SECTION 17000 – DIRECT DIGITAL/AUTOMATIC TEMPERATURE CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. Furnish and install a complete system of automatic temperature controls to make a fully operational and controllable building HVAC system.

B. The system shall be all electric DDC (direct digital control).

C. All system components shall be installed in accordance with local and State codes.

D. Secure all permits and local/State approval for all components and installation as specified under this Section.

E. Provide complete commissioning for all control system components and sequences of operation.

F. Preparation and submission of shop drawings.

1.3 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

B. Division 15

C. Division 16

1.4 REFERENCES

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

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

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

1.5 SYSTEM DESCRIPTION

A. Furnish and install, as hereinafter specified, a combination direct digital/ electric/electronic temperature control system and Building Automation System (BAS). The system shall be comprised of a network of various independent Stand-alone Digital Controllers (SDC's), electric/electronic control equipment, thermostats, sensors, controllers, valves, dampers, actuators, panels and related hardware, software and other accessory equipment, along with a complete system of electrical control wiring, and software generation to fill the intent of the specifications and provide for a complete and operable system.

B. The control systems shall be installed by competent control mechanics and electricians regularly employed by the manufacturer of the control equipment. All control equipment shall be the product of one (1) manufacturer and all components shall be capable of interfacing with the HVAC equipment. The factory trained Contractor must maintain adequate staff and offer standard services to fully support the owner in the timely maintenance, repair, and operation of the control system. Contractors who do not maintain such staff and offer services or must develop some for this project are not acceptable.

C. Bids from franchised dealers or others whose principal business is not the manufacture, installation and service of temperature control systems will not be acceptable.

D. The Contractor shall submit a copy of the manufacturer's standard software and firmware licensing agreement for the owner's signature. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets constrained within such software.

E. All products of the Building Automation System shall be provided with the following agency approvals. With the submittal documents, verification that the approvals exist for all submitted products, shall be provided. Systems or products not currently offering the following approvals, are not acceptable.

1. UL-916; Energy Management Systems
2. UL-873; Temperature Indication and Regulating Equipment UL-864; Subcategories UUKL, QVAX, UDTZ; Fire and Smoke Control Systems
3. FCC; Part 15, Subpart J, Class A Computing Devices

F. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, Local and National Codes.

1.6 SUBMITTALS

A. See Section 15050 and General Conditions for additional requirements.

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

C. Shop Drawings.

1. Indicate trunk cable schematic showing programmable control unit locations and trunk data conductors.
2. List connected data points, including connected control unit and input device.
3. Indicate all system graphics for all controlled systems including all air handling systems, hydronic pumping systems, monitored systems, data (connected and calculated) point addresses and operator notations.
4. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems and interconnections.
5. Indicate description and sequence of operation of operating, user and application software
6. Develop and provide emergency, fire, smoke management control and device response matrices in an MS Excel spreadsheet format.
7. Show electric/electronic ranges for each valve, damper, inlet vanes actuators etc., (i.e. 4-20 ma or 0-10 vdc).

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

E. Project Record Documents: Record actual locations of control components, including control units, thermostats and sensors, trunk cable routing, junction boxes, transformers, VAV terminal box power circuiting, box addresser.

1. Revise shop drawings to reflect actual installation and operating sequences.
2. Include submittal data in final "Record Documents" form.
3. Provide start-up/checkout documentations for all DDC controllers connected to the BMS network. Documentation shall include all controller points used and unused (spare). Furthermore, all final settings, calibration, coefficient valves, K factors, spanning, actual spring ranges, etc., shall be indicated for all active points in use.
4. Revise all control sequence for all controlled sequences for operation. Sequence of operation that restate the Design Engineer's sequences will be acceptable. Complete details will be given within the sequences of operation provided by the Contractor. Details shall include but not limited to the following items control strategy, timers, delays, logic sequencing, start/stop, end devices involved, sensors involved, set points, globally commanded valves, shared data between panels and controllers.

5. VAV controller startup/commissioning documentation shall include as a minimum but not limited to the following final as-built information:

a. Min/max CFM settings.

b. Controller volume tracking differential.
c. Box size and area multiplier.
d. Box K factor as determined by ATC and TAB.
e. Controller network master address.
f. Controller address on master.
g. Auto-zero enabled/disabled.
h. Auto-zero scheduled time.
i. Communications priority (life safety, critical, normal).
j. Tstat set point override range (+/- 5°F).
k. Rom set point (base).
l. Generic additional points added to controller.

F. Operations and Maintenance Data:

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

1.7 QUALITY ASSURANCE

A. Perform work in accordance with NFPA 70.

B. Design system software under direct supervision of a Professional Engineer experienced in design of this Work and licensed within the State of Maine.

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

D. Installer Qualifications: Company specializing in performing the type of work specified in this section with minimum ten (10) years of documented experience and approved by manufacturer.

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

1.8 WARRANTY

A. See Section 15050 and General Conditions for additional requirements.

B. The system specified herein and shown on the drawings, shall be guaranteed to be free from original defects in both material and workmanship for a period of twelve (12) months of normal use and service, excepting damages from other causes. This guarantee shall become

effective starting the date the Contract work is accepted as complete by the Owner and in accordance with the General Provisions/Conditions.

C. Provide five (5) year manufacturer's warranty for field programmable micro-processor based units.

D. Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.9 MAINTENANCE SERVICE

A. Provide service and maintenance of energy management and control systems for one (1) year from Data of Substantial Completion.

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

1.10 PROTECTION OF SOFTWARE RIGHTS

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

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

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufactures subject to compliance with the specifications

1. Siemens
2. Johnson Controls
3. Honeywell
4. Andover Controls
5. Automated Logic

B. The entire system and all control components shall be powered with emergency power.

2.2 ELECTRIC LOW VOLTAGE WIRING

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

B. All electric wiring, wiring connections and all interlocking required for the installation of the temperature control system, as herein specified, shall be provided by the Contractor, unless specifically shown on the Electrical drawings or called for in the Electrical specifications.

C. Furnish all labor and material to install necessary relays, general purpose enclosures and appurtenances to control designated devices relative to the DDC.

D. All wiring throughout shall be concealed where possible.

E. All conduit used shall be IMC, 3/4" minimum size or larger. Conduit sizes shall be large enough to permit the individual conductors to be readily installed or withdrawn without damage to the conductors or their insulation. Splicing of wires will be permitted only in junction boxes or pull boxes. Conduit shall be rigid up to 12’-0″ AFF in mechanical rooms.

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

G. The ground system shall not be used as a current carrying conductor except for faults and noise suppression. The grounding system shall be used to control noise and transients which might affect the operation of the automation system. As such, the ground requirements shall be in excess of a grounding system used solely for physical protection minimum (Code requirement).

H. In all cases, the bond to ground shall be as short as possible. A ground point shall be derated by one (1) point (in order of preference) for each 50’-0″ of conductor run between it and the automation equipment to be grounded. Therefore, a water pipe bond located 10’-0″ away will be preferable to a structural steel bond located 150’-0″ away.

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

J. Flexible conduit shall be used at field devices, i.e., pressure switches, flow switches, temperature devices, etc. Convolutions shall be steel, interlocked continuously. Aluminum will not be permitted. "Liquidtight" shall be used in wet locations. Flexible connector shall be a minimum of 18" long.

K. Only core drilling is permitted to pierce the floors in the electrical closets and elsewhere. The use of water for drilling shall be controlled by a suitable vacuum system, using proper dams to prevent damage to floors below. The ATC Contractor shall be responsible for providing a suitable sleeve in all core drilled holes as specified herein.

L. All wiring shall be run in IMC and as noted below:

1.	Sensor to Panel (Block Wall):	In Wall
2.	Sensor to Panel (Stud Wall):	In New Conduit (IMC)
3.	Sensor to Panel (Mechanical Room):	In New Conduit (IMC)
4.	Panel to Front End Workstation:	In New Conduit (IMC)
5.	Front End:	In New Conduit (IMC)

M. Wiring

1. Type THHN solid #18 AWG for control wiring in dry location up to 194°F.
2. Type THWN in wet location up to 167°F (solid #18 AWG).
3. Twisted shielded pair (18 gauge), with PVC cover, Belden #8760 or approved equal.
4. Conduit is not considered as a shield.
5. All wiring associated with the control signals to the smoke damper control/sequence must be in approved conduit.
6. All signal wiring to all field devices shall be run with no splices, separately from any wiring having voltage greater than 30 volts.

N. The Contractor shall install all shielded cable and ground systems in accordance with Division 16. The installation of ground loops shall not affect any sensing or control circuits.

O. All devices and equipment shall be mounted in minimum NEMA 1 enclosures.

P. In addition to the requirements specified above, all communication wiring cables shall include a minimum of (1) individually 100% shielded pair ([2] conductors) as unused spare conductors. Where the number of conductors and specific cable specified above for each type of communication wiring will not meet this requirement for spare conductors, Contractor shall provide approved equivalent product of Belden or other manufacturer with the necessary number of conductors and which meets the requirements specified above.

Q. Low Voltage Control Wiring (30 VAC or Less)

1. Low voltage control wiring shall be minimum 16 gauge, or heavier if required, twisted pair, 100% shielded with PVC cover Belden #9316 or approved equivalent product of other manufacturers run in conduit with no splices, separate from any wiring above 30 volts.

R. Coordination of Interfacing/Interlocking

1. The Contractor shall be responsible for coordinating all required interface/interlocking software, software logic, sequencing and wiring necessary to provide a fully automated and fully functional operable system to met or exceed the intent of the Design Engineer's Sequence of Operation. Coordination may include but not limited to the following at no additional cost to the Owner. Variable frequency drive (VFD) interlocking and wiring logic including software, relays factory/field installed wiring and/or VFD drive modifications.

This would include coordination of miscellaneous points as specified under point list in this specification. Systems to include all points analog, digital, pneumatic sensors wiring, software, wiring, communications gateways, etc., to connect and communicate to any Fire, Plumbing, HVAC, Lighting, ATC, Security, World Wide Web (Internet) systems installed under this project.

2.3 BUILDING AUTOMATION SYSTEM (BAS) ARCHITECTURE

A. General

1. The BAS shall consist of a number of Nodes and associated equipment connected by industry standard network practices. All communication between Nodes shall be by digital means only.
2. The BAS network shall at minimum comprise of the following:

    a. Operator Workstations – fixed and portable.
    b. Network processing, data storage and communication equipment including file servers.
    c. Routers, bridges, switches, hubs, modems and the like communications equipment.
    d. Active processing Nodes including field panels.
    e. Intelligent and addressable elements and end devices.
    f. Third-party equipment interfaces.
    g. Other components required for a complete and working BAS.

3. The BAS shall be accessible via Enterprise Intranet and Internet browser with security protection for user access.
4. The BAS shall support auto-dial/auto-answer communications to allow BAS Nodes to communicate with other remote BMS Nodes via standard telephone lines.
5. The PC Workstations, File servers and principal network equipment shall be standard products of recognized major manufacturers available through normal PC vendor channels. “Clones” are not acceptable.
6. Provide licenses for all software residing in the BAS system and transfer these licenses to the Owner prior to completion.

B. Network

1. The BAS shall incorporate a primary Tier 1 network. At the Contractor’s option, the BAS may also incorporate integrated secondary Tier 2 and tertiary Tier 3 networks.
2. The BAS Network shall utilize an open architecture capable of:

    a. Utilizing standard Ethernet communications and operate at a minimum speed of 10Mb/sec
    b. Connecting via BACnet.
    c. Connecting via LonMark.

3. The BAS network shall support both copper and optical fiber communication media.

C. Third-Party Interfaces

1. BAS Contractor shall integrate real-time data from systems supplied by other trades as required.
2. The BAS system shall include necessary BAS hardware equipment and software to allow data communications between the BAS system and systems supplied by other trades.
3. The trade contractor supplying other systems will provide their necessary hardware and software and will cooperate fully with the BAS contractor in a timely manner at their cost to ensure the complete data integration.
4. BAS Contractor shall provide all necessary coordination with vendors, contractors, owners, engineers, and other representatives at no additional cost to the Owner. Provide a completed fully functional, operational, integrated and seamless communicating infrastructure system.

D. Power Fail / Auto Restart

1. Provide for the automatic orderly and predefined shutdown of parts or all of the BAS following total loss of power to parts or all of the BAS.
2. Provide for the automatic orderly and predefined startup of parts or all of the BAS following total loss of power to those parts or all of the BAS. Archive and annunciate time and details of restoration.
3. Provide for the orderly and predefined scheduling of controlled return to normal, automatically time scheduled, operation of controlled equipment as a result of the auto restart processes.
4. Maintain the BAS real-time clock operation during periods of power outage for a minimum of 72 hours.
5. As part of this required feature of Power Fail/Auto Restart, the ATC Contractor shall uninterruptible power supplies (UPS) the entire BAS networked infrastructure including all third party interfaces to determine feasibility, time, delays, shutdown network traffic anticipated, etc.

E. Downloading and Uploading

1. Provide the capability to generate BAS software-based sequences, database items and associated operational definition information and user-required revisions to same on designated OWS, and the means to download same to the associated application AN.
2. Provide the capability to upload BAS operating software information, database items, sequences and alarms to the designated OWS with automatic archiving of same on the OWS.
3. The functions of this Part shall be governed by the codes, approvals and regulations applying to each individual BAS application.
4. The entire control system shall be approved and listed by UL 916 - Energy Management and UL-864 – Fire Control.
5. All DDC panels shall be powered through uninterruptible power sources (UPS) with sufficient capacity to ride through a (2) minute power interruption between transfers

from normal to emergency power. UPS's and wiring shall be provided by the ATC Contractor.

F. Application Nodes (AN)

1. General

a. The Application Nodes (AN) shall include all monitoring, control and information Nodes including field panels.
b. AN shall be programmable and governed by the requirements of their applicable codes, approvals and regulations.
c. The AN shall be designed, packaged, installed, programmed and commissioned in consideration of their specific service and prevailing operating conditions. They shall be proven standard product of their original manufacturer and not a custom product for this Project.
d. A failure at an AN shall not cause failures or non-normal operation at any other system AN other than the possible loss of active real-time information from the failed AN.
e. Ancillary AN equipment, including interfaces and power supplies, shall not be operated at more than 80% of their rated service capacity.

2. HVAC Node

a. HVAC Node shall provide both standalone and networked direct digital control of HVAC systems.
b. A dedicated HVAC Node shall be configured and provided for each primary HVAC system (air handler, chiller, boiler) and each terminal HVAC system (VAV Box, Unit Heater, Cabinet Heater, CV Box).
c. Each HVAC Node shall be able to retain program, control algorithms, and setpoint information for at least 72 hours in the event of a power failure, and shall return to normal operation upon restoration of power.
d. Each HVAC Node shall report its communication status to the FMS. The FMS shall provide a system advisory upon communication failure and restoration.
e. For each primary HVAC system, provide means of indication of system performance and setpoints at, or adjacent to the HVAC Node.
f. For each primary HVAC system, provide a means to adjust setpoints and start/stop equipment at, or adjacent to the HVAC Node.
g. Provide a means to prevent unauthorized personnel form accessing setpoint adjustments and equipment control functions.
h. The HVAC Node shall provide the ability to download and upload configuration data, both locally at the Node and via the FMS communications network.
i. The HVAC Node shall be provided with a permanently-mounted local graphic terminal where required in the sequences of this specification. The local graphic terminal shall provide dynamic graphical representation of the associated system status, with the ability for the operator to enter commands with proper password protection.

j. Each HVAC mode shall be a dedicated controller without the need to use expansion modules to accomplish the entire primary control sequences. Sharing controller, sensor, input/output data over any high level or low level network to accomplish the specified control sequences is unacceptable. Global sharing of general data such as OA-T, OA-RH OA-CO^2 levels between controllers over the BMS network is acceptable as long as speed of transmitting the data des not impact the HVAC mode controller ability to perform in any mode of operation.

k. If it is determined that the HVAC mode controller cannot perform specified sequence of operation because of dependency for shared information that Contractor shall provide a higher level controller at no additional cost. This change shall be identified by separate submittal to Design Engineers.

2.4 PORTABLE OPERATOR'S TERMINAL

A. Acceptable Manufacturers subject to compliance with the specification:

1. Dell
2. Compaq
3. Toshiba
4. IBM

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

C. General

1. Furnish portable operator's terminal for system. Portable operator's terminal shall allow for local accessing of program information.
2. Laptop terminal portable operator's terminal shall have as a minimum, the following features:

a. Intel Pentium 4, 2.2 GHz microprocessor
b. Full active matrix color display with minimum 1024 x 680 resolution, 15".
c. AC adapter
d. Battery pack / battery charger
e. 60 GB fixed disk drive
f. 1028 MB of RAM
g. 3.5" 1.44 MB disk drive
h. 24X DVD drive
i. PCMCIA card modem
j. Audio built in
k. Latest version of Microsoft DOS
l. PCMC1A Ethernet Adapter Card with UTP/BNC connector

m. Equipped with both 1 Type III or 2 Type II PCMCIA Slots

1) Type III 4
2) Type II PCMC1A Slots

n. Integrated pointing device

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

1. Access all controllers on the network.
2. Backup and/or restore controller data bases for all system panels, not just the DDC controller.
3. Display all point, selected point and alarm point summaries.
4. Display trending and totalization information.
5. Add, modify, and/or delete any existing or new system point.
6. Command, change setpoint, enable/disable any system point.
7. Program and load custom control sequences as well as standard energy management programs.

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

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

2.5 OPERATOR WORKSTATION

A. Basic Interface Description

1. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.
2. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

B. Computer System Access Operation Control Stations (OCS) Description: This system access workstation is also referred to as the Building Automation System “Front end”.

C. Provided Workstation with:

1. Workstation shall be general purpose, commercially available, personal computer with sufficient memory and processor capacity to perform all functions described in this specification.
2. Sufficient hard drive memory storage shall be provided to accommodate all fully configured point data bases, all application databases, all graphics data bases, all user-defined reports, and all historical data archival as described in this specification.
3. The display provided for system operation shall have a diagonal screen measurement of no less than 15" (i.e. nominal 17" unit) and a minimum display resolution of no less than 640 x 320 pixels. Separate controls shall be provided for color, contrast, and brightness. The screen shall be non-reflective.
4. Each Shall include as a minimum, the following:

    a. 3.0 GHz Pentium D processor with 1 GB of (SDRAM) random access memory (RAM).
    b. 3 1/2" diskette drive (high density).
    c. 17" color monitor 1280X 1024 (SGVA).
    d. SVGA video output (4 MB RAM).
    e. 160 MB fixed disk.
    f. HI-RES bus mouse.
    g. (1) Printer for alarms, minimum 240 characters/seconds.
    h. (1) Printer for reports, minimum Laser printer similar to HP 4000.
    i. 48X Read/Write CD Rom
    j. Telephone modem (56K)
    k. Campus network interface card
    l. Zip drive
    m. Server type platform shall have high performance RAID multiple fixed disk for hot redundancy. Provide minimum three fixed disks.

5. The operator functions provided by the system access Operator Terminal shall include, but not be limited to, the following:

    a. Start and Stop Points
    b. Modify Setpoints
    c. Modify PID Loop Setpoints
    d. Override PID Control
    e. Change Time/Date
    f. Add/Modify Start/Stop Weekly Scheduling
    g. Add/Modify Setpoint Weekly Scheduling
    h. Enter Temporary Override Schedules
    i. Define Holiday Schedules
    j. View Analog Limits
    k. Enter/Modify Analog Warning Limits
    l. Enter/Modify Analog Alarm Limits
    m. Enter/Modify Analog Differentials
    n. View Point History Files

6. UPS system with one hour backup.
7. The workstation shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a subset of predefined "global points", but shall provide totally open exchange of data between the operator terminal and any DDC panel in the network.
8. Provide English language prompting to eliminate the need for the user to remember command formats or point names. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error.
9. On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "help" function shall provide general system operating instructions, and specific descriptions of commands available in the currently displayed menus.
10. Identification for all real or calculated points shall be consistent for all network devices.
11. In addition to instantaneous summaries, the Operator's Terminal shall allow a user to view a Point History file for system points. Point History files shall provide a record of value of analog points over the last 24 hours, at 30 minute intervals, or a record of the last (10) status changes for binary type points.

D. Dynamic Color Graphic Displays: Color graphics shall be provided as specified in the Execution portion of this specification to optimize system performance analysis and speed alarm recognition.

1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, and text-based commands.
2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.
3. Windowing: The windowing environment of the workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.

    a. The Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
    b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:

        1) Define symbols
        2) Position and size symbols
        3) Define background screens

4) Define connecting lines and curves
5) Locate, orient and size descriptive text
6) Define and display colors for all elements
7) Establish correlation between symbols or text and associated system points or other displays.

c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aids the operator in the analysis of the facility. To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers used for DDC unitary or VAV terminal unit control.

5. Graphic

a. Provide graphic screens each system for this project.
b. Provide the following as a minimum:

1) Each air handling unit.
2) Chilled water system.
3) Condenser water system, coordinated with variable speed drive pumping.
4) Process chilled water system.
5) Steam system.
6) Hot water system, coordinated with variable speed drive pumping.
7) Each heat exchanger.
8) Each chiller.
9) Each hot water system.
10) Each glycol system.
11) Each exhaust fan.
12) Each supply fan
13) Each piece of equipment.
14) Each O.R.
15) Each Isolation Room.
16) Differential Control Valves.
17) Each typical type of VAV or Constant Volume Box, including occupied/unoccupied control for each box/terminal.
18) Each controlled system.
19) Each floor plan indicating location of central panels and equipment including smoke management control damper/zone pressurization.

c. Provide graphic representation of building's form and site plans locating all equipment and panels.
d. Each hardware point shall be represented on graphic screen.
e. Selected software points shall be represented on respective process system graph as determined by the Owner. Examples of these software points are:

1) Control loop setpoint value.
2) Control loop auto/manual selection.
3) Lead/lag selection for pumps and other motors.
4) Campus chilled water global points.
5) Calculated points such as run time.

f. The Contractor shall coordinate all required graphical modes, features, binding, logic, etc., for a complete fully functional graphical operating system. All graphical schemes shall be submitted and approved by Architect/Engineer and Owner prior to programming.

E. Database Configuration

1. Provide database configuration for each hardware and software point.
2. Specific point parameters, such as alarm limits, alarm message, point name and point description shall be as approved by the Owner.

F. Trends

1. Provide real time and historical trends for hardware and software points as directed by the Owner.

G. Internet / Intranet Browser

1. A multi-user color graphics and textual interface shall be provided that allows customers to access their FMS data via the Internet or Intranet. This interface shall use HTML-based pages to send and receive data from an FMS system to a web browser.
2. Browser shall:

a. Automatically reflect any changes made to the FMS system without additional programming.
b. When installed behind a corporate firewall, shall work in conjunction with other security measures that have been implemented.
c. Allow the user to navigate and command the FMS using the same format as the OWS.
d. Be an industry-standard browser
e. Provide user password access control.
f. Provide the means by which the user can create, edit and view groups of FMS data points.
g. Provide navigation tools for moving between the views. In addition, it shall provide tools for gaining access to help and for logging out of the system.

H. Paging

1. Provide the means of automatic alphanumeric paging of personnel for user-defined FMS events.

a. System shall support both numeric and alpha-numeric pagers, using Alphanumeric, PET, or IXO Protocol at the owner's option.
b. Users shall have the ability to modify the phone number or message to be displayed on the pager through the system software.
c. System shall utilize pager schedules to send pages to the personnel that are "on-call".
d. Contractor shall be responsible for providing a modem for connection to the paging service.

I. Reports

1. Provide reports for hardware and software points as directed by the Owner.
2. The ATC Contractor shall program and test all alarming and alarm report routing to final devices such as printer, computers, pagers, monitors, cell phones, www, etc. Alarming requirements and routing shall be coordinated with the Owner by first compiling and all points listing for Owner's review.

J. Network Speed and Transmission

1. Network speed (communication rate) 10 megabits per second (MBPS) for all level one controllers.
2. Network configurations shall be Star, Bus or mixed (Star and Bus).

2.6 DIAL-UP COMMUNICATIONS

A. Auto-dial/auto-answer communications shall be provided to allow stand-alone DDC panels to communicate with remote operator stations on an intermittent basis via telephone lines.

1. Dial-Up Stand-Alone DDC Panels: Auto-dial panels shall automatically place calls to workstations to report critical alarms, or to upload trend and historical information for archiving.

a. Stand-alone DDC panels shall analyze and prioritize all alarms to minimize the initiation of calls. Non-critical alarms shall be buffered in memory and reported as a group of alarms, or until an operator manually requests an upload of all alarms.
b. The auto-dial shall include provisions for handling busy signals, "no answers", and incomplete data transfers. Default devices shall be called when communications cannot be established with primary devices.

2. Dial-Up Workstations: Operators at dial-up workstations shall be able to perform all control functions, all report functions, and all database generation and modification functions as described for workstations connected via the local area network. Routines shall be provided to automatically answer calls, and either file or display information sent from remote DDC panels, The fact that communications is taking place with remote control systems over telephone lines shall be completely transparent to an operator.

a. An operator shall be able to access remote buildings by selection of any facility by its logical name. The PC dial-up program shall maintain a user-definable cross-reference of buildings and associated telephone numbers, so the user shall not be required to remember or manually dial telephone numbers.

b. A PC workstation may serve as an operator device on a local area network, as well as a dial-up workstation for multiple auto-dial DDC panels or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with local area network activity, nor shall local area network activity keep the workstation from handling incoming calls.

3. Modem Characteristics: Dial-up communications shall make use of Hayes compatible 56K modems and voice grade telephone lines. Each stand-alone DDC panel may have its own modem, or a group of stand-alone DDC panels may share a modem.

2.7 END DEVICES

A. Local Control Panels

1. All controls, relays and switches for equipment located within the mechanical equipment rooms shall be mounted on enclosed control panels with hinge lock type door and locking mechanism mounted adjacent to the system controlled.
2. Details of each panel shall be submitted for review prior to fabrication. Locations of each panel shall be convenient for adjustment and service. All manual switches shall be flush mounted on the hinged door.
3. All electrical devices within the panels shall be factory prewired to a numbered terminal strip. All wiring within the panel shall be in accordance with NEMA and UL Standards and shall meet all Local Codes.
4. All panels shall include UL listing label.

B. Sensors, Transducers, and I/O Devices

1. Linear precision resistance elements or thermistors and resistance averaging elements shall be provided for temperature sensing. Their range and type shall be applicable to their installation.
2. All temperature sensors in air handling units and in ductwork shall be averaging type, long enough to completely cover the airflow area.
3. Binary Temperature Devices

a. Low-voltage space thermostat shall be 24 V, bimetal-operated, snap action type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C [55°F to 85°F] setpoint range, 1°C [2°F] maximum differential, and vented ABS plastic cover.

b. Line-voltage space thermostat shall be bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint.

c. Low-limit thermostats. Low-limit thermostats shall be vapor pressure type with an element 6 m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any 30 cm {1 ft} section. The low-limit thermostat shall be manual reset only. Electric low temperature warning sensors shall be provided and shall have 20'-0" low point sensitive elements installed to cover the entire coil area. Where there are multiple coils, provide at least (1) freezestat per coil and at least (1) freezestat per 20 sq. ft. of coil area (i.e., a 10'-0" x 3'-0" coil would require two freezestats). Single freezestat sensing elements shall not be utilized to cover more than one coil. Sensors shall be wired to their respective monitoring panel (for freeze alarm) and, separately, to shut down the fan motor. Provide remote indicators for the freezestats located at the side of the air handling unit.

4. Temperature Sensors

a. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
b. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 1.5 m [5 feet] in length.
c. Immersion sensors shall be provided with a separable stainless steel, or copper well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.
d. Space sensors shall be equipped with set point adjustment, override switch, display, and/or communication port as shown.
e. Provide matched temperature sensors for differential temperature measurement.

5. Humidity sensor/transmitters

a. Duct and room sensors shall have a sensing range of 5% to 95%.
b. Duct sensors shall be provided with a sampling chamber.
c. Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH. They shall be suitable for ambient conditions of -40°C to 75°C [-40° F to 170° F].
d. Humidity sensor's drift shall not exceed 3% of full scale per year.

6. Flow switches

a. Flow-proving switches shall be either paddle or differential pressure type, as shown.
b. Paddle type switches (water service only) shall be UL Listed, SPDT snap-acting with pilot duty rating (125 VA minimum). Adjustable sensitivity with NEMA 1 enclosure unless otherwise specified.
c. Differential pressure type switches (air or water service) shall be UL Listed, SPDT snap- acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application, or as specified. Dirty filter shall be sensed by an electric differential pressure relay with adjustable setpoint. Range shall be as required to meet project

requirements. Every filter bank shall be provided with a filter pressure relay switch.

7. Relays

   a. Control relays shall be UL Listed plug-in type. Contact rating, configuration, and coil voltage suitable for application.
   b. Time delay relays shall be UL Listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

8. Override timers

   a. Override timers shall be spring-wound line voltage UL Listed, contact rating and configuration as required by application. Provide 0-to-6 hour calibrated dial unless otherwise specified; suitable for flush mounting on control panel face, located on local control panels or where shown.

9. Current transmitters

   a. AC current transmitters shall be self-powered combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit range shall be scaled to the requirements of the expected load. A full scale, internal zero and span adjustment, and ±2% full-scale accuracy at 500 ohm maximum burden.
   b. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.
   c. Unit shall be split-core type for clamp-on installation on existing wiring.
   d. Acceptable manufacturers: Veris Industries 700 and 900 Series, Greystone 300 Series, Flexcore PCM Series or Functional Devices R1BX Series.

10. Current transformers

   a. AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic material.
   b. Transformers shall be available in various current ratios and shall be selected for ±.5% accuracy from 1% to 100% of rating, and 5 A full scale output.
   c. Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively.
   d. Acceptable manufacturers: Flexcore Series 600, Veris H681 or approved equal.

11. Voltage transmitters

   a. AC voltage transmitters shall be self-powered single loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.

b. Ranges shall be 0 to 150, 0 to 300, 0 to 600 VAC, with ± .5% full-scale accuracy with 500 ohm maximum burden.
c. Transmitters shall be UL/CSA Recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.
d. Acceptable manufacturers: Flexcore VTR Series or approved equal.

12. Potential transformers

a. AC voltage transformers shall be UL/CSA Recognized, 600 VAC rated.
b. Transformers shall be suitable for ambient temperatures of 4 to 55°C [40 to 130°F] and shall provide ±0.5% accuracy at 120 VAC and a 5 VA load.
c. Windings (except for terminals) shall be completely enclosed with metal or plastic material.
d. Acceptable manufacturers: Flexcore Model 460 or 467, Square D Power Logic or approved equal.

13. Power meters (Sub-metering Applications)

a. Power monitors shall be three-phase type furnished with three-phase disconnect/shorting switch assembly, UL Listed voltage transformers and UL Listed split-core current transformers.
b. Shall provide a selectable rate pulse output for kWh reading and a 4 to 20 mA output for kW reading. Shall operate with 5 A current inputs with a maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.
c. Acceptable manufacturers: Flexcore Model PC5 Series, Square D Power Logic or approved equal.

14. Energy Meters (Electrical – Sub-metering Applications)

a. Provide meters with multi-variable out puts: Voltage, Current, Active Power, Active Energy, Frequency, Demand Limit Alarms, and Tamper Detect. Provide where shown on drawings.
b. Meters shall be Enfo Solutions Three-Phase Energy Meters or approved equal.

15. Energy Meter (Domestic Water)

a. Monitor and record pulsed output signals from plumbing cold water supply and "deduct" meters ([2] meters). Meters shall be furnished and installed by the Division 22 Contractor.

16. Current switches:

a. Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.
b. Acceptable manufacturers: Greystone 300 Series, Veris H-708, 908 or approved equal.

17. Pressure and differential Pressure transmitters (Hot water and Chilled Water):

    a. Transducer shall have linear output signal. Zero and span shall be field-adjustable. Accuracy shall be +/- .07% span.
    b. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
    c. Water pressure transducer shall have 316 stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves. Provide local LCD indicator.
    d. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.
    e. Transmitters shall be calibrated and spanned for full expected range plus 10%.
    f. Acceptable manufacturers: Foxboro IGP10 – Gauge Pressure Transmitter, Foxboro IDP10 – Differential Pressure Transmitter, Mamac 264-Gauge Pressure Transmitter, Mamac 282-Differential Pressure Transmitter or Rosemont.

18. Pressure and differential pressure type switches – Water and Air Service

    a. Water Service

        1) Differential pressure switches shall be UL listed, SPST mercury – wetted, 5 amp rated at 120VAC, metal enclosure, with scale range and differential suitable for intended application, or as shown. Range 0-5.5 PSID to 0-5000 PSID.

            a) Acceptable manufacturers: Mercoid PG and BB Series.

        2) Pressure switches shall be UL listed, SPDT snap-acting switch, rated at 15 amps at 120 VAC. Adjustable setpoint and deadband. Range 0-30”HG to 10-300PSIG.

            a) Acceptable manufacturers: Mercoid DA Series, Penn P74 (pump status only).

    b. Air Service

        1) Differential Pressure switches shall be diaphragm operated, actuating a single pole, double throw snap acting switch rated at 15 amps, at 120 VAC. Mas surge pressure 25 PSIG, Rated Pressure 10 PSIG. Ranges .05-.25 “wc to 9-85 “wc.
        2) Acceptable manufacturers: Dwyer Series 1620, 1630 or 1800; Penn P32 (fan status only).

C. Installation of Sensors

1. Install sensors in accordance with the manufacturer's recommendations.
2. Mount sensors rigidly and adequately for the environment within which the sensor operates.
3. Room temperature sensors shall be installed on concealed junction boxes properly supported. Additionally, the wiring to the sensor shall not be required to be polarity sensitive. The design of the sensor shall be modular that allows for the rough-in of all wiring without the presence of the electronics or esthetic covering.
4. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
5. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across duct. Each bend shall be supported with a capillary clip.
6. Low limit sensors used in coil discharge shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1ft of sensing element for each square ft of coil area.
7. All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
8. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
9. Differential air static pressure.

    a. Supply duct static pressure: Pipe the high pressure tap to the duct using a pitot tube. Pipe the low pressure port to a tee in the high pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high pressure tap and leave open to the plenum.
    b. Return duct static pressure: Pipe the high pressure tap to the duct using a pitot tube. Pipe the low pressure port to a tee in the low pressure tap tubing of the corresponding building static pressure sensor.
    c. Building static pressure: Pipe the low pressure port of the pressure sensor to the static pressure port located on the outside of the building at roof level to serve as a common outdoor reference. Pipe the high pressure port to a location behind a thermostat cover.
    d. The piping to pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
    e. All pressure transducers other than those controlling VAV boxes shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without the use of ladders or special equipment.
    f. All air and water differential pressure sensors shall have gauge tees mounted adjacent to all taps. Water gauges shall also have shutoff valves installed before the tee.

D. Fan and Pump Status (Under 3 HP)

1. Water flow for each pump shall be indicated by means of a differential pressure switch which opens an electrical contact as the differential pressure falls below a

preadjusted pressure range setting. Water differential pressure switch shall be the Penn Model P-74 or similar. High pressure differential switch shall be suitable for the flow and pressure of each system.

2. Differential pressure sensing devices shall be provided for each fan specified as requiring such application in the point list. Differential pressure switch shall be the Penn Model P-32, Dwyer 1910 or similar. This point shall be used as start/stop feedback for points specified as feedback on the point list. Auxiliary contact shall be provided for each fan as specified as requiring such application in the point list.

E. Fan and Pump Status (3 HP and Larger)

1. Verification of all air and water for all fans and pumps shall be by an analog current transformer device, which shall be furnished under the Electrical Section of these specifications. The current transformer output shall be a true analog value. Digital output devices will not be considered acceptable.
2. The Contractor shall provide any devices and/or transducers required to communicate with, scale, or interpret the current transformer to receive an accurate actual amperage reading through the DDC system.

F. Motor Start/Stop

1. Start/stop relay module shall provide either momentary or maintained switching action as appropriate for the motor being started.
2. All relays shall be plugged in, interchangeable, mounted on a circuit board and wired to numbered terminal strips.

G. Low Limit Alarms

1. Electric low temperature warning sensors shall be provided and shall have 20’-0″ low point sensitive elements installed to cover the entire coil area. Provide a minimum of one freezestat per 30 sq.ft. of coil area. Where there are multiple coils, provide one (1) freezestat per coil. Sensors shall be wired to their respective monitoring panel (for freeze alarm) and, separately, to shut down the fan motor. Assure that the bottom 6" of each coil is protected by a freezestat.

H. Valve and Damper Operators/Actuators

1. All damper operators shall be of the molded rubber diaphragm piston type and shall be fully proportioning. Operators shall be quiet in operation and shall have ample power to overcome friction of damper linkage and air pressure, to position dampers accurately and smoothly. The damper operator mounting arrangement shall be outside the airstream wherever possible, all exceptions shall be approved by the Owner’s representative prior to installation. All automatic control dampers with actuators shall have (2) end switches to prove them open and closed. Initial setpoint shall be for end switch to activate at 80% (adj.) open position and 100% closed position. All damper and valve actuators used for modulating control shall be provided with adjustable pilot positioners.

2. The operators shall be capable of operating at varying rates of speed to correspond to the dictates of the controllers and variable load requirements. The operators shall be capable of operating in sequence when required by the sequence of the operation. The operators shall have external adjustable stops to limit the stroke in either direction. The operator linkage arrangement shall be such as to permit normally open or normally closed positions of the dampers as required.
3. At air handling units, all control valve actuators shall be provided with valve position feedback which shall be output to the PLC controlling said valve/unit.
4. All damper and valve operators exposed to weather shall have weatherproof enclosures and shall be electrically actuated, with industrial grade actuators. All damper and valve actuators serving all of the roof-mounted equipment shall be electric, industrial grade. All electric actuators shall be spring return with 300% of the required design calculated torque requirements, as manufactured by Limitorque or Bick. Units shall be suitable for outdoor mounting under several weather and environmental conditions.
5. All multiple damper sections must have jack-shafts. For dampers larger than 20 sq.ft., provide (1) actuator motor for each 15 sq.ft. of damper area or portion thereof (i.e., a 40 sq.ft. damper requires [3] actuators).
6. Reheat/radiation valve actuators at reheat coils/radiation elements shall be electronic and shall mount on the valve body and provide complete modulating control of the valve.

    a. The valve actuator motor shall be of the non-stall type and shall de-energize when the valve has reached either the operator or system determined position.
    b. Actual valve position status shall be monitored from the central or remote operator's terminal and shall be displayed in percent open notation. Systems which provide only end switch feedback are not acceptable.
    c. Changes made during setup or normal operation to the Terminal Equipment Control Unit by the portable operator's terminal or central terminal shall not be affected by loss of communication on the LAN communication bus.
    d. It shall not be necessary to disconnect the communications bus for communication between the Portable Operator's Terminal and the Terminal Equipment Control Unit.
    e. All valves shall be capable of manual remote adjustment via the DDC System.

7. Tracking conventional VAV box damper actuators shall be electronic and shall mount on the damper shaft and shall provide complete modulating control of the damper.

    a. The actuator motor shall de-energize when the damper has reached the operator or system determined position.
    b. Damper actuator position status shall be monitored from the central or remote operator's terminal and shall be displayed in percent open notation. Systems which provide only end switch feedback are not acceptable.
    c. The actuator shall be a removable and separate device from the Terminal Equipment Control Unit. If integral to the Terminal Equipment Control Unit, the actuator shall be removable for servicing without removing the Terminal Equipment Control Unit.

I. Valves

1. All automatic control valves, other than radiation and reheat terminal device valves (which shall be electronic), shall be fully proportioning, electrically actuated with modulating plug or V-port inner guides, unless otherwise specified. The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of control failure. Except where noted to otherwise, chilled water valves shall be fail "open", heating and reheat hot water valves shall be fail "open". All valves shall be capable of operating in sequence when required by the sequence of operation. All control valves shall be suitable for the pressure conditions and shall close against the differential pressure involved. Valve operators shall be of the molded synthetic rubber diaphragm type. All valve operators are to be funneled with pilot positioners.
2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

    a. Water Valves:

        1) Two-way: 150% of total system (pump) head.
        2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

    b. Steam Valves: 150% of operating (inlet) pressure.

3. Water Valves:

    a. Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
    b. Sizing Criteria:

        1) Two-position service: Line size, unless otherwise shown.
        2) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
        3) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa [5 psi] maximum.
        4) Valves ½" through 2" shall be Electronic Pressure Independent Characterized Control Valves (PICCV). The valves shall be forged brass body rated at no less than 600 PSI for ½"-1" and 400 PSI for 1.25"-2", with chrome plated brass ball and stem, female, NPT union ends.

            a) The modulating control valves shall be pressure independent.
            b) The control valve shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow

characteristic. The flow shall not vary more than ±5% due to system pressure fluctuations across the valve with a minimum of 5 PSID across the valve.

c) Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSI.

d) The control valve shall require no maintenance and shall not include replaceable cartridges.

e) The actuator shall be directly coupled to the valve at the factory.

f) The actuator shall be same manufacturer as valve, integrally mounted to the valve via a single screw on a four-way DIN mounting base.

g) Strainers shall not be required in front of each valve.

h) Actuators shall be Multi-Function Technology as manufactured by Belimo AirControls (USA), Inc. Multi-turn actuators are NOT acceptable. Running time shall be 100 seconds independent of flow setting while rotating a maxi-90 degrees.

i) Control valves shall be as manufactured by Belimo AirControls Model Series PICCV or approval equal.

5) 2 –1/2" valves and larger shall be cast iron ANSI Class 250 with guided plug and Teflon packing, unless otherwise shown.

c. Water valves shall fail normally open or closed as scheduled on plans, or as follows:

1) Water zone valves – normally opened preferred.
2) Heating coils in air handlers – normally open.
3) Chilled water control valves – normally closed.
4) Other applications – as scheduled or as required by sequences of operation.

4. Steam Valves:

a. Body and trim materials shall be per manufacturer's recommendations for design conditions and service. Linear ports for modulating service.

b. Sizing Criteria:

1) Two-position service: pressure drop 10% to 20% of inlet psig.
2) Modulating service: 100 kPa [15 psig] or less: pressure drop 80% of inlet psig.
3) Modulating service: 101 to 350 kPa [16 to 50 psig]: pressure drop 50% of inlet psig.
4) Modulating service: over 350 kPa [50 psig]; pressure drop as scheduled on plans.

c. Steam control valves shall be single seated type with equal percentage flow characteristics. Valves shall be normally open type. The valve discs shall be composition type with bronze trim for steam pressure up to 15 psig and shall be of the stainless steel type for steam pressures above 15 psig. Whenever the steam flow rate is such as to require a single valve larger than 2 1/2 inches, there shall then be installed two (2) valves in parallel (which shall operate sequentially), one of which shall not be in excess of 2 1/2 inches in size. Where 1/3-2/3 valves are shown or specified, (2) valves sized at 1/3 and 2/3 of total capacity shall be provided, regardless of whether or not the valves are less than 2 1/2" in size. Steam control valves shall be selected with a maximum pressure drop of 5 pounds.

5. Butterfly Valves

a. Butterfly valve construction/performance shall comply with the requirements of Specification Section 15100. Actuator shall be factory mounted, electric with spring return, with factory mounted end of travel limit switches.
b. Refer to Section 15100 for acceptable manufacturers.

6. Ball Valves

a. Ball valve construction/performance shall comply with the requirements of Specification Section 15100.
b. Refer to Section 15100 for acceptable manufacturers.

J. Electrical Power Consumption and Demand Meters

1. The building shall have two electric power services. The Division 16 Contractor shall furnish and install new consumption and demand initiation devices on each of the two (2) new building electric consumption and demand check meters. The Contractor shall wire and program the above devices such that electricity consumption (KWH) and demand (kW) are read and recorded by the Building Automation System (BAS).
2. The pulse rate shall be determined by the Division 16 Contractor.

K. Room Type Instruments

1. DDC room thermostats, humidistats and transmitters shall be linear precision resistance elements with accuracies as specified elsewhere. Local setpoint adjustment shall be available to change setpoint ±4°F. DDC thermostats and humidistats shall be furnished with high impact plastic cover with tamperproof screws with concealed adjustment without thermometer in all public areas. Thermostats and humidistats for patient rooms, private offices, conference rooms, laboratories, and single-occupancy areas shall be provided with local adjustment.
2. The setpoint shall be capable of being overridden by the Building Automation System.
3. Mechanical and electric room thermostats shall be of the heavy duty, all-metal type.
4. Provide electric/electronic thermostats as required to suit the control application as outlined herein.

5. DDC temperature sensors serving Psychiatric Suite rooms shall be tamper proof panel sensor mounted in the wall and humidistats shall be duct-mounted in each room's exhaust duct. All humidistats shall have replaceable sensor tips.
6. DDC sensors and humidistats serving Infectious Isolation rooms shall include in-wall room sensors with remote electronic setpoint devices located exterior to the Isolation Room. The electronic setpoint device shall include a security feature requiring input of a Security Code by medical staff to modify setpoint.
7. The ATC Contractor shall submit thermostat samples for review by the Owner, Architect and Engineer, prior to shipment of product to the job site.

L. Smoke Detection System

1. The HVAC Contractor shall install smoke detectors furnished by the Electrical Subcontractor in all ductwork and/or equipment, as applicable. The Contractor shall provide all interlocking of air handling units to shut down upon activation (units and fans with capacity of 2000 cfm and larger). Alarm connection of the smoke detectors to building fire alarm system shall be by the Division 16 Contractor.
2. All supply and return ventilation systems 2000 cfm and larger shall automatically stop when the in-duct smoke detectors are activated, except where return systems are utilized for smoke exhaust.
3. For supply systems 15,000 cfm and larger, the HVAC Contractor shall provide normally closed smoke dampers. The ATC Contractor shall provide all interlocking required controlled in a way that upon fan shutdown, due to fire and/or smoke detection, the smoke dampers will automatically close. The reverse sequence shall occur where dampers are called for to be normally closed.
4. Smoke dampers (at air handling units) shall be properly controlled in a way that the system fans shall not start until dampers are open, except where coordination for fan start-up is required in the Sequences of Operation and system fans shall be shut off before smoke dampers are fully closed. All end switches, damper switches, etc., required shall be provided by the Contractor.
5. All smoke dampers associated with the floor smoke zones and actuators shall be furnished and installed by the HVAC Contractor.

    a. Power wiring shall be by the ATC Contractor unless specified or indicated to be by the Division 16 Contractor. ATC will pick up power at junction boxes on floors and wire to smoke control dampers.
    b. Interlock wiring shall be by the ATC Contractor.
    c. Interlock wiring from the fire alarm system to the HVAC equipment (for smoke control) shall be by the ATC Contractor.

6. The Division 16 Contractor, when providing smoke detectors, shall include additional contacts, as required, to allow for other control functions, as specified hereinafter. Close coordination shall be exercised to allow for the provision of contacts.
7. The HVAC Contractor shall install all smoke dampers and all smoke detectors as recommended by the smoke detection system manufacturer in sheet metal ducts or plenums to ensure that the sensing elements are effective. The HVAC Contractor shall coordinate installation of smoke detectors with the Division 16 Contractor and detector manufacturer.

a. The HVAC Contractor shall provide access to make all such detection heads accessible and shall provide bracing for smoke detection sampling tubes, as required, to properly and securely support such tubes.

M. Dampers

1. All automatic dampers shall be furnished by the HVAC Contractor. Dampers shall be single or multiple blades as required. Dampers shall be installed by the Sheet Metal Subcontractor, under the supervision of the ATC Subcontractor to ensure proper installation and servicing requirements for the damper control operators. All blank-off plates and conversions necessary to install smaller or larger than duct size dampers shall be the responsibility of the Sheet Metal Subcontractor. All dampers shall be equal to Ruskin Models CD-50 (rectangular) or CDR-25 (round).

   a. Each damper operator shall control a maximum of 20 sq.ft. of damper and a maximum 5 ft. of damper width per operator. All damper operators shall be furnished and installed by the ATC Contractor.

2. All damper frames shall be constructed of extruded aluminum with 5"x1"x1.25" extruded aluminum and shall have flanges for duct mounting. All multiple damper sections must have jackshafts.
3. Damper blades shall not exceed 6" in width. All blades shall be of extruded aluminum airfoil type construction, fabricated from 6063-T5 aluminum. Blades shall be suitable for high velocity performance, ultra-low leakage type, with leakage not greater than 6.2 cfm/sq.ft. at 4" w.g. pressure differential for 48"x48" damper size, as published and certified under AMCA Certified Ratings Program. Damper leakage shall be less than 0.1% of total CFM at maximum damper system velocity. Dampers in stainless steel ductwork shall be constructed of Type 316 stainless steel.
4. All damper bearings shall be made of nylon or molded synthetic, bushings that turn in the bearings are to be oil impregnated sintered metal.
5. Replaceable butyl rubber seals shall be provided with the damper. Seals shall be installed along the top, bottom and sides of the frame and along each blade edge. Seals shall provide a tight closing, low leakage damper. Leakage and flow characteristic charts must be submitted to the Engineer prior to approval of dampers.
6. The HVAC Contractor shall provide an access door upstream and downstream of each automatic damper location.

N. Smoke Control Dampers/Operators

1. All smoke control dampers (SCD) shall be furnished and installed by the HVAC Contractor. All smoke control actuators shall be furnished and installed by the HVAC Contractor.
2. The smoke control dampers shall be low leakage automatic control dampers.
3. The dampers shall be equipped with 120 VAC spring return, normally open actuators.
4. Electronic direct-coupled actuation shall be provided on all dampers unless the damper shafts are not accessible.
5. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp

assembly shall be of a "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage.

a. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05" when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable.

6. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
7. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable except for a central, emergency, backup power source.
8. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
9. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a two-year manufacturer's warranty, starting from the date of installation. Actuators shall be as manufactured by BELIMO Model 1509001 or approved equal.

O. High Static Pressure Sensors (Typical All Air Handling Systems)

1. For each fan, provide a pair of analog static pressure sensors located in each of the supply and exhaust fan's suction/discharges, which shall be hardwired to the motor starter to stop the fan(s) upon activation and, in addition, send their signals to the DDC system. One side of each switch shall sense the pressure to be measured and the other side shall reference atmospheric pressure. Should a static pressure be sensed greater than a selected high limit or 6" differential pressure (adj.), the unit shall shut down and an alarm condition shall be annunciated.
2. Transducer shall have a minimum accuracy of 0.5% of span. The span shall match the minimum to maximum station design cfm.

P. Fume Hood Monitor

1. Furnish and install, on the chemical fume hoods, a fume hood face velocity monitor similar to Everwatch Model 8610, as manufactured by TSI or approved equal.
2. Constant volume/variable sash velocity hood application. Installation shall be complete with monitor, velocity sensor, transformer, and cables, and factory calibration.
3. The low flow alarm contact shall be monitored by the DDC control system.

Q. Oxygen Depletion Monitors (Gas Storage Rooms; MRI Rooms)

1. Furnish and install a gas monitor system to measure and display the oxygen level. The system shall provide audio and visual alarms when preset limits are exceeded, including 4-20 mA output for remote annunciation. Gas monitor shall be similar to the Toxgard II Gas Monitor as manufactured by MSA, instrument division, Pittsburgh, PA.
2. The gas monitor system shall consist of a monitor/readout unit with an integral gas sensor element. The gas monitor shall be enclosed in a wall mount type enclosure designed to meet a NEMA 4X rating. A switch accessible from the outside of the enclosure shall be provided for the purpose of alarm relay reset audible alarm silencing. The oxygen monitor sensor will be the electrochemical fuel cell type. The sensor will not require the periodic addition of reagents.
3. Monitor Readout Displays – A four digit LED readout shall be provided to display the gas concentration. The value displayed shall be a direct reading of the oxygen concentration (0 to 25%). System status indictors will also be provided with the LED display.
4. Alarm Set Point Levels – Three separate alarm set point levels shall be provided. The set points shall be independently adjustable for any value in the readout range. The set points shall provide drive signals to user interface relays.
5. Visual Alarm Indicators – The monitor shall have separate lights indicating when the present limits for “Caution”, “Warning”, and/or “Alarm” set points have been exceeded.
6. Front Panel Horn/Alarm Acknowledge Switch – This push button switch shall silence audible alarm indicators when alarm points are exceeded. Visual alarms will remain on as long as alarms are exceeded.
7. System Power Requirements – The system shall operate on 120 VAC, 60 Hz. Power shall not exceed 40 Watts from its internal DC supply. An internal, push button, reset circuit breaker shall be provided.
8. Maximum System Maintenance Requirements – The system shall require no periodic maintenance other than periodic checking of sensor response to a known concentration of gas. The system shall have approval by UL.

R. Temperature Sensors (Air Handling Units)

1. All air handling unit temperature sensors shall be averaging sensors which cover the entire area of airflow with multiple sensors provided as necessary to assure a maximum distance of 24” between sensor elements. Units shall be RTD type.

2.8 FLOW MEASURING STATIONS

A. Provide all FMSs in ductwork and at fans as shown and scheduled on the drawings and as required to provide the specified control sequences and monitoring data. Some FMSs may be provided by the built-up air handling unit manufacturer under Section 15721, coordinate accordingly and provide compatible transmitters and display readouts and all required wiring/tubing to make these FMSs fully functional and complete.

B. Airflow Measuring Stations: Differential Type

1. Differential Airflow Measuring Stations

a. Individual airflow measuring stations shall be provided for each fan system and located as shown on the Drawings.

b. Each airflow measuring station shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of Fundamentals, as well as the Industrial Ventilation Handbook. Each airflow measuring station shall contain multiple total and static pressure sensors positioned at the center of equal area of the station cross-section and interconnected by their respective averaging manifolds. For stations of 4 sq.ft. or less, one total and one static pressure shall be present for every 16 square inches of station area respectively. For stations of larger area, one total and one static pressure sensor shall be present for every 36 square inches of station area respectively.

c. The airflow measuring station shall be fabricated of a minimum of 14 ga. Galvanized steel, welded casing in 8" depth with 90° connecting flanges in a configuration and size equal to that of the duct it is to be mounted into. Each station shall be complete with an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to the casing, total and static pressure sensors located on an equal area basis and connected to symmetrical averaging manifolds, internal piping, and external pressure transmitter ports. An identification label shall be placed on each station casing listing model number, size, area, and specified airflow capacity. The maximum allowable pressure loss through the station shall not exceed .015" w.c. at 1000 fpm, or .085" w.c. at 2000 fpm. Each station shall be capable of measuring the airflow rate within an accuracy of 2% of actual flow. Product shall be as manufactured by Air Monitor fan evaluator, Paragon Series FE1500 or Ebtron.

d. The electronic transducer/transmitter and components shall be of industrial process control quality with operating features described herein and capable of producing the outlined performances. Commercial grade devices are not acceptable. The instruments and components shall be of module design, and shall be capable of being reconfigured and replaced without need for terminal connection rewiring or control knowledge. The performance requirements herein outlined are expressed in terminology in accordance with ANSI/ISA S51.1-1979 American National Standard Process Instrumentation Terminology, and ANSI MC 4.1 – 1975 (ISA-S26) Dynamic Response Testing of Process Controls. Control instrument components shall be temperature stabilized to achieve the indicated performance requirements when operating at any temperature from 40°F to 140°F.

2. Airflow Traverse Probes

a. Airflow traverse probes shall be mounted in fan inlet bell(s) or cone(s) and shall be capable of continuously monitoring the air volume of the respective vane-axial fan.

b. The airflow traverse probes shall contain multiple total and static pressure sensors located along the exterior surface of the cylindrical probe and internally connected to their respected averaging manifolds. Sensors shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.

c. The airflow traverse probes shall be dual end support swivel brackets suitable for mounting in the fan inlet bell (two per inlet) with symmetrical averaging signal takeoffs and fittings, and shall be of aluminum construction with hard anodized finish.

d. The airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level within the system be amplified by its presence in the fan inlet bell. The airflow measuring probe shall contain multiple and static pressure sensors placed at concentric area centers along the probe length.
The airflow traverse probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 2% of actual flow over a fan operating range of 6 to 1 capacity turndown.

e. The airflow traverse probes shall be the VOLU-probe, type F1, as manufactured by Air Monitor Corporation, Santa Rosa, California, Paragon Series FE1050 or Ebtron.

3. Static Pressure Probes

a. Duct (or system) static pressure traverse probes. Provide where indicated duct static traverse probes capable of continuously monitoring the duct or system static pressure it serves.

b. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Said sensor shall not protrude beyond the surface of the probe.

c. The duct static traverse probe shall be of extruded aluminum construction and (except for 3/4" dia probes with lengths of 24" or less) be completed with threaded end support rod, sealing washer or nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressured, without need for correction factors, with an instrument accuracy of 0.5%.

d. The duct static pressure traverse probe(s) shall be the STAT-probe/1 as manufactured by Air Monitor Corporation, Santa Rosa, California, Paragon Series FE1500 or Ebtron.

4. Electronic Differential Pressure Transmitter

a. The electronic differential pressure transmitter shall be capable of receiving signals of duct and reference static pressure and of amplifying and scaling the sensed differential pressure of inches W.C. into a 4-20mADC or 0-5 VDC output signal linear to flow velocity and volume. The air volume velocity transmitter shall be capable of the following performance and application criteria:

b. The air volume, velocity transmitters shall incorporate an integral square root extractor capable of automatically using the square root of the differential (velocity) pressure signal from a flow station or probe to produce an output signal linear to flow (velocity). This linearizing circuit is factory set and requires no field adjustment. In addition, an integral scaling multiplier permits scaling of the output signal magnitude (for flow station or duct area) to produce a signal linear and scaled to air volume.

c. Integral Zeroing Means each transmitter is furnished with a built-in 3-way zeroing manifold valve, permitting the transmitter to be zeroed by simply positioning the valve switch, eliminating the potential of transmitter membrane damage that routinely occurs during disconnecting and reconnecting input signal lines.

d. Performance Characteristics Common to All Transmitters

1) Accuracy. Transmitter shall be capable of maintaining an accuracy of ±0.5% of Full Span. For flow transmitter with a 0 to 896 FPM minimum span, this accuracy is equivalent to a signal transmitter accuracy capability of ±4 FPM.
2) Output Signal: 4-20mADC or 0-5 VDC standard
3) Power Supply: 12 to 40 DC unregulated; 2 wire, 4 to 20mADC; 3 wire, 0 to 5 VDC
4) Temperature Effect: ±2.0% of full span from 40°F to 120°F.

e. The transmitter shall not be damaged by over-pressurization up to 200 times greater than span, and shall be furnished with a factory calibrated span and integral zeroing means. The transmitter shall be housed in a molded polyethylene (NEMA 1 steel) enclosure with external signal tubing, power and output signal connections.

f. The electronic differential pressure transmitter shall be the VELTRON series 1500 as manufactured by Air Monitor Corporation, Santa Rosa, California, Paragon Series FT1000 or Ebtron.

C. Installation

1. Install airflow probes and transducers at locations indicated on the drawings and in accordance with manufacturer's installation instructions.
2. Install monitor electronics at locations indicated on the drawings and in accordance with manufacturer's installation instructions.
3. Install probes such that pressure connections are at or above the centerline of the probe. Connection tubing attaching to the probes should be pitched downward so that any accumulated moisture can drain back towards the probe. Tubing should be installed so that there are no pockets where moisture might accumulate.
4. Install the transducer such that it is located at a slightly higher elevation than the highest probe. Transducer shall be mounted so that the pressure connections are on the bottom of the enclosure. Connecting tubing should be pitched downward and away from the transducer so that any accumulated moisture can drain back towards the probe. Tubing should be installed so that there are no pockets where moisture might accumulate.

5. Cable connecting the transducer and monitor shall be installed in a neat and workmanlike manner. Penetrations through the air handler walls shall provide some means to prevent chafe.
6. Airflow monitoring devices shall not be installed in the inlets of centrifugal fans.

2.9 DDC CFM TRACKING TERMINAL BOXES (VAV, VCV, CV, VVE, CVE Designations)

A. General

1. For this project, all air terminal boxes shall be purchased/furnished/installed by the HVAC Contractor. Successful terminal box manufacturer shall receive the terminal box controller and actuator from the ATC Contractor and mount them onto the boxes at the box factory. The ATC Contractor shall pay for installation of the controllers, actuators, etc. onto the boxes. The HVAC Contractor shall coordinate the shipment of the components, and the ATC Contractor shall pay for shipment of controllers to the air terminal box manufacturer and provide the controls to the box manufacturer in a coordinated sequence to enhance the construction phase.
2. The following control manufacturers shall be acceptable for CFM tracking air terminal box controls contingent on compliance with the specifications:

    a. Johnson Controls
    b. Siemens
    c. Andover Controls
    d. Automated Logic
    e. American Automatrix
    f. Dayton General Systems

3. The DDC CFM tracking air terminals shall be totally integrated with the central automation system.
4. The DDC CFM tracking air terminal control manufacturers must certify their company's/product capability and reliability to furnish, install, start-up and maintain their proposed system configuration.
5. The following type of air terminal controllers shall be required:

    a. Variable Air Volume Supply
    b. Constant Volume (with heat coil) Supply
    c. Combination Variable/Constant Volume (with heat coil) Supply
    d. Variable Volume Exhaust
    e. Constant Volume Exhaust
    f. Variable Control Volume Exhaust

6. The ATC Contractor shall submit to the Architect and Owner for approval, within 60 days of receipt of his Contract, a complete submittal on the proposed airflow control systems, to include, but not be limited to, system flow schematic wiring and tubing diagram, identifying control, instruments listing the manufacturer, model number, and their performance capabilities.

7. The direct digital controller shall communicate to the DDC terminal front end automation system through a 2-wire, optically isolated interface. This 2-way interface shall allow commands to be sent to the controller, which shall in turn send status information back to the system. Up to 32 controllers may be daisy-chained on one (1) loop.
8. The ATC Contractor shall provide all necessary factory and/or field labor for complete calibration and adjustment of the airflow control components and shall be responsible for setting all control setpoints, operating sequences and alarming systems contained within the airflow control centers to produce the following overall system performance.
9. In conjunction with the system start-up, the ATC Contractor shall instruct the Owner's personnel in the proper operation of the airflow control system.
10. The ATC Contractor shall guarantee the proper operation of the airflow control system and shall calibrate the initial system installation.
11. The ATC Contractor shall guarantee the proper operation of the system and furnish all required service for one (1) full year from the date of system acceptance.
12. Damper and reheat coil hot water actuators shall be fully modulating electronic, furnished by the ATC Contractor and installed by the terminal box manufacturer (installation paid for by the ATC Contractor).
13. The ATC Contractor shall provide auto-zeroing function with all required software, programming, timers, scheduling and controller hardware to prevent terminal boxes and their controllers from disrupting the integrity of the environment being served. Disruption of airflow, room pressure relationship, temperature and/or humidity levels will be unacceptable.

B. Air Terminal Box Controller

1. The Controller shall be as specified above.

C. Room Temperature Sensor (with Setpoint Control)

1. Room sensors with integral setpoint adjustment shall be provided where shown on the drawings. Controller shall be capable of receiving both adjustments from the sensor and separate EEPROM communications interface. The sensors shall be supplied by the Controller manufacturer. The room temperature sensors (RTS) shall be an RTD type room temperature sensor and shall have an RS-232C communication port. A single cable interface from RS232 to a RJ48 jack on the space sensor is acceptable. Room sensors shall have an accuracy of ±2% at 70°F with a tolerance of 0.4°F. The unit shall provide room temperature data to the controller. The communication port shall allow for direct communication to both of the pair of air terminals directly associated with the sensor, via a hand-held laptop computer.
2. Control of each pair of terminal boxes shall be stand-alone (one [1] controller) and shall not depend on control information from any other Air Terminal Box Controller for primary control. Failure of any component, including the individual microprocessor controlling the unit, shall not cause interruption of control on any other VAV box controller. The DDC controller shall have programmable parameters stored in a non-volatile EEPROM. Each controller shall be capable of addressing read only memory for a specific integrated circuit containing all logic analog amplifiers

with programmable gain and offset, analog to digital converter for RS-485 communication. No battery backup shall be necessary. Controller shall also have capabilities of random access memory operating at a communication rate of 4800 baud as standard. Software capabilities shall have multiple stand-alone control strategies which shall be programmed at the factory through service tool or lap-top computer, or BAS active strategy initiated through BAS communications or physical device such as pressure switches, duct sensors, etc., as indicated. The control system shall be capable of tracking one exhaust box based upon the combined supply airflows of multiple supply boxes.

3. The following information (minimum) shall be communicated into the front end and the local room sensors:

Room Without Fume Hood		
Item	**Readout (Units)**	**Adjustment**
Room CFM Differential (Actual)	Yes (Volume)	Yes
Room Temperature (Actual)	Yes (°F)	Yes
Supply Volume	Yes (CFM)	Yes
Exhaust Volume	Yes (CFM)	Yes
Temperature Setpoint	Yes (°F)	Yes
Differential Volume Setpoint	Yes (CFM)	Yes
Occupied/Unoccupied	Yes	Yes
Relative Humidity (Actual)	Yes (% RH)	Yes (Room with in-duct humidifier)
Relative Humidity (Setpoint)	Yes (%RH)	Yes (Room with in-duct humidifier)

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

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

1. Construct and maintain project schedule.
2. On-site coordination with all applicable trades and subcontractors.
3. Authorized to accept and execute orders or instructions from Owner/Architect.
4. Attend project meetings as necessary to avoid conflicts and delays.
5. Make necessary field decisions relating to this scope of work.
6. Coordination/Single point of contact.

3.2 NUMBERING/NAMING CONVENTIONS

A. The Contractor shall collaborate with the Owner directly to determine the Owner's preference for naming conventions, etc. before entering the data in the system.

B. As a minimum the ATC Contractor shall submit to the Architect/Engineer and Owner the layout of the network, identifying all DDC controllers. Each controller will be identified by address and system being served. All physical and software generated objects, points and attributes shall be listed along with a description.

3.3 START-UP AND COMMISSIONING

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

B. Provide any recommendation for system modification in writing to Owner. Do not make any system modification, including operating parameters and control settings, without prior approval of Owner.

C. The ATC Contractor will provide industry standard checkout and startup checklists for each DDC controller installed for the project. If not standard is available, the ATC Contractor shall develop a spreadsheet in MS Excel format and submit to the Engineer for approval prior to system checkout.

3.4 INSTRUCTION AND ADJUSTMENT

A. The Contractor shall provide factory-trained instructor to give full instructions to the owner designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The Contractor shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 AM to 5:00 PM weekdays.

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

1. Fine-tune and “de-bug” all software control loops, routines, programs and sequences of control associated with the control system supplied.
2. Completely adjust and make ready for use, all transmitters, relays, damper operators, valves, etc., provided under this Section. This Contractor shall furnish copies of complete, detailed, calibrating checkout and commissionary documentation for reach controller. Documentation shall list each procedure and shall be signed by the control specialist performing the service.
3. Furnish a complete set of system operation manual, including standard manufacturers’ operating manuals, complete as-built installation diagrams, and complete software hardcopy documentation, as well as a magnetic media back-up.

4. Provide an on-site training program for the Owner's staff in the operation and use of the control system. Training shall include three (2) segments, as follows:

   a. Segment 1 shall include 16 hours of classroom and hands-on training. This segment shall instruct personnel in the system configuration, component characteristics, control strategy on each controlled system and all requirements for daily operation and use of the system. This segment shall give the Owner's representative a working proficiency in the day-to-day operational requirements (i.e., system monitoring, alarm acknowledgment, HVAC system troubleshooting techniques, setpoint and time schedule adjustments, manual override, etc.).
   b. Segment 2 shall include 6 hours of on-site training. This segment will be geared for the Owner's designated prime operator. An emphasis on overall software management and manipulation shall be made, to allow the prime operator(s) to make control strategy and overall facility and system management changes as required. Attendees shall have attended Segment 1.
   c. All training shall take place at the site and at times mutually agreed to between that ATC Contractor and the Owner. The ATC Contractor shall provide to the Owner's designated representative, at least three (3) weeks before each segment, a course syllabus outline and schedule. The ATC Contractor shall provide all training material, reference material and training aids, as required, all as part of his Contract cost.

PART 4 - SCHEDULES

4.1 POINT SCHEDULE

A. Note: For point software association, see sequence of operation. All points shall be able to integrate to all trends, totalizations, etc., as applicable. For additional points, refer to drawings and sequences of operations. Additional points not specifically called for herein but required to perform the sequence as herein specified shall be provided at no additional cost to the Owner.

B. THE ATC CONTRACTOR SHALL CARRY AN ALLOWANCE FOR INSTALLING, WIRING AND SOFTWARE PROGRAMMING FOR 20 ADDITIONAL MONITORING AND CONTROL POINTS OF EACH TYPE (AI, AO, DI, DO) FOR OWNER'S USE (I.E. 80 POINTS). These 80 points are over and above points required that are not specifically listed below but will be required to provide the specified sequences.

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
TYPICAL FOR AHU-1 & AHU-2								
START/STOP SUPPLY FAN #1				X			X	
START/STOP SUPPLY FAN #2				X			X	

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
SUPPLY FAN #1 STATUS	X				X		X	VIA AMPERAGE SENSOR
SUPPLY FAN #2 STATUS	X				X		X	VIA AMPERAGE SENSOR
SUPPLY FANS HIGH STATIC SAFETY			2		X		X	VIA DELTA P SWITCH
START/STOP RETURN FAN #1				X			X	
START/STOP RETURN FAN #2				X			X	
RETURN FAN #1 STATUS	X				X		X	VIA AMPERAGE SENSOR
RETURN FAN #2 STATUS	X				X		X	VIA AMPERAGE SENSOR
RETURN FANS HIGH STATIC SAFETY			2		X		X	VIA DELTA P SWITCH
MINIMUM OUTSIDE AIR INTAKE DAMPER			2	X				OPEN/CLOSE, WITH END SWITCHES
50% OUTSIDE AIR DAMPER		2						MODULATING
MAXIMUM/ECONOMIZER O.A. DAMPER		2						MODULATING
RETURN AIR DAMPER		2						MODULATING
EXHAUST/RELIEF AIR DAMPER		2						MODULATING
SUPPLY FAN #1 ISOLATION DAMPER/DOOR			2	X				OPEN/CLOSE, WITH END SWITCHES
SUPPLY FAN #2 ISOLATION DAMPER/DOOR			2	X				OPEN/CLOSE, WITH END SWITCHES
RETURN FAN #1 ISOLATION DAMPER			2	X				OPEN/CLOSE, WITH END SWITCHES
RETURN FAN #2 ISOLATION DAMPER			2	X				OPEN/CLOSE, WITH END SWITCHES
COOLING COIL LEAVING AIR TEMP.	X				X	X		
UNIT SUPPLY DISCHARGE TEMP.	X				X	X		
OUTSIDE AIR HUMIDITY AND TEMPERATURE	2							
MODULATE COOLING COIL VALVES (1/2-2/3)	2	2						PROVIDE VALVE POSITION FEEDBACK
CHILLED WATER RETURN TEMP. @ COIL	X				X	X		
CHILLED WATER SUPPLY TEMP. @ COIL	X				X	X		
LOW LIMIT SENSOR (40°F)	X					X		INDEPENDENT SENSOR
FREEZE THERMOSTATS (AT COOLING COIL)			X				X	
MIXED AIR TEMPERATURE	X							
RETURN AIR TEMPERATURE AND HUMIDITY SENSORS	2							
STEAM PREHEAT COIL DISCHARGE AIR TEMP.	X				X	X		

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
MODULATE HEATING COIL VALVES (1/3-2/3)	2	2						PROVIDE VALVE POSITION FEEDBACK
SUPPLY SYSTEM STATIC PRESSURE (IN DUCTWORK)	X				X			
RETURN SYSTEM STATIC PRESSURE (IN DUCTWORK)	X				X			
DUCT MOUNTED SUPPLY AFM STATION	X							
DUCT MOUNTED RETURN AFM STATION #1	X							
DUCT MOUNTED RETURN AFM STATION #2	X							
MODULATE SUPPLY FAN #1 SPEED VIA VFD		X	X				X	PROVIDE VFD TROUBLE ALARM AND ALL VFD POINTS SPECIFIED
MODULATE SUPPLY FAN #2 SPEED VIA VFD		X	X				X	PROVIDE VFD TROUBLE ALARM AND ALL VFD POINTS SPECIFIED
MODULATE RETURN FAN #1 SPEED VIA VFD		X	X				X	PROVIDE VFD TROUBLE ALARM AND ALL VFD POINTS SPECIFIED
MODULATE RETURN FAN #2 SPEED VIA VFD		X	X				X	PROVIDE VFD TROUBLE ALARM AND ALL VFD POINTS SPECIFIED
SUPPLY UNIT PREFILTER ΔP & HIGH LIMIT ALARM	X		X		X			
SUPPLY UNIT INTERMEDIATE FILTER ΔP & HIGH LIMIT ALARM	X		X		X			
SUPPLY UNIT HEPA/FINAL FILTER ΔP & HIGH LIMIT ALARM	X		X		X			
DISCHARGE HUMIDITY	X							REPLACEABLE RH SENSOR TIPS
RETURN RELATIVE HUMIDITY	X				X	X		
HUMIDITY HIGH LIMIT SENSOR AT UNIT	X	X			X		X	RESET MAXIMUM HUMIDIFIER OUTPUT VIA THIS SENSOR TO LIMIT DUCT RH TO 85% (ADJ.)
MODULATE HUMIDIFIERS (IN PARALLEL)	X	X					X	POSITION FEEDBACK FOR MODULATING VALVE
SUPPLY AND RETURN AIR SMOKE DETECTORS			2				2	EACH AHU
UNIT SMOKE ISOLATION DAMPER(S)			X				X	

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
AHU-3 (BOILER ROOM)								
SUPPLY FAN START/STOP				X			X	INTERLOCK WITH BOILER PLANT
EXHAUST FAN START/STOP				2			2	EX-18 & EX-19
SUPPLY FAN STATUS	X				X		X	VIA AMPERAGE SENSOR
SUPPLY FAN HIGH STATIC			X				X	VIA DELTA P SWITCH
UNIT DISCHARGE AIR TEMPERATURE	X				X	X		
O.A. TEMP.	X							
MODULATE O.A. DAMPER	X	X	2					POSITION FEEDBACK
MODULATE STEAM COIL VALVES (1/3-2/3)	2	2						PROVIDE VALVE POSITION FEEDBACK
STEAM PREHEAT FACE & BYPASS DAMPER		X						
FREEZESTAT LOW LIMIT (40°F)			X			X	X	
SUPPLY SMOKE DETECTOR			X				X	
SUPPLY AIR VOLUME (FMS)	X							
MODULATE SUPPLY FAN SPEED AND FLOW VIA VFD		X	X				X	PROVIDE VFD TROUBLE ALARM
FILTERS ΔP & HIGH LIMIT ALARM	X		X		X			
RETURN AND/OR EXHAUST BOX (VVR/VVE)								
DAMPER CONTROL		X						
CFM MEASUREMENT AND ADJUSTMENT	X							CFM TRACKING/ TOTALIZING & OFFSET VIA SOFTWARE
VAV WITHOUT REHEAT								
ROOM TEMPERATURE W/OVERRIDE & SETPOINT ADJUSTMENT	X							
DAMPER CONTROL		X						
CFM MEASUREMENT AND ADJUSTMENT	X							
RADIATION/RADIANT PANEL VALVE (IF REQUIRED)		X						
CV/VAV BOXES WITH REHEAT								
ROOM TEMPERATURE W/OVERRIDE & SETPOINT ADJUSTMENT	X							
DAMPER CONTROL		X						
REHEAT VALVE CONTROL		X						
RADIATION/RADIANT PANEL VALVE (IF REQUIRED)		X						
CFM MEASUREMENT AND ADJUSTMENT	X							

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
OUTSIDE AIR TEMPERATURE/HUMIDITY								
OUTSIDE AIR TEMPERATURE SENSOR	X							
OUTSIDE AIR HUMIDITY SENSOR	X							
IN-DUCT HUMIDIFIERS								
SPACE HUMIDITY	X							
SUPPLY HIGH LIMIT WITH DUCT HUMIDISTAT AND RESET	X				X			
HUMIDIFIER VALVE		X					X	ON/OFF VIA SOFTWARE INTERLOCK WITH CENTRAL STATION AHU OPERATION
RADIATION / IN-REHEAT COILS								
SPACE TEMPERATURE	X							
RADIATION VALVE CONTROL		X						
RESET		X					X	
STEAM-TO-HOT WATER HEAT EXCHANGER SYSTEM								
HEAT EXCHANGER WATER SUPPLY TEMP. AT HEAT EXCHANGERS	X				X	X		
HEAT EXCHANGER WATER RETURN TEMP. AT HEAT EXCHANGERS	X				X	X		
MODULATE STEAM VALVES (1/3-2/3)	2	2						WITH POSITION FEEDBACK
HOT WATER PUMP (PRIMARY)	X			X			X	START/STOP AND STATUS VIA CURRENT SENSOR
HOT WATER PUMP (STANDBY)	X			X			X	START/STOP AND STATUS VIA CURRENT SENSOR
START/STOP & MODULATE VFD FOR DIFFERENTIAL PRESSURE CONTROL		X						SIGNAL TO VFD, PROVIDE ADDITIONAL FLOW PROOF VIA FLOW SWITCH
SYSTEM DIFFERENTIAL PRESSURE	2							TWO SEPARATE LOCATIONS
HOT WATER PUMP VFD (EACH PUMP)	2	X	X					MODULATE PUMP SPEED; PROVIDE VFD TROUBLE ALARM, % OF AMPERAGE & ALL VFD POINTS SPECIFIED
CHILLER/COOLING TOWER								
COOLING TOWER FAN START/STOP				X				PER CELL

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
COOLING TOWER FAN STATUS (PER CELL)	X				X	X		VIA CURRENT SENSOR
COOLING TOWER FAN VFD SPEED CONTROL	X	X	X					MODULATE FAN SPEED, PROVIDE VFD TROUBLE ALARM, % OF AMPERAGE & ALL VFD POINTS SPECIFIED
COOLING TOWER VIBRATION			X					
CHILLED AND CONDENSER WATER SUPPLY TEMP.	2				2	2		
CHILLED AND CONDENSER WATER RETURN TEMP.	2				2	2		
TOWER SUMP BASIN TEMP. (PER BASIN)	X					X		
COOLING TOWER BASIN HEATERS		X		X				START/STOP & STATUS
CONDENSER WATER PIPING HEAT TRACE		X		X				START/STOP & STATUS
MODULATE TOWER BYPASS CONTROL VALVES	X	X						PROVIDE VALVE POSITION FEEDBACK
CHILLER START/STOP				X				
CHILLER STATUS & ALARMS			X		X	X		
CHILLER VFD SPEED & STATUS	X			X				
CHILLER EVAPORATOR LEAVING WATER TEMP.	X							
CHILLER EVAPORATOR RETURN WATER TEMP.	X							
CHILLER CONDENSER LEAVING WATER TEMP.	X							
CHILLER CONDENSER RETURN WATER TEMP.	X							
CHILLED WATER SUPPLY TEMP. RESET	X							
CHILLED WATER PUMP (PRIMARY) (START/STOP & STATUS)	X			X			X	START/STOP & STATUS VIA CURRENT SENSOR
CHILLED WATER PUMP (STANDBY) (START/STOP & STATUS)	X			X			X	START/STOP & STATUS VIA CURRENT SENSOR
CHILLER WATER PUMP VFD (EACH PUMP)	2	X	X					MODULATE PUMP SPEED; PROVIDE VFD TROUBLE ALARM, % OF AMPERAGE & ALL VFD POINTS SPECIFIED
CHILLED WATER DIFFERENTIAL PRESSURE & BYPASS VALVE CONTROL	X	X						

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
CONDENSER WATER PUMP (START/STOP & STATUS)	X		X				X	VIA CURRENT SENSOR
CONDENSER WATER PUMP (STANDBY) (START/STOP & STATUS)	X		X				X	VIA CURRENT SENSOR
CHILLED WATER AND CONDENSER WATER FLOW THROUGH CHILLERS	4		4					DIFFERENTIAL PRESSURE & FLOW SWITCHES
CHILLER CONTROL PANEL INTERFACE (GATEWAY)								
PLUMBING EQUIPMENT								
DOMESTIC HOT WATER HEATERS SUPPLY TEMPS. W/ALARM (EACH)	2		2		X	X		SENSORS BY PSC
COLD WATER FLOW METER			X					FROM PULSE METERS
IRRIGATION WATER FLOW METER	X						X	
FIRE PROTECTION WATER PRESSURE	X					X		SENSOR BY PSC
FIRE PUMP COMMON ALARM			X				X	FROM PANEL DRY CONTACTS
FIRE JOCKEY PUMP COMMON ALARM			X				X	FROM PANEL DRY CONTACTS
CITY WATER PRESSURE	X					X		SENSOR BY PSC
DOMESTIC WATER PRESSURE BOOSTER PUMP ALARM (EACH)	X				X	X	X	
SEWAGE EJECTOR HIGH LEVEL ALARM					X			FROM PANEL DRY CONTACTS
WATER ALARM (EACH)			X			X		
VACUUM PUMP PRESSURE (EACH)	X					X		
FIRE PUMP PRESSURE	X							
MEDICAL AIR COMPRESSOR PRESSURE (EACH)	X				X	X		
LAB SYSTEM AIR COMPRESSOR PRESSURE (EACH)	X				X	X		
MOISTURE CONTENT METER (AIR) MEDICAL AIR COMPRESSOR	X							
MEDICAL GAS SERVICES HIGH PRESSURE SYSTEM (EACH SYSTEM)	X				X			
MEDICAL GAS SERVICES LOW PRESSURE SYSTEM (EACH SYSTEM)	X					X		
MASTER AND LOCAL MEDICAL GAS ALARM PANELS	X					X		DATA LOGGING
FIRE PROTECTION SYSTEM PRESSURE SWITCHES (EACH)	X							

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
FIRE PROTECTION TAMPER SWITCHES (EACH)	X							
EMERGENCY GENERATOR								
EMER. GEN. FUEL OIL TRANSFER PUMP COMMON ALARM & LEAK DETECTION SYSTEM			2				2	FROM PANEL DRY CONTACTS
EMER. GEN. DAY TANK HI/LOW LEVEL ALARMS			2					FROM PANEL DRY CONTACTS
EMER. GEN. ON/OFF/TESTING STATUS			3					FROM PANEL DRY CONTACTS
EACH EMERGENCY POWER TRANSFER SWITCH ACTIVATED			3					FROM PANEL DRY CONTACTS
GENERATOR COMMON TROUBLE			X					FROM PANEL DRY CONTACTS
FUEL OIL SYSTEM (EACH SYSTEM)								
FUEL OIL STORAGE (GALLONS) (EACH TANK) (TYP. 2)	X							
FUEL OIL TANK LEAK DETECTION ALARM (EACH TANK)			X					
FUEL OIL TANK SELECTOR VALVES (EACH)	X	X						PROOF
FUEL OIL PIPING LEAK DETECTION ALARMS (EACH)			X					
FUