe position when the power supply is disrupted or the signal goes to 0.
      6) Valves shall have a means to manually open the valve when power is not available, such as a hand wheel or a geared crank with a clutch. A release button (clutch) or handle on the actuator shall be provided to allow for manual override.
      7) The actuator shall be designed with a current limiting motor protection.
      8) Actuator shall provide minimum torque required for proper valve close-off. The close-off differential pressure rating of the valve shall exceed the highest possible head pressure available at the pump plus 10%, and still be rated for a Class IV leakage.
      9) The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
      10) Actuators shall be UL and CSA listed.
   e. Pneumatic Actuators

1) Pneumatic, rolling diaphragm, spring loaded, piston type, pilot positioner with gauges, spring return, factory tested, factory lubricated.
2) Spring range shall be as required for non-overlapping sequencing or as indicated on drawings.
3) Ratio relays or accumulators used for sequencing valves are not acceptable unless specifically indicated on the drawings.

6. Valve body/actuator control action shall be as follows unless noted otherwise:
   a. Heating coil valves (non-vivarium) shall be normally open to flow through the coil.
   b. Heating coil valves (vivarium) shall be normally closed to flow through the coil.
   c. Heat exchanger valves (steam or water) shall be normally open to flow through the heat exchanger.
   d. Cooling coil valves shall be normally closed to flow through the coil.
   e. Humidifier valves shall be normally closed to flow through the humidifier.
   f. Condenser water valves shall be normally open to flow through the cooling tower.
   g. Isolation valves shall be normally open.
   h. Drain valves shall be normally closed.

2.15 AUTOMATIC CONTROL DAMPERS

EDITOR'S NOTE: CONTROL DAMPERS SHALL BE SCHEDULED ON THE DRAWINGS. INDICATE THE DAMPER STATIC PRESSURE AND VELOCITY RATING IN THE SCHEDULE. FOR DAMPERS USED IN ANY APPLICATIONS REQUIRING SPECIALTY MATERIALS OF CONSTRUCTION, REFER TO SECTION 2.15.E (CONSULT WITH UM DESIGN MANAGER).

A. Multi-blade type. Provide with parallel blades for two-position, throttling, and modulating service unless noted otherwise. Provide required drive axles, linkage, jackshafts, and accessories for proper damper operation. Damper blades, frames, linkages, jackshafts and other parts of the damper actuation system shall not distort or rack during operation. Dampers shall close tightly, and operate in a smooth, hesitation and slack-free manner over the entire range of travel, at the maximum air pressure and velocity at the mounting location. Additionally, multiple section dampers shall operate in unison section-to-section.

B. Face and bypass dampers shall each be capable of passing 100% of unit rated CFM. Pressure drops shall be approximately the same in either extreme position, including the pressure drops of coils and bypass components.

C. All automatic control dampers shall conform to these specifications, including those provided by equipment manufacturers.

D. All control dampers shall be low leakage type and shall meet the following minimum requirements:

1. Leakage: 6.0 CFM/sq. ft. max. at 3" WC.
2. Frames: 12 gauge channel/ 16 gauge roll formed (minimum) galvanized steel, minimum 2 inches in frame depth, welded or riveted with corner reinforcement.

3. Blades: 16 gauge (minimum) stamped galvanized steel or aluminum airfoil type, maximum blade size 8 inches wide, 48 inches long. Axles and axle extensions shall be minimum 1/2 inch solid galvanized steel. Dampers which are required to have a static pressure rating over 4" WC shall have minimum 3/4 inch solid galvanized steel axles/axle extensions.
4. Blade Seals: Synthetic elastomeric or neoprene, inflatable type, mechanically attached, field replaceable.
5. Jackshafts: Provide to drive adjacent vertical sections of multiple damper assemblies to ensure uniform operation. Minimum 3/4 inch solid or 1" hollow (minimum 1/8 inch wall thickness) galvanized steel. Where jackshafts penetrate air handling casing walls, provide greasable ball bearing supports sleeved and sealed to prevent casing leakage. Provide intermediate greasable ball bearing supports bolted to damper frames for jack shafts extending across multiple damper sections.
6. Jamb Seals: Stainless steel.
7. Bearings: Oil impregnated sintered bronze or lubricant free, solid stainless steel. Provide thrust washers at bearings for all dampers that are to be mounted with blades in the vertical position.
8. Linkages: Deflection and slack-free. Zinc plated, fully exposed, connected to blade faces (located in the air stream). Linkages may be located in-jamb for single damper flange mounting arrangements, provided linkage is external to the duct and easily accessible for maintenance.
9. Static pressure Rating: As scheduled on the drawings, or provide dampers rated for the maximum pressure to be encountered at the mounting location but not less than 4" WC.
10. Velocity Rating: As scheduled on drawings, or provide dampers rated for the maximum velocity to be encountered at the mounting location.
11. Temperature Limits: -40 to 200 deg. F.
12. Provide through-bolted connections for connecting axle or jackshaft extensions. Set screw arrangements are not allowed.
13. Selection and sizing criteria: Damper selection and sizing shall be based on damper schedule shown on the drawings. For dampers that are not scheduled on the drawings, selection and sizing shall be based on the procedure contained in Engineering Manual of Automatic Control, Honeywell, Inc., 1997.

E. For dampers located in stainless steel ductwork, PVC coated ductwork, fume hood exhaust ductwork, and exhaust fan outside air bleed-in ductwork, fabricate and size as indicated above, with the following additional requirements:

1. Frames, blades, blade axles and extensions, blade seals, jackshafts, linkages, and all other components exposed to the airstream: Type 316 stainless steel.
2. Bearings: Solid stainless steel.
3. Damper operators shall be mounted outside of air stream. Extend damper axles and jackshafts to permit mounting outside of air stream.

F. Damper End Switch

1. For dampers specified with confirmation of open/ closed position back to the BMS, provide end switches as part of the damper package, factory installed and tested by the damper manufacturer.
2. Minimum temperature limits of -50 to 40 degC
3. Minimum tested operational life of 10,000,000 cycles
4. End switches shall be constructed of similar materials (ie all aluminum/ stainless construction), NEMA rating for weatherproofness and UL/ CSA listing as damper.

G. Approved Manufacturers:

1. Honeywell
2. Ruskin
3. Vent Products
4. American Warming & Ventilating
5. Arrow United Industries
6. White Environmental
7. Johnson Controls
8. Nailor

2.16 DAMPER OPERATORS

EDITOR: WHENEVER POSSIBLE, THE USE OF ELECTRIC ACTUATION FOR DAMPER ACTUATORS IS PREFERRED. PNEUMATIC ACTUATION MAY ONLY BE CONSIDERED FOR PARTIAL RETROFITS OF EXISTING SYSTEMS WITH PNEUMATIC CONTROLS. CONSULT WITH THE UM DESIGN MANAGER IF PNEUMATIC CONTROLS ARE REQUIRED.

A. General:

1. Damper operators shall be electric unless specifically noted otherwise on the drawings.
2. Damper operators shall be installed in accessible locations. Damper operators shall not be installed inside ducts or air units that convey hazardous exhaust.
   a. Single section dampers should be configured with an extended shaft actuator mounting arrangement with the actuator mounted in an accessible location outside the ductwork.
   b. Multiple section dampers should be connected with a jackshaft arrangement which is extended to an accessible location outside the duct. Where possible tandem mounted actuation should be provided on one side of the damper assembly.
   c. Damper actuators mounted onto the same jackshaft should be controlled using a leader/follower wiring design with the DDC panel signal being wired to the master actuator and the remaining slave actuators being controlled through the master feedback signal.
3. Electric Operators:
   a. Maintenance free electric actuator, reversible, with push rod and bracket for swivel mounting and for the transmission of power.
   b. Synchronous motor with load independent running time providing parallel operation of several operators. Gear train with low noise level.
   c. Magnetic hysteresis coupling with magnetic transmission of torque, with no mechanical contact between the coupling members.

d. The actuator shall be safe against blocking and overload proof even when operated continuously.
e. 24 or 120 VAC, 4-20 mA or 0-10 VDC input, reversible, direct-drive, metal or aluminum housing, brushless DC motor with stall protection, quiet, low-power operation, have visual position indicator, manual override, and a 0-10VDC feedback signal output.
f. Actuators located outdoors shall be provided with internal heaters and should operate in the ambient temperature range of -20˚F to 140˚F.
g. Actuators located outdoors shall be NEMA4x or IP66 rated or shall be provided with weatherproof NEMA 4X stainless steel enclosures that have removable covers with clasps or machine screws (no sheet metal screws) and that do not require removing fasteners.
h. Electric actuators contained within air handling unit enclosures (and thereby subjected to maintenance power washing as part of regular PMs) shall be NEMA 4X or IP66 rated or shall be provided with weatherproof NEMA 4X stainless steel enclosures that have removable covers with clasps or machine screws (no sheet metal screws) and that do not require removing fasteners.

4. Electronic damper operators used with TECs
   a. Operators shall be 24 VAC 3-position floating control type and utilize a 90-degree rotation.
   b. Operators shall be direct-drive, have sufficient power to operate the damper against system pressures, provide visual position indication, have manual override, and shall be UL-listed for plenum installations. Operators shall be of the fail-in-place type.

5. Pneumatic Operators: Rolling diaphragm piston type with 8-13# spring range, as indicated on drawings, or as required to achieve specified performance.

B. Provide operator mounting brackets. Provide devices to connect operator drive shafts to dampers, damper linkages, and jackshafts.

C. Quantity of operators: Provide a sufficient number to achieve unrestricted movement throughout damper range, such that one operator does not operate more than the maximum square footage of damper area as recommended in standard catalog of manufacturer. Minimum torque rating for sizing electric actuators on duct systems that operate above 1” of static pressure is 14 in-lbs/ft^2. Provide sufficient number so dampers close tightly, operate in a smooth, hesitation and slack-free manner over the entire range of travel at the maximum air pressure and velocity at the mounting location, and so that multiple section dampers operate in unison section-to-section. Provide spring return to normal position.

D. Where end switches are shown on control diagrams, it is not acceptable to utilize the internal damper operator end switches. Where shown, external end switches should be provided that are secured to the damper blades, linkages, or jackshaft independently of the damper operator(s).

E. Approved Manufacturers:

1. Honeywell
2. Johnson

3. Siemens
4. Belimo

2.17 PNEUMATIC CONTROL COMPONENTS

A. Components shall be Honeywell, Johnson, or Siemens, unless listed otherwise.

B. Electric-pneumatic relays/ solenoid valves shall be two-position, have a metallic body, can be field or panel mounted, have a 24 VAC coil, and 3 or 4 ports. Only Johnson E.P. relays are acceptable.

C. Pressure-electric switches shall be two-position, appropriate range and element, suitable for the service, single or double pole, normally open or normally closed as required. Set point shall adjustable over the full range. Switch rating shall be 8.0 amps at 120 VAC, minimum.

D. Differential pressure transmitter shall be one-pipe, 3-15 psig output, capable of measuring pressure differentials of positive or negative type, operate on the force-balance principal, have an overpressure rating of 30" WC, accuracy of 5 percent full scale, and of the range suitable for the service.

E. Pneumatic room thermostats shall be direct acting, dual (minimum 5°F dead band – 2 output branch lines) or single setpoint, 2-pipe, large capacity, adjustable proportioning type, containing dual or single bi-metallic elements, adjustable differential, minimum setting no greater than 1-1/2 deg. F over a range of 55 to 85 deg. F. Provide tamperproof covers with exposed setpoint indicator in black lettering, exposed thermometer, exposed setpoint adjustment in non-public areas and key operated setpoint adjustment in public areas.

F. Pneumatic humidistats shall be of the adjustable proportioning, 2-pipe type, duct or wall mounted, reverse acting, adjustable sensitivity, sensitive hydroscopic membrane, temperature compensated, 20-90% RH range room, 25-65% RH range for duct, and 55-95% RH range for high-limit applications. Room type shall have tamperproof cover. Duct type shall come mounted inside a galvanized duct mounting box.

G. Temperature transmitters shall be one pipe, directly proportional output signal to measured variable, linearity within plus or minus 1/2% of range for 200 deg. F span and plus or minus 1% for 50 deg. F span, with appropriate 50, 100, 200 deg. F temperature range, compensated bulb, averaging capillary, rod and tube or room transmitter operating on 20 psig input pressure and 3 to 15 psig output. Room transmitter shall be provided with cover and wall plate.

H. Humidity transmitters shall be one pipe, directly proportional output signal to measured variable, linearity within plus or minus 1% of range, temperature compensated, sensitive hydroscopic membrane, room or duct mounted, operating on 20 psig input pressure and 3 to 15 psig output. Room transmitter shall be provided with cover and wall plate.

I. Receiver-controllers shall be single or dual input models direct or reverse acting with mechanical set point adjustment, calibrated proportional band adjustment, and calibrated authority adjustment. Provide proportional control mode for temperature control applications, and proportional plus integral control mode for differential pressure control applications. Proportional band shall extend from 2 to 40% of primary sensor span, authority from 0 to 200% of primary sensor span and integral time from 1/2 to 20 minutes. Suitable for input signal of associated transmitter and output signal required by controlled device.

J. Signal selector relays shall be capable of receiving two or more input signals and transmitting the highest or lowest pressure, with 1:1 input/output ratio.

K. Booster relays shall be proportional type for increasing the volume capacity of an input signal to a directly proportional output signal.

L. Pneumatic switching relays shall be snap acting, switching type with adjustable switching setpoint and fixed differential, single or double pole, and metallic body, for connecting a common port to either of two other ports based on the switching signal.

M. Pneumatic multi-purpose relays shall be two-valve design, high accuracy, high repeatability, metallic body, internal relief, high capacity, proportional, with adjustable set point, capable of being used as direct or reverse acting, amplifying, signal advancing, minimum pressure output, or lower pressure transfer. Removal of main air to the relay causes the branch line output to go to zero.

N. Pneumatic gradual position switches shall provide regulated pressure to a controlled device, with knob and pointer for manual adjustment, graduated scale plate with appropriate markings, suitable for surface or flush mounting on wall or panel as indicated.

O. Pneumatic selector switches shall be two or three position with metallic bodies, have indicating plates with appropriate markings, and suitable for panel or wall mounting. Switches installed in finished rooms shall be recessed in wall and provided with faceplate.

P. Field Mounted Gauges:

1. Provide 1-1/2” air pressure gauges on branch lines of pneumatic systems at controllers, transmitters, valve and damper operators, relays, switches, regulators; and DDC output points. Accuracy shall be 2.5 percent of full scale for the middle half of scale and 3.5 percent elsewhere. At dampers or devices that utilize multiple actuators, a single gauge in a readily visible location is acceptable.

Q. Panel Mounted Pneumatic Gauges:

1. All transmitters shall be provided with receiver gauges.
2. Door mounted analog indicator gauges shall be 3-1/2” diameter with 1% accuracy.
3. Sub-panel mounted analog indicator gauges shall be 2-1/2” diameter with 1% accuracy.
4. A 1-1/2” gauge shall be provided on the main air supply inside each control panel.

2.18 DDC, LOCAL, AUXILIARY, UPS AND SIMILAR PANELS

A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face, or as detailed on drawings.

B. Doors shall be removable, right or left hand hinged, locking, keyed alike and to other U-M control panels.

C. Removable perforated subpanel to permit mounting of controls without drilling holes.

D. Wall mounted or support kit or unistrut type frame for floor mounting.

E. Unit shall have knockouts, NEMA Type 1, and listed under UL508 Industrial Control Panel Enclosures.

F. UPS panel minimum size shall be 19-1/2" high by 20" wide by 10" deep. Confirm with UPS dimensions & clearances

2.19 UNINTERRUPTABLE POWER SUPPLIES (UPS)

SPECIFICATION EDITOR: UMH REQUIRES ALL UPS'S TO BE INTEGRATED TO THE KODE FRONT END DIRECTLY OVER THE HITS NETWORK. AE SHALL PROVIDE A HITS DATA DROP AT ALL UPS LOCATIONS AND NETWORK COMM CARD INTEGRAL TO ALL UPS'S (SEE BELOW SPEC) TO FACILITATE INTEGRATION TO FRONT END.

A. Provide local tower, dual conversion UPS for DDC Controllers and associated controlled devices. UPS shall meet the following minimum requirements:

1. UPS shall be sized for continuous full load use of all components served plus an additional 25% for a period of at least 5 minutes. Minimum size shall be 300 VA/ 120V.
2. UPS features:
   a. Audible alarm when main power is not available
   b. Automatic internal bypass to automatically maintain power to the load upon failure of the batteries.
   c. Provide with a network communication card for remote monitoring by Web/SNMP thru UMH's layer 3 network.
   d. RF noise filtering.
   e. Over-voltage protection.
   f. Four outlet receptacles minimum.
   g. Visual status alert light.
   h. Sealed maintenance-free batteries.
   i. Batteries shall be replaceable while maintaining power to the load (hot-swappable)
3. UPS installations within electrical & telecommunication rooms free from dirt/ dust & damage shall mount the UPS exposed, with brackets securely anchoring the UPS to the wall. Installations elsewhere (i.e. mechanical rooms) shall mount the UPS in a dedicated, ventilated panel enclosure. Provide panel with filtered supply fan (Dayton 2RTE8, 120V, 3"dia, 40 CFM) powered from UPS with filter guard assembly (Dayton 4YD95) and 3" dia. aluminum screened outlet opening (Dayton 31CC63). The supply fan shall be mounted to blow through the filter into the panel so the panel is pressurized with filtered air.

4. Provide with and install UPS interface power control module, Functional Devices PSM2RB10. Do not cut plug head off UPS cords.
5. Integrate UPS into the MCS via dedicated HITS network connection.
6. Approved Manufacturers:
   a. Eaton 9SX with Network Communication Card
   b. APC SMART UPS SRT with Network Management Card

2.20 AHU SAFETIES ENCLOSURES (FIRE ALARM TO TEMPERATURE CONTROL INTERFACE BOX)

A. Enclosures shall utilize a standard 4-11/16” x 4-11/16” square electrical box and blank clover. One half of the blank cover shall be painted red and the other blue. A red neon indicator light shall be installed in the red half of the cover and a blue neon indicator light shall be installed in the blue half of the cover. A terminal strip shall be installed inside the electrical box with two terminals in one half, labeled "H1" and "H2" (for HVAC use), and two additional terminals in the other half, labeled "F1" and "F2" (for fire alarm use). The red neon indicator shall be wired to the F terminals and the blue neon indicator to the H terminals.

2.21 PNEUMATIC ACCESSORIES

THE UNIVERSITY’S HIGH PRESSURE AIR SUPPLY IS AVAILABLE ON CENTRAL CAMPUS VIA THE STEAM TUNNEL SYSTEM. AS OF SEPTEMBER 2020 THE DEWPOINT IS NOT GUARANTEED. NEW PROJECTS CONNECTING TO THE TUNNEL SHOULD VERIFY THE DEWPOINT WITH UM CENTRAL UTILITY PLANT TO DETERMINE IF DESICCANT DRYERS ARE REQUIRED FOR THE CONTROL AIR.

A. Control Air Supply

1. Control air supply shall be from the University's high-pressure (steam tunnel) air supply or from a temperature control compressed air station as indicated on the project documents. System shall be sized for expected use, including air usage of laboratory airflow units or process control actuators (whether this equipment is provided by the MSCC or not), plus 10 percent extra capacity. When providing a control compressed air station, provide a Refrigerated Air Dryer if none of the pneumatic tubing or pneumatic components are exposed to outside air conditions. Provide a Regenerative Desiccant Air Dryer when pneumatic tubing or pneumatic components are exposed to outside air conditions. For projects utilizing the University’s high pressure air supply, unless indicated otherwise on the drawings, no air dryers are required.

B. Compressed Air Station

1. Temperature control air compressors shall be reciprocating oil type through 25 HP, rotary screw over 25 HP, specifically designed for pneumatic controls, shall be of the simplex or duplex type, tank or base mounted unit assemblies, have combination intake filter/silencer, and totally enclosed belt guards. Compressors shall be sized based on no more than 1/3 run time with an appropriately sized tank and an average tank pressure of 70 psig for optimum performance. Simplex units shall only be used when backing up another control air supply.
2. Tank shall be of adequate size and contain a shut-off ball valve, ASME safety relief valve, pressure switch operated start/stop control, 120 VAC electronic automatic drain with manual bypass and air pressure gauge.
3. Duplex models shall be complete with NEMA 1 enclosure, starters, disconnects, automatic alternator, H-O-A switches (left H position spring return for test only), low oil shutdown switch, push-to-test pilot lights, and 3-position switch for selection of: compressor 1 only/automatic alternate/compressor 2 only operation. PRV/filter/dryer assemblies may be mounted to the compressor/tank assembly.

INCLUDE BELOW PARAGRAPH "4" FOR CRITICAL INSTALLATIONS REQUIRING COMPRESSED AIR REDUNDANCY WITHOUT CONNECTIONS TO THE UNIVERSITY'S HIGH PRESSURE AIR SUPPLY, OTHERWISE DELETE. EDIT ABOVE ACCORDINGLY

4. Provide (2) two fully redundant simplex or duplex air compressors, each sized for 100% of the total demand, per above requirements. Provide compressor alternating switch and associated piping and 120V power to automatically alternate lead compressor (similar to Ingersoll-Rand "Alternator Switch").
5. Approved Manufacturers:
   a. Quincy
   b. ACP
   c. Divilbis
   d. Ingersol-Rand

C. Tubing

1. Copper tubing shall be new hard drawn, air grade, ASTM B75 for 3/8 inch and smaller or type L, ASTM B68 for 1/2 inch and larger, with solder joint or compression type fittings, at the option of the MSCC.
2. Plastic tubing (all sizes) shall be black virgin, polyethylene, ASTM D1248, Type 1, Class C, Grade 5, meeting crack test performance required by ASTM D1693 and be fire retardant (FR) rated. Multi-tube harness material shall be as specified above with a polyester film barrier and vinyl jacket not less than 0.062 inches thick. All non-metallic tubing shall be 1/4" O.D. minimum; micro-sleeve is not acceptable.

D. Pressure Reducing Valves:

1. Pressure reducing valves (PRV) shall be diaphragm operated, self-relieving, designed to provide precision control of air supply pressures, and shall be located after any filters or dryers.
2. PRV shall be capable of being mounted in any position, shall have locking set point handle, and SS inlet strainer.

3. PRV shall have metal or plastic body and shall be provided with 2-1/2" gauge of appropriate units.
4. PRV's that are not self-relieving shall be provided with a separate relief valve of appropriate range.
5. Approved Manufacturers:
   a. Wilkerson
   b. Hankison
   c. Parker
   d. Van-Air
   e. Johnson
   f. Honeywell
   g. Siemens

E. DDC/Auxiliary/Local Control Panel Air Filters:

1. Provide an in-line air filter for main air supply to all DDC, auxiliary and local control panels capable of removing solids and petroleum-based oils.
2. Filter efficiency shall be 99.9% of 0.5 micron particles.
3. Filter element shall be visible and shall change color to indicate when to be replaced.
4. Minimum capacity shall be 500 SCIM and 30 psig.
5. Approved Manufacturers:
   a. Wilkerson
   b. Hankison
   c. Parker
   d. Van-Air

F. Coalescing Air Filters:

1. Provide a duplex set of coalescing air filters for the main air supply to all building temperature controls.
2. Duplex assembly shall include upstream and downstream pressure gauges and isolation ball valves for each filter.
3. Filter shall have a replaceable cartridge and drain port.
4. Filter shall be designed to remove oil and water droplets down to 0.01 microns and particulates down to 0.08 microns. Minimum capacity shall be 10 SCFM and 150 psig.
5. Coalescing filters shall be located downstream of refrigerated air dryers and upstream of chemical or desiccant dryers.
6. Approved Manufacturers:
   a. Wilkerson
   b. Hankison
   c. Parker
   d. Van-Air

G. Particulate Air Filters:

1. Whenever chemical or desiccant dryers are used, provide a duplex set of particulate air filters for the main air supply to all building temperature controls located downstream of chemical or desiccant dryers.
2. Duplex assembly shall include upstream and downstream pressure gauges and isolation ball valves for each filter.
3. Filter shall have a replaceable cartridge and drain port.
4. Filter shall be designed to remove particulates down to 0.1 microns. Minimum capacity shall be 10 SCFM and 150 psig.
5. Approved Manufacturers:
   a. Wilkerson
   b. Hankison

c. Parker
d. Van-Air

H. Refrigerated Air Dryers:

1. Provide a 120 VAC air-cooled refrigerated dryer capable of providing 35 deg. F dew point air.
2. Unit shall have power on light, high temperature light, valved air bypass piping, and air-to-air precooler/reheater.
3. Heat exchanger to be non-fouling, tube-in-tube, self-cleaning with smooth surfaces.
4. Compressor shall have hot gas bypass, as required, and shall be protected by thermal and current overloads.
5. Condenser fan shall have thermal overload protection.
6. Approved Manufacturers:
   a. Wilkerson
   b. Hankison
   c. Parker
   d. Van-Air

I. Regenerative Desiccant Air Dryers:

1. Provide a 120 VAC regenerative type desiccant dryer of the optimal size to ensure sufficient contact time and capable of providing –40 deg. F dew point air at 150 psig.
2. Units shall have an adjustable solid-state timer and purge flow economizer valve, on/off switch, power on light, separate fill and drain ports for ease of desiccant replacement without piping removal, heavy duty purge exhaust mufflers for quiet operation, non-lubricated air control valves, Teflon seated check valves, visible moisture indicator, visible purge flow indicator, pressure relief valve, ASME code constructed/stamped pressure vessels, SS support screens and air diffusers, tower pressure gauges, structural floor frame and stand for large sizes, wall mounting brackets and supports for small sizes, pre-piped and wired, and complete with air bypass piping.
3. Approved Manufacturers:
   a. Wilkerson
   b. Hankison
   c. Parker
   d. Van-Air

J. In-line Desiccant Air Dryers:

1. Provide an in-line desiccant dryer of the optimal size to ensure sufficient contact time and capable of providing 4,000 cubic feet of –40 deg. F dew point air at 150 psig with a dryer inlet temperature of 68 deg. F.
2. Units shall have a removable bowl or fill port for ease of desiccant replacement without piping removal, visible moisture indicator, and air bypass piping.
3. Not to be used as a substitute for Regenerative Desiccant Air Dryers when providing a control compressed air station.
4. Approved Manufacturers:
   a. Wilkinson
   b. Hankison
   c. Parker
   d. Van-Air

2.22 IDENTIFICATION AND LABELS

A. The MSCC shall provide black phenolic nameplates with engraved white minimum 1/4" high lettering, for each DDC or auxiliary panel and panel door mounted devices, permanently attached, to identify field panel number, building, area, service, etc.

B. All control devices located within auxiliary panels shall be labeled with legible identification that corresponds with the as-built drawings via black permanent marker. Use plastic or metal tags when it is not possible to mark directly on the device.

C. MSCC shall label panel power supply with power circuit and electrical panel information.

D. All wiring and pneumatic tubing shall be suitably identified by thermal print labels at controller and input/output device.

PART 3 - EXECUTION

SPECIFICATION EDITOR: ONLY USE THE FOLLOWING PARAGRAPH FOR ADDITION & RENOVATION PROJECTS. REMOVE THE FOLLOWING PARAGRAPH FOR NEW, STAND-ALONE FACILITIES.

3.1 DEMOLITION

A. All existing control panels, devices, wiring, conduit/ raceway and tubing that are to be abandoned as part of renovation work shall be demolished completely by the MSCC.

B. All demolished controllers or control devices that are still in working condition shall be returned to UMH's HVAC maintenance department.

C. Control wiring shall be demolished from field device back to the respective controller, unless otherwise in design documents.

D. Control panel 120VAC power wiring shall be demolished from the control panel to the distribution panel, unless indicated otherwise in design documents.

E. Abandoned pneumatic tubing shall be demolished back to the nearest main line tap and shall be capped with a mechanical fitting.

F. When controllers are removed, the MSCC shall ensure that the existing DDC panel communication bus is maintained during and after all demolition work.

G. The MSCC shall be responsible for identifying the additional demolition/ decommissioning scope on UMH's legacy Siemens, Honeywell, Johnson Controls, and/ or ASI DDC systems impacted by the project scope.

1. UMH Systems Monitoring shall be responsible for the removal/ decommissioning of all graphics, alarms, trends on UMH's legacy BMS front ends (ie Honeywell EBI & JCI Metasys) related to points, devices & controllers that have been modified as part of the MSCC's work.

2. UMH BAS Controls shall be responsible for the removal/ decommissioning of all legacy DDC panel databases (ie Honeywell EBI & JCI Metasys) related to points, devices & controllers that have been modified as part of the MSCC's work.

3.2 INSTALLATION

A. Install all system components as recommended by the manufacturer, including air compressors, dryers, filters, etc.

B. Thermostats, room temperature sensors, push-buttons, Indoor Air Quality (IAQ) Monitors and other adjustable devices meant for room occupant operation shall be mounted 44" to center above the finished floor (or as permitted by ADA requirements referenced in UM Design Guideline 1.0 Codes and Regulatory Agencies). This requirement does not apply to control panels and devices mounted in penthouses, mechanical rooms, and other spaces normally inaccessible to room occupants. Contractor shall refer to architectural elevations for locations of sensors.

C. Zone thermostatic controls used to control both heating and cooling, e.g. a variable volume terminal unit also controlling a reheat coil and/or fin tube radiation, shall be programmed (DDC systems) or set up (non-DDC systems) with a heating setpoint of 71°F and cooling setpoint of 76°F, and a dead-band of 5°F, unless indicated otherwise on the Drawings.

D. System I/O's shall not be split between different DDC panels.

E. AHU safeties enclosure shall be mounted at the wiring/tubing DDC panel array interface trough.

F. Install all conduit, wiring, cable, tubing and equipment in a first-class manner, using proper tools, equipment, hangers, and supports, and in locations as required for a neat, attractive installation. No material shall be exposed if it is possible to conceal it. Exposed materials shall be installed only with consent of the Owner. Conduit shall not be supported from work of other trades.

G. Support all sensors as recommended by the manufacturer. Space sensors shall be mounted on an electrical box. Averaging element temperature sensors shall be mounted securely from coil frames in a horizontal serpentine manner at intervals not to exceed 4 feet; provide rigid supplemental metallic support structure when required. For element directional changes, minimum bend radius shall be no less than 2". Use mounting clips which prevent element wear due to vibration.

H. Install low temperature detectors as recommended by the manufacturer: devices shall be mounted securely from coil frames horizontally with no upward pitch at intervals not to exceed 1 foot. Provide rigid supplemental metallic support structure when required. For element directional changes, minimum bend radius shall be no less than 2". Use mounting clips which prevent element wear due to vibration.

I. Provide a control air shut-off valve for each panel.

J. Panels and meter enclosures shall be rigidly mounted.

K. Plastic tubing may be used in all locations, except in mechanical rooms, shafts, or exposed locations, unless run in conduit.

L. Tubing shall not be attached to conduits with current carrying conductors or fire protection piping. It shall be adequately supported with no noticeable sagging between supports, and protected from abrasion and galvanic corrosion. All pneumatic tubing shall be concealed in finished areas.

M. A PRV shall be installed on each floor to provide control air supply.

N. All wiring to devices installed inside auxiliary/local panels shall enter/exist via terminal strips, except twisted/shielded sensor wiring.

O. Provide a pouch or other containing method inside each control panel and insert a copy of the corresponding system control drawings and panel wiring diagrams.

P. Provide supplemental Hand-Off-Auto switches and contactors, as required, to permit automatic operation of equipment from the DDC system (i.e. single phase equipment which uses fractional motor starters, etc.).

Q. Extreme care shall be used in making connections to other equipment to see that the safeties on this equipment are not inadvertently bypassed or overridden by the DDC.

R. All equipment having moving parts and controlled by the DDC shall be provided with warning labels no less than 2 in. in height, and in bright warning color, stating that the equipment is remotely started by automatic controls. Such labels shall be posted clearly in the area of any moving parts, such as belts, fans, pumps, etc. The University of Michigan will furnish and install these warning labels.

S. Ensure all dampers, valves, thermowells, flow meters, and other miscellaneous control components are located and installed correctly so that the specified and intended performance and the Sequence of Operation is achieved, including components supplied and installed by others.

T. Limit switches used on dampers shall be set at approximately 95% of full stroke (opened and closed). Where a single limit switch is indicated, set at approximately 75% of full stroke.

U. MSCC shall provide all necessary equipment, test gases, etc. for calibration, and shall calibrate all sensors (i.e. CO2, CO, combustible gas, etc.) in accordance with the manufacturer's recommendations. Specialized equipment, test gases, etc. shall be turned over to owner upon completion and acceptance.

V. Flow meters shall be installed with at least 10 diameter of straight pipe length upstream and five diameter of straight pipe length downstream. Power supply to flow meters and BTU meters shall be 115 VAC from the auxiliary DDC panel, and power connection for each device shall be installed with a lockable local service disconnect. Flow meter transmitters/ displays and BTU meters, shall be mounted 4 feet above finished floor. They shall be located at the DDC panel array unless the maximum available cable length is exceeded. All meter components, including sensors, shall be mounted in accessible locations.

W. Airflow sensors shall be installed with the appropriate upstream and downstream clearances per manufacturer's instructions.

X. Remove any unused items that are part of demolition, including, but not limited to: enclosures, conduit, wire, tubing, controllers, controlled devices, relays, enclosures, etc. Do not abandon in place.

Y. DDC sensor cabling shall not be spliced.

Z. DDC Wiring shall be terminated at DDC sensors, relays, transducers, switches and control panels. Intermediate stops or terminations at any other terminal strips are not acceptable.

AA. DDC signal wiring and pneumatic tubing shall be routed directly to respective panel where wire/tubing is to be terminated. Routing signal wiring/tubing through adjacent panel/enclosure is not acceptable.

BB. All panel mounted devices and accessories shall be fastened to panel with mechanical fasteners or DIN-rail. Double-sided tape is not acceptable.

CC. Locate all control components and accessories such that they are easily accessible for adjustment, service and replacement.

DD. Participate in the commissioning process in accordance with the project commissioning documents.

EE. Fire Alarm to Temperature Control Interface Boxes shall be mounted at the DDC panel arrays.

FF. All set points and alarm points shown on the documents are preliminary. Finalize with the Engineer and Commissioning Authority prior to programming. Revise settings as required during commissioning.

GG. For fan coil/ terminal unit controllers and similar programmable electronic controllers, obtain approval of programmable settings from the Engineer and Commissioning Authority prior to programming. Revise settings as required during commissioning.

HH. Install constant flow fume hood sash position sensors and sash travel limit brackets in a neat and workmanlike manner. Install cables and wires in a manner which avoids contact by the user during normal use, and allows vertical sashes to be positioned without binding, twisting or tangling.

II. Except as specified otherwise, throttling ranges, proportional bands, and switching differentials shall be centered on the associated set point.

JJ. All set points, unless otherwise indicated, are adjustable and shall be programmable for all control loops. All set points and alarm points shown on the documents are preliminary. Finalize with the Engineer and Commissioning Authority prior to programming. Revise settings as required during commissioning.

KK. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the system start commands shall be staggered by 60-second (adj.) intervals to minimize inrush current.

LL. Optimal start/stop programs shall be applied to all regularly scheduled mechanical and electrical systems.

MM. Configure modular DDC panel terminations such that analog inputs and analog outputs terminate on separate modules, do not intermix analog outputs and inputs on the same module.

NN. Seal conduit penetrations in fire rated walls using fire-sealing caulk approved by a Nationally Recognized Testing Laboratory.

OO. Provide temporary programming to provide building heating or cooling during construction.

PP. Programming lines shall be grouped into subparts and explained with comment fields. The comment fields shall include the related part of the project sequence of operation that each program subpart is intended to accomplish.

QQ. MSCC shall be responsible for adding all DDC devices, logic, project files, etc. in the project scope of work to the UMH managed vendor specific engineering software to allow UMH to fully manage system code/logic, network settings, definitions, parameters, etc.

RR. Coordinate with 3rd party equipment supplier BACnet object lists and integrate into Owner's BMS system, including assigning Instance numbers based on Owner's convention. Submit a list of available BACnet objects and proposed naming convention for owner approval. Map all BACnet objects selected by owner (using owner designated naming convention) to be viewable at the field panel and BAS server.

SPEC WRITER NOTES: FUME HOOD MONITORS ARE TYPICALLY NOT PROVIDED BY THE MSCC ON UMH PROJECTS, BUT ARE RATHER PROVIDED WITH THE FUME HOOD. FOR RARE OCCASIONS WHERE THE MSCC WILL PROVIDE THE FUME HOOD MONITOR, CHANGE THE FOLLOWING PARAGRAPH FROM HIDDEN TEXT.

SS. Install constant flow fume hood monitors surface mounted on the front of the fume hood. Furnish exact dimensions and location to the fume hood factory to allow for concealed wiring to the monitor.

TT. Temperature and/ or humidity sensors using 10k or 20k thermistors shall be field calibrated with a NIST calibrated field device for the full span of control.

UU. Indoor Air Quality (IAQ) Monitors shall be securely attached to the wall with screws, per manufacturer recommendations. Do not mount directly over heat sources (monitors, printers, etc). Once installed, the MSCC shall verify accuracy of temperature and humidity readings via a NIST calibrated device, for all of the sensors used. Submit testing report, including date, time, NIST device (and last calibration), IP sensor reading and NIST device reading, to UMH FPD for records.

3.3 CONTROL PANELS

A. All wire and pneumatic tubing within the control enclosure shall be neat and suitably bundled and contained in "Panduit" wire duct, or equivalent, parallel and/or perpendicular with enclosure. Alternately, bundle at 4-inch intervals using nylon tie straps. Wire bundle straps shall be secured to panel backplane using screws or mounting rails. Free-hanging, loose installations are not acceptable.

B. All panels, enclosures, sub-panels, junction boxes, pull boxes, troughs, trays, etc. shall not exceed 70% maximum conductor fill.

C. Each input/output device shall be controlled from a dedicated 2-pair conductor.

D. Each input/output device requiring power shall have a dedicated power wire run to the control enclosure and shall be terminated to a dedicated terminal strip.

E. Maintain separation of class 1 and class 2 wiring. Use separate conduit connections to control panel for each wire type. I/O wiring shall enter control panel through a conduit directly above the module that it will connect to.

F. For door mounted devices, the installing contractor shall properly dress and bundle the wiring or tubing in a way that does not interfere with fully opening and closing the door.

G. Wiring shall be tagged with point address or wire number 4 inches down from the point at which the wire enters the cabinet.

H. The 24VAC power supply in the DDC panel shall only be used to power the controller and shall be fed by a dedicated 120V circuit. Provide separate control transformers as required to power other devices.

I. Controller module labels shall be installed into each module with final point names and addresses listed. Where not possible, include a printout of panel point addresses with the as built drawing set left in panel.

J. Auxiliary panels shall be powered with a dedicated 120VAC circuit and contain a service disconnect in the upper right corner. Final circuit number shall be tagged on switch cover and enclosure cover.

K. Auxiliary panel components shall be laid out in an organized manner and positioned to conserve available space for future use. All devices shall be mounted on panel backplanes. Auxiliary panels shall not be loaded beyond 70% of the backplane capacity.

L. Motor load wiring shall not be routed into or through control panels.

M. No voltage higher than 120 VAC shall be routed into or through control panels.

N. MSCC shall label panel power supply with power circuit and electrical panel information.

O. All wiring and pneumatic tubing shall be suitably identified by thermal print labels at controller and input/output device.

P. Labelling convention for DDC Panels shall follow that set forth under the Field Device Identification section of Part 3 "BACNET OBJECT / CONTROL POINT NAMING", along with the room number where the panel is mounted, and shall include a list of systems controlled/ monitored/ alarmed by that field device. Examples of this include:

1. 0316-PNL-B2C326 services 0316-AHU-0202 and FCU-B2345. Panel is mounted in room B2C326.
2. 0517-PNL-4745-IO1 services 4th Floor VAV boxes (indicates a remote I/O module off PNL2)

3.4 INSTALLATION – POWER, CONTROL, AND NETWORK WIRING

A. All wiring to devices installed inside auxiliary/local panels shall enter/exist via terminal strips, except twisted/shielded sensor wiring.

B. DDC sensor or network cabling shall not be spliced.

C. Where multiple controllers reside in a single control panel, provide a separate control transformer with disconnect (or fuse/circuit breaker) for each controller.

D. Provide circuit breakers for each 120VAC power connection inside of a control panel.

E. Refer to Part 2 for additional installation requirements.

F. Ground controllers and control panels to a good earth ground. Grounding of the green AC ground wire, at the breaker panel, alone is not sufficient. Run metal conduit from controller panels to adequate building grounds. Contractor is responsible for correcting all associated ground loop problems

3.5 INSTALLATION – PNEUMATIC AIR

A. Provide a control air shut-off valve for each panel. Downstream, install an in-line air filter for main air supply to each DDC, auxiliary and local control panel.

B. Provide a control air shut-off valve for each panel. Downstream, install an in-line air filter for main air supply to each DDC, auxiliary and local control panel.

C. Plastic tubing may be used in all locations, except in mechanical rooms, shafts, or exposed locations, unless run in conduit.

D. Tubing shall not be attached to conduits with current carrying conductors or fire protection piping. It shall be adequately supported with no noticeable sagging between supports and protected from abrasion and galvanic corrosion. All pneumatic tubing shall be concealed in finished areas.

E. PRV shall be installed on each floor to provide control air supply, when control air is required on the floor.

F. Provide all required control air and associated tubing.

3.6 LABELLING

A. Labelling methods and color scheme shall be reviewed and approved by UM before proceeding.

B. Labels for devices in offices, public, and similar spaces shall be thermal printed on clear adhesive tape.

1. Label terminal unit controllers with address (non-BACnet) or Instance number (BACnet), affixing label to ceiling grid or access panel at unit location. Use nominal 3/16” high black block-style font.
2. Label exterior of room mounted control devices with address (non-BACnet) or Instance number (BACnet). Use nominal 12 point block-style black font.

C. Label the field end of every DO/DI/AO/AI connected to a controller. Labels shall be thermal printed on white adhesive tape.

1. Nomenclature shall include point name and address (non-BACnet) or Instance number (BACnet). Use nominal 12 point block-style black font attached to exterior of device.

D. Refer to Part 2 for additional labelling requirements.

3.7 HUMAN MACHINE INTERFACE PANEL(HMI) INSTALLATIONS

SPECIFICATION EDITOR: THE AE SHALL EDIT BELOW AND CLEARLY INDICATE ON CD'S WHERE LOCAL DDC PANEL HMI'S ARE REQUIRED. IN GENERAL, DDC HMI'S SHOULD BE PROVIDED FOR ALL CONTROLLERS SERVING THE EQUIPMENT IDENTIFIED BELOW IN ALL INPATIENT FACILITIES AND AMBULATORY SURGERY CENTERS. INSTALLATIONS WITHIN OUTPATIENT BUILDINGS OR MEDICAL OFFICE BUILDINGS TYPICALLY DO NOT WARRANT THE NEED FOR DDC PANEL HMI'S.

A. MSCC shall provide a Human Machine Interface Panel (HMI) for the following room types/ applications, or as shown on contract documents:

a. All DDC Panels as specified herein and/ or as indicated on contract documents. The exception to this are DDC HMI's are NOT required for:
   1) DDC controllers only serving unitary/ terminal infrastructure (ie VAV's, CUHs, FCU's, etc).
   2) DDC controllers in non-Inpatient facilities and non-Ambulatory Surgery Centers (ie medical office facilities, outpatient facilities).

b. HMI shall be provided with a network connection to the HITs network as well as a connection to the local DDC controller.

c. MSCC shall be responsible for providing and installing the HMI, including all required power, communication and associated raceway. MSCC shall mount HMI in DDC panel door. MSCC shall validate proper IP & MS/TP communication to HMI.

d. Touch panel displays shall be powered from dedicated power supplies/power supply panels.
   1) Power for touch panel displays shall not be sourced from dedicated control transformers.
   2) Provide supply power fuse or circuit breaker for each touch panel display sized per manufacturer recommendations.

e. MSCC shall be responsible for the configuration and generation of graphics on the HMI.
   1) HMI shall display DDC points, as indicated on contract documents points list, in a tabular format, organized in columns. Provide point descriptor (ie AC-6 Discharge Air Temperature) along with point value and unit of measurement (ie 55 degF).
   2) All process control points shall be provided with current process control loop setpoint value adjacent to process variable (i.e. heating hot water supply temperature setpoint shown next to heating hot water supply temperature value).

3) HMI shall identify points that are in alarm or out of service.
4) HMI shall provide a system shutdown alarm and operational alarm page.
5) For HMI's providing interfacing for multiple systems:
   a) Provide a screen for each system.
   b) Provide a main menu page with links to each system page.
   c) Provide a link on each system page to the main menu page
6) HMI layout and graphic appearance shall match existing HMI's. Layout shall utilize yellow text on a blue background and include the UMH logo, panel name and date/ time in the upper banner.
7) HMI information shall be readily available and always displaying. Passwords/ locked screens are not allowed.
8) System operation/override (equipment start/stop, control loop setpoint change, etc.) shall not be provided on HMI.
9) For each HMI, MSCC shall provide functional demonstration of fully configured display for Owner review and approval prior to installing.

B. MSCC shall integrate HMI to the BMS. MSCC shall power monitors from system Aux Panel power or an emergency power source, as shown on contract documents.

C. Flush-mount room mounted HMI's adjacent to the door into each space, in the corridor wall. For rooms with an anteroom, mount monitor in corridor wall, outside anteroom.

D. Contractor shall refer to architectural elevations for exact location of HMI's.

3.8 CRITICAL ROOM TYPES

A. The following room types are deemed critical rooms by UMH:

1. Delivery Room
2. Emergency Department Decontamination
3. Emergency Department Public Waiting Room
4. Medical/ Anesthesia Gas Storage
5. Newborn Intensive Care
6. Operating Rooms (Type 1 Infection Control Room Type per SBA 5.13)
7. Procedure Rooms (Type 2 & 3 Infection Control Room Type per SBA 5.13)
8. Bronchoscopy Rooms (Type 6 Infection Control Room Type per SBA 5.13)
9. Radiology Waiting Room
10. Trauma Room
11. Triage
12. Airborne Infection Isolation Rooms & Anterooms
13. Protective Environment Rooms & Anterooms
14. Morgue/ Autopsy Rooms
15. Endoscope Cleaning
16. Clean Workroom (CSPD)

17. Decontamination Room (CSPD)
18. Sterile Storage Rooms
19. Laboratories
20. Pharmacy (including Radiopharmaceutical) Compounding, Workroom and Storage Areas (see SBA 5.17)
21. Nuclear Medicine Hot Labs
22. Nuclear Medicine Treatment Room

3.9 ROOM PRESSURE MONITOR/ INDICATOR AND PRESSURE TRANSMITTER INSTALLATIONS

SPEC WRITER NOTES: AE SHALL SHOW RPM/ RPI LOCATIONS ON CONTRACT DOCUMENTS.

A. MSCC shall provide and configure Room Pressure Monitors (RPMs) for all critical room types as defined under section 3.8 "Critical Room Types", or as shown on contract documents:

B. MSCC shall provide and configure Room Pressure Indicators (RPIs) for the following room types, or as shown on contract documents:

1. Dialyzer Reprocessing Room
2. Nonrefrigerated Body-Holding Room
3. Sterilizer Equipment Room
4. Clean Linen Storage
5. Soiled Linen Sorting & Storage
6. Clean Workroom/ Holding
7. Soiled Workroom/ Holding
8. Hazardous Material Storage

C. Transmitters shall be mounted in a wall mounted panel enclosure above the ceiling on the corridor side of the door into the space. Confirm mounting location with project engineer.

D. The pressure port tube distance between transmitter and room pickup should be minimized as much as possible. Remote mounted transmitters utilizing extensive pickup tubing lengths have proven to yield in-accurate room pressure readings and are not allowed.

E. Configure RPM's/ RPI's to display, allow adjustability and alarm DDC points as indicated on contract documents. Configure time delays as indicated on contract documents. Silence audible alarm (ie visual alarm only) as indicated on contract documents.

F. MSCC shall field measure room volume to use in calculating room air change rates.

3.10 UNINTERRUPTABLE POWER SUPPLIES (UPS) INSTALLATIONS

SPECIFICATION EDITOR: THE AE SHALL CLEARLY INDICATE ON CD'S WHERE LOCAL UPS'S ARE REQUIRED TO POWER DDC PANELS. IN GENERAL, UPS'S SHOULD BE PROVIDED TO PROTECT AGAINST DAMAGE DUE TO POWER QUALITY AND TO MINIMIZE DISRUPTION.

A. Provide local UPS as specified herein for all front-end DDC panel installations and/ or as indicated on contract documents. Local UPS is NOT required for:

1. DDC controllers powered from a central UPS system.

2. DDC controllers serving non-critical (see section 3.8) unitary/ terminal infrastructure (ie VAV's, CUHs, FCU's, etc).
3. DDC controller installations that can utilize an existing, local UPS on an adjacent DDC installation. MSCC shall provide all raceways & cabling needed to extend power to new DDC devices. MSCC shall be responsible for validating that the existing UPS is capable of supporting the additional loads.
4. DDC controllers in non-Inpatient facilities and non-Ambulatory Surgery Centers (ie medical office facilities, outpatient facilities).

B. Rigidly mount and anchor UPS to wall, either in ventilated panel enclosure or on wall brackets, per specification section 2.5. Do not mount UPS on floor.

C. Where a UPS serves multiple DDC panels, provide a terminal strip for interfacing of power wiring from the UPS to the DDC panels. If UPS is not provided with individual circuit protection, provide circuit breakers on each DDC panel power feed.

D. Connect HITS provided patch cable at UPS and configure network communication card to facilitate communication and SNMP integration to the Vykon Niagara frontend.

3.11 BACNET OBJECT / CONTROL POINT NAMING

A. The contractor shall use the BMS point naming convention outlined below. In instances where character restrictions prohibit use of this convention, or for other unique systems not covered below, contact project engineer for direction.

B. The contractor shall provide a submittal for owner review and approval for the specific point naming convention proposed on the project. This shall be included in the BMS Temperature Controls submittal.

C. All control points shall include two sections with decimal point separation: system identification and point description identification. See the example below:

1. AHU22.DAT = Discharge Air Temperature on air handler AHU-22.

D. Field Device Identification

1. All field device identification shall include three sections with decimal point separation: B (for building) followed by the 4 digit UM Building number, device identification and sequential number, and room where device is located. See the example below:
   a. B0316.PNL1.3000M = DDC Panel #1 in room 3000M in the University Hospital Building (ID #0316).
2. Device abbreviations shall conform to the following:
   a. FCU = Terminal fan coil unit controller
   b. HMI = Human Machine Interface Panel
   c. RPM- Room Pressure Monitor
   d. MON = Terminal controller with monitoring points only
   e. PNL = DDC Panel (Controller)
   f. RTR = Router (BACnet IP)
   g. UPS = Uninterruptable Power Supply
   h. VAV = Terminal VAV box controller

i. PM = General Power Meter
j. PQ = Power Quality Meter
k. ATS = Automatic Transfer Switch
l. STS = Static Transfer Switch
m. GW = Gateway

E. System Identification

1. The point system identification shall associate a point with the system it is directly related to. A system shall be an air handling unit, a heating system, a chilled water system, a VAV box, etc.
2. System and equipment designations shall match those set forth on the equipment schedules in the project documents. When not clearly defined, systems shall be abbreviated in the point name as follows:
   a. AHU = Air Handling Unit
   b. CHW = Chilled Water and Primary Chilled Water Loop
   c. CRAC = Computer Room Air Conditioning unit
   d. CW = Condenser Water
   e. DHW = Domestic Hot Water
   f. FCU = Fan Coil Unit
   g. HHW = Heating Hot Water
   h. PCHW = Process Chilled Water
   i. RTU = Rooftop Unit
   j. SCHW = Secondary Chilled Water
   k. TCHW = Tertiary Chilled Water
   l. UH = Unit Heater
   m. VAV = Variable or Constant Air Volume Box. Use SVAV for Supply VAV, RVAV for Return VAV or EVAV for Exhaust VAV.
3. If the system is one of multiple common systems in a building (AHU's, etc.), the System Identification shall include the system identifier. See the examples below:
   a. AHU01 = Air Handling Unit AHU-1
   b. AHUH52 = Air Handling Unit AHU-H5-2
   c. AHUOA1 = Outside Air Handling Unit AHU-OA-1
4. Terminal equipment, such as VAV boxes or fan coil units, shall include the room number of the space served in the System Identification. If the equipment serves multiple rooms, the primary room or room including the thermostat shall be used for this identification. For areas such as operating rooms, where the room ID would be more commonly used than the actual room number, the ID shall be used (ie. OR-5 instead of 1C204). See the examples below:
   a. VAVB2C205 = VAV box serving room #B2C205
   b. VAVOR5 = VAV box serving operating room OR-5
   c. EVAVB1345 = Exhaust VAV box serving room B1345

F. Point Description Identification

1. The point description identification shall identify the specific point and its function in the system. A Point Description shall identify and describe the field or virtual device, sensor, setpoint, mode, etc. It is understood and accepted that many terminal equipment controllers for VAVs, etc., will include pre-programmed Point Descriptions that do not match the identifications below. In those cases, terminal equipment points shall be named so its clear what the point is.

2. Points shall not be bundled into combined points. For example, a motor start DO and status DI points shall remain fully independent points with a separate programmed alarm point when these two do not match (ie. Siemens L2SL points, or equivalent, are not acceptable).
3. Spare DDC points shall be labelled as SPARE in the point description.
4. Descriptions shall be abbreviated in the point name as follows:
   a. AHU = Air Handling Unit
   b. AC = Air Conditioning Unit
   c. BPV = Bypass Valve
   d. BTU = Energy Units Btu
   e. BTUH = Energy Rate Units Btu/hour
   f. CCT = Cooling Coil Leaving Air Temperature
   g. CCV = Cooling Coil Control Valve
   h. CFM = Air Volume Flowrate
   i. CH# = Chiller (ie. CH-1 is "CH1")
   j. CO2 = Carbon Dioxide
   k. CT# = Cooling Tower (ie. CT-1 is "CT1")
   l. CT#VFD = Cooling Tower VFD (ie. CT-1 VFD is "CT1VFD")
   m. DAPRS = Discharge Air Static Pressure
   n. DARH = Discharge Air Relative Humidity
   o. DAT = Discharge Air Temperature
   p. DECGPM = Decoupler Liquid Volume Flowrate
   q. DIFCFM = Air Volume Flowrate Differential
   r. DP = Differential Pressure
   s. DPR = Damper
   t. EAT = Exhaust Air Temperature
   u. EODPRS = End of Duct Static Pressure
   v. FLT = Filter Differential Pressure
   w. FPM = Speed in Feet Per Minute
   x. FRZ = Freezestat
   y. GPM = Liquid Volume Flowrate
   z. HCV = Heating Coil Control Valve
   aa. HUV = Humidifier Control Valve
   bb. HX# = Heat Exchanger (ie. HX-1 is "HX1")
   cc. KW = Kilowatt
   dd. KWH = Kilowatt Hour
   ee. LVL = Level
   ff. MAD = Mixed Air Dampers
   gg. MAT = Mixed Air Temperature
   hh. MAX = Maximum
   ii. MIN = Minimum
   jj. OACFM = Outside Air Volume Flowrate
   kk. OAE = Outside Air Enthalpy
   ll. OARH = Outside Air Relative Humidity
   mm. OAT = Outside Air Temperature
   nn. OAW = Outside Air Humidity Ratio
   oo. OCC = Occupied Mode
   pp. OS = Occupancy Sensor
   qq. P# = Pump (ie. P-12 is "P12")
   rr. P#VFD = Pump VFD (ie. P-12 VFD is "P12VFD")
   ss. PHT = Preheat Coil Leaving Air Temperature
   tt. PRS = Static Pressure
   uu. RACFM = Return Air Volume Flowrate
   vv. RAE = Return Air Enthalpy
   ww. RAFVFD = Return Air Fan VFD

xx. RAF = Return Air Fan
yy. RARH = Return Air Relative Humidity
zz. RAT = Return Air Temperature
aaa. RAW = Return Air Humidity Ratio
bbb. RETT = Return Temperature (water)
ccc. RLA = % Rated Load Amps
ddd. RMT = Room Temperature
eee. SACFM = Supply Air Volume Flowrate
fff. SAFVFD = Supply Air Fan VFD
ggg. SAF = Supply Air Fan
hhh. SCV = Steam Control Valve
iii. SUPT = Supply Temperature (water)
jjj. TON = Cooling Load Tons
kkk. UNOC = Unoccupied Mode
lll. V# = Isolation/2-Position Valve (ie. V-12 is "V12")
mmm. VIBSW = Vibration Switch
nnn. VLT = Voltage

5. Point description shall include an underscore and additional tag for extra description such as setpoint, alarm, etc. Description add-ons shall be abbreviated in the point name as follows:
   a. _ALM = Alarm
   b. _CLD = Closed
   c. _CMD = Command
   d. _END/DIS = Enable/ Disable
   e. _HLSP = High Limit Setpoint
   f. _LLSP = Low Limit Setpoint
   g. _OPN = Open
   h. _SP = Setpoint
   i. _STS = Status

G. See below for several examples of implementation of this point naming convention:

1. AHUC4.DAT_SP = Discharge air temperature setpoint for AHU-C4.
2. AHU18.SAF_STS = Status of supply fan in AHU-18.
3. CHW.CH1SUPT = Chilled water supply temperature from Chiller CH-1.
4. CHW.SUPT = Main primary chilled water loop supply temperature.
5. SCHW.SUPT = Secondary loop chilled water supply temperature.
6. HHW.HX1SCV_CMD = Command to Steam control valve on heat exchanger HX-1 in the Heating Hot Water plant.
7. SCHW.DP_SP = Secondary chilled water loop differential pressure setpoint.
8. C9VAV9938.*"sub-points"* = Terminal DDC controller for a VAV box with a thermostat in room 9-938, served by Air Handling Unit AHU-C9. Terminal controller pre-programmed sub-points then follow in the Point Description Identification section.

3.12 TRENDING, ALARMING & CHANGE OF VALUE SETTINGS

A. Controllers shall have the capability of a time delay or maintenance mode to allow alarms to be delayed during maintenance overrides.

B. Configuration of all required alarm and point/object trending is a shared responsibility between the MSCC & MSI, as indicated by project documents.

1. In general, all alarms and trends shall be configured by the MSCC at the local DDC panel and shared via BACnet objects with the BMS front-end.
2. See "Alarm and Trend Requirements" Table on Contract Documents for alarm & trend requirements.
3. All setpoints, time delays, and other control parameters shall be integrated and available for override or adjustment from the Vykon Niagara Supervisor.

C. For all equipment where the MSCC has provided a command and status (ie fan, pump, valve with endswitch, etc), the MSCC shall program and broadcast a virtual point for alarming. Whenever the "enable" command does not match the status point, the virtual binary alarm point must change from normal to alarm.

D. For every indicated or implied setpoint, MSCC shall create a variation from setpoint alarm. Examples include air handler discharge temperature, chilled water temperature, end-of-line DP, etc.

1. MSCC shall disable variation from setpoint alarms when the associated equipment is not in use, i.e., disable discharge temperature alarm when the air handler is in unoccupied mode.

E. Unless specifically indicated, alarms are not required for air terminal unit controllers (VAV's, etc) serving non-critical spaces.

F. UMH uses a points' Change Of Value (COV) as a basis for trending, graphics and alarming. In order to limit excessive network communication traffic, the MSCC shall program controller COV settings to the maximum necessary threshold relative to the point being trended. In general, COV's shall be set to 5% of the point value. The exception to this would be room differential pressure readings, which shall use a COV of 0.01"

1. Data communication from DDC controllers to the BMS shall be programmed to use Change of Value (COV) data sending and not continuous data polling to limit network traffic.
2. Data communication parameters for analog inputs and analog values shall be operator configurable and setup as follows:
   a. Minimum Send Time (where property is available): 1 minute
   b. Maximum Send Time (where property is available): 15 minutes
   c. Send on Delta (COV):
   d. Space Temperature: ±1.0°F
   e. Process Temperature: ±1.0°F
   f. Duct Static Pressure: ±0.1"WC
   g. Relative Humidity: ±1.0%
   h. Air Flow: ±5% of calibrated span
   i. Water Flow: ±2% of calibrated span
   j. Water Pressure: ±0.5 psi
   k. Space Pressure (Pharmacy & ORs): ±0.001" W.C.
   l. Space/ Building Pressure (General): ±0.01" W.C.
   m. Space CO2 sensors: ±100 ppm
   n. Gas Monitoring (O2 Depletion): ±0.1% O2
   o. Not Mentioned Above: ±5% of range of sensor
   p. Analog Values (calculated values): Same as COV for calculation input values (e.g. calculated space air flow offset would have a COV of ±5% of the value range, same as individual air terminal air flows)

3. Digital data points shall be sent whenever a state change occurs.

3.13 CONTROLLER ADDRESSING

A. Connection of new BACnet IP routers and Controllers to the HITS network shall be closely coordinated with Facilities Applications and the MSI.

B. The MSCC shall obtain IP addresses for new devices and the necessary IP addresses of other BACnet IP devices (for the BACnet Broadcast Distribution Table) thru Facilities Applications.

C. The MSCC shall obtain the BACnet Device Instance, Network numbers and MS/TP MAC address from the Facilities Applications group.

D. The MSCC shall begin Device Instance Numbers where they were left off on the last installation that the MSCC performed so that Device Instance Numbers are never duplicated. MSCC shall verify the next available Device Instance Number with Facilities Applications group prior to installation.

3.14 NETWORK CONNECTIONS

SPECIFICATION EDITOR: THE AE SHALL CLEARLY SHOW ON PROJECT CD'S WHERE HITS NETWORK CONNECTIONS/ JACKS ARE REQUIRED- AE SHAL DIFFERENTIATE HOME RUN DATA CONNECTIONS VS DAISY CHAIN DATA CONNECTIONS. LOCATIONS ON CD'S ARE REQUIRED SO AS TO COORDINATE HITS NETWORK REQUIREMENTS OF PROJECT.

A. New MCS installations shall communicate with the existing Vykon Niagara servers over the HITS layer 3 network via BACnet IP communication. The following device types shall be provided with HITs network connections:

1. DDC Controllers and devices communicating BACnet IP
2. UPS's
3. HMI's (DDC Panel)
4. Routers (MS/TP to IP and IP to IP)
5. Utility Meters

B. BMS BACnet IP network shall be designed to provide both star (single controller "home run") and multi-drop (daisy-chained) line topologies with initial Ethernet connections to UMH's HITS Layer 3 network switches. Line topology initial connection to the HITS Layer 3 Network shall be provided by HITS. Daisy chain Ethernet cable between controllers provided by MSCC.

1. Star topology shall be provided for all critical system/utility level controllers as follows and as indicated on design documents:
   a. All centralized utility plants/ systems, like:
      1) Chilled water plant (chillers, pumps, cooling towers, etc.), including low temperature and process cooling.
      2) Heating hot water plant (boilers, heat exchangers, pumps, etc.).
      3) Air handling units (AHU) and associated Return air units (RAU).
   b. Critical exhaust fans:

1) Med Gas exhaust
2) Specialty exhaust
3) Airborne Infection Isolation (AII) exhaust
4) MRI Exhaust
5) Sterile Processing exhaust

2. Line topology shall be limited to eight (8) controllers on a trunk and all controllers associated with a space shall reside on the same trunk (i.e. space supply and return air terminal controllers). Line topology shall be allowed for the following applications:
   a. Non-critical room control (air terminals- See section 3.8 "Critical Room Types")
   b. Fan Coil Units in non-critical applications (See section 3.8 "Critical Room Types")
   c. Miscellaneous monitoring
3. Critical room controllers shall utilize a star topology with a direct Ethernet connection to the HITS network switch. Where a critical space encompasses multiple rooms within a larger suite (i.e. Pharmacy), these controllers shall be allowed to be daisy-chained (line topology) as a suite-dedicated trunk. Critical room types are defined under section 3.8 "Critical Room Types".

C. The MSCC shall provide a single BACnet Broadcast Management Device (BBMD) per IP sub-net to properly broadcast a BACnet Distribution Table reflecting all BACnet devices connected to the BACnet network. This is required to permit streamlined and efficient integration with the BMS B-AWS. MSCC shall contact Facilities Applications to determine if an existing BBMD is present or if new is required.

D. Devices connected to the HITS network must meet HITS minimum security requirements (ie MM "UDEW Process"). MSCC shall submit all network devices to be used on a project to the MM Facilities Applications group, who will validate devices are UDEW compliant. See Section 1.9.

1. The MSCC shall remediate all devices that are not UDEW compliant and if necessary, provide alternate devices that meet the UDEW vulnerability scan.

E. The MSCC shall obtain IP addresses for new devices and the necessary IP addresses of other BACnet IP devices (for the BACnet Broadcast Distribution Table) from the HITS group thru the Facilities Application group. See Section 1.9.

F. MSCC shall provide a 1" conduit from the DDC panel to the cable tray for network connectivity (cabling by HITS). In facilities where a cable tray system is not provided, the MSCC shall provide a 1" conduit raceway to the nearest Telecommunication Room. Coordinate location of Telecommunication Room with HITS thru Project Manager. HITS shall provide all network patch cables and biscuit jack inside the MCS enclosure; MSCC shall be responsible for connecting all patch cables at respective IP devices and establishing communication.

G. HITS typically pulls two data cables to each IP device, as indicated on contract documents, yet only activates one cable. The second cable is there to be used for future IP connections. The MSCC shall verify the cable used is the active cable and shall not use the inactive cable unless authorized by UMH.

3.15 COORDINATION WITH OTHERS

A. The MSCC shall provide all necessary coordination with the Master Systems Integrator (MSI) to achieve an operational front-end user interface for the project.

B. Coordination requirements are outlined in the UMH BMS Integration Process flow diagram: BMS Project Integration Process.pdf (drop-box.com)

C. All correspondence with the Master System Integrator or other UMH departments (ie HITS, Fac Apps, Systems, BAS Controls) involved in the project shall copy the respective owner's project manager (ie AEC).

D. Provide all device PICS, a list of BACnet objects, approved submittals, as-built documents and all other relevant information to the SI before construction and at substantial completion as described in 1.9 "Submittals".

E. Coordinate with MSI as necessary to ensure that all system alarms that are generated by the DDC Controllers are communicated to the central BMS server(s) properly.

3.16 CALIBRATION, START-UP AND COMMISSIONING

A. Perform commissioning activities as described here-in and in accordance with Related Sections. Participate in the commissioning process in accordance with the project commissioning documents. This applies to all controls including those provided as part of 3rd party equipment.

B. The MSCC will start-up the DDC panels and provide calibration and start-up for temperature control devices and systems, including compressors, dryers, etc.

C. MSCC shall provide commissioner with completed check-out and commissioning test reports, customized for each panel or system, filled out by the technician during start-up.

D. Program all auto calibration routines to self-calibrate outside the hours of normal space occupancy. When this is not possible, program the self-calibration to occur during hours of lowest occupancy. Establish with the Owner, working with the Commissioning Authority, a self-calibration schedule that will be the least intrusive to building occupants. Phase self-calibration routines (as opposed to all devices simultaneously calibrating) to avoid negatively impacting air handler operation.

E. Provide all necessary equipment, test gases, etc. for calibration, and calibrate all sensors (i.e., CO2, CO, combustible gas, etc.) in accordance with the manufacturer's recommendations. Specialized equipment, test gases, etc. shall be turned over to owner upon completion and acceptance.

F. Provide tuning of all control loops:

1. Adjust PID control loop parameters to optimize system performance and response time.
2. Loops shall be tuned to provide the accuracy indicated on the contract documents. Where not indicated, provide the following:

a. Temperature +/- 1 deg F
b. Duct static Pressure +/- 0.1 in WC
c. Hydronic pressure +/- 0.5 PSIG.
d. Other setpoints: As required for the application and directed by the Engineer.

3. For system setpoints that are impacted by seasonal variations, return to verify and optimize control loop tuning.
4. Response time to achieve setpoint shall be as typically achievable for such control loops or as indicated on the contract documents. Interpretation of typically achievable response times shall be as determined by the Engineer.

G. After control components have been installed and connected, test, adjust and re-adjust as required all control components in terms of function, design, systems balance and performance. Control devices, linkages and other control components shall be calibrated and adjusted for stable and accurate operation in accordance with the design intent and to obtain optimum performance from the equipment controlled. MSCC shall utilize NIST calibrated devices for all device calibration/ verification. All control valves shall be stroked and spring ranges verified and set. All dampers shall be stroked to verify proper and smooth operation. Cause every device to automatically operate as intended to ensure its proper functionality. Make systems ready for acceptance tests.

H. Provide any trend setup, reporting and trend graphs in advance of functional testing and by dates specified by the Commissioning Authority to verify proper operation of controls and systems. Trend intervals and storage duration shall be as designated by the commissioner. All such trends shall be deleted before each panel is connected to the BMS server.

I. Perform point-to-point verification for all control inputs and outputs to confirm that all hardwire points are terminated properly, ranges are calibrated and I/O's are functioning. MSCC shall schedule a remote verification exercise with the Master Systems Integrator for this exercise. Verification shall involve validating proper performance from device (i.e. sensor) to BMS graphic.

J. Work with the MSI to confirm that all control inputs and outputs are reporting properly to the BMS server(s) and that Systems Monitoring personnel are able to override all system outputs.

K. After equipment has been accepted and operated in normal service for two weeks, check the adjustment of control components and recalibrate/replace where required.

L. The following applications shall utilize NIST Certified sensors (temperature, humidity and pressure sensors), complete with NIST certification:

1. Pharmacy (including Radiopharmaceutical) compounding, general pharmacy and drug storage areas.

M. Submit report documenting NIST certification to the owner for all NIST certified devices. Where NIST certification is not an option with the sensor used (i.e. IAQ Monitor), contractor shall calibrate and certify the sensor accuracy in the field with NIST certified devices and submit documentation to the owner.

SPEC WRITER NOTES: FUME HOOD MONITORS ARE TYPICALLY NOT PROVIDED BY THE MSCC ON UMH PROJECTS, BUT ARE RATHER PROVIDED WITH THE FUME HOOD. FOR RARE OCCASIONS WHERE THE MSCC WILL PROVIDE THE FUME HOOD MONITOR, CHANGE THE FOLLOWING PARAGRAPH FROM HIDDEN TEXT.

N. Set constant flow fume hood monitor alarms as follows:

1. Insufficient differential static pressure/air volume:
   a. Face velocity 80 FPM (standard hoods) or 60 FPM (Reduced Face Velocity Hoods.
2. Sash above the sash stop position.
   a. Time delay to re-alarm after silence button pushed: 10 minutes.
   b. Alarm shall clear when sash returned to sash stop position or lower.
   c. Floor mounted hoods: Alarm shall activate when any sash is above its sash stop position; time delay and alarm clear shall be same as above.

3.17 ACCEPTANCE PROCEDURE

A. Upon successful completion of start-up and recalibration as indicated in this section, commission all mechanical controls provided. Provide a detailed list of every control point installed to the project Commissioning Authority (CxA) and verify proper operation of each component prior to commissioning the controls with the CxA. Include, in checklist format, a detailed procedure to verify all aspects of the controls' sequence of operation.

B. Demonstrate, with the assistance of the Master Systems Integrator, operation of all control systems, including each individual component, to the Owner's Commissioning Agent.

C. Validate that all security vulnerabilities identified by the HITS security scan have been remediated.

D. After correcting all items appearing on the punch list, make a second written request to the Owner's Commissioning Agent for inspection and approval.

E. After all items on the punch list are corrected and formal approval of the control systems is provided by the Architect/Engineer, the MSCC shall indicate to the Owner in writing the commencement of the warranty period.

3.18 OWNER INSTRUCTION AND TRAINING

SPECIFICATION EDITOR: THE REQUIRED AMOUNT OF TRAINING WILL DEPEND UPON THE SIZE AND COMPLEXITY OF THE PROJECT. FOR SMALLER, SIMPLER PROJECTS UMH MAY REQUIRE ONLY A LIMITED AMOUNT OF TRAINING (IE 8 HOURS) OR NO TRAINING AT ALL. FOR LARGER PROJECTS WITH COMPLEX SYSTEMS, UMH MAY REQUIRE SIGNIFICANT TRAINING HOURS (MIN 24 HOURS OF COMBINED ON-SITE & CLASSROOM INSTRUCTION) FOR BOTH MAINTENANCE AND SYSTEMS MONITORING PERSONNEL. TRAINING MAY ALSO NEED TO TAKE PLACE IN SEPARATE SESSIONS FOR DIFFERENT SHIFTS OF PERSONNEL. COORDINATE REQUIREMENTS WITH THE UMH FPD DESIGN MANAGER IN THE DESIGN PROCESS AND MODIFY THE FOLLOWING PARAGRAPH AS NECESSARY.

A. Provide comprehensive training for the entire mechanical controls system.

B. The party that performed the portion of the control work as outlined in Section 1 shall provide the training related to that work.

C. Provide an agenda of the proposed training for approval by the Commissioning Authority.

D. Training shall include a combination of site walkthrough and classroom training as required to review the complete control system. At minimum provide the following:

1. One half hour minimum of classroom training per each construction drawing sheet included for the mechanical controls. Provide a complete explanation of the following for the controls on each sheet:
   a. The Sequence of Operation, alarms, and trend logs
   b. Schedule and grouping for each piece of equipment
   c. Overview of program layout and modules including explanation of each section of code and variables used.
   d. Identify which sensors are critical for the proper function of the controls.
   e. Location of critical sensors and manual reset devices
   f. The calibration, setup, and maintenance of all control devices
   g. Review the contents of the O&M relative to the controls on each sheet.
   h. Graphical user interface training. Review each system and floor plan graphic and explain the meaning of each point type.
   i. Review of terminal equipment controller applications used for the project including all subpoints and custom applications.
   j. Interfaces to other systems (e.g. fire alarm system, packaged controllers, etc.)
2. Also to be provided as part of classroom training:
   a. A review of the network diagram and the type, location, and function of each network device
   b. Demonstrate bench calibration of critical or unique sensors. The Owner and Commissioner shall have exclusive rights to identify which sensors require this training. Maximum 8 hours training.
   c. Programming of non-DDC controllers including passwords, alarms and setting tuning parameters and set point limits.
3. One half hour minimum of field training per each construction drawing sheet included for the mechanical controls. At minimum provide the following:
   a. Walk down each piece of equipment controlled, generally reviewing the Sequence of Operation.
   b. Identify the location of:
      1) Controllers and DDC panels
      2) Critical sensors and manual reset devices. Demonstrate the reset of devices.
      3) Damper operators and control valves
      4) Meters, including any UM data acquisition panels
      5) Pneumatic system components
      6) UPS
      7) Network devices

c. Review the information presented and operation of touch-screen displays and other indicating devices.
d. Interfaces to other systems (e.g. fire alarm system, packaged controllers, etc.)

END OF SECTION 230905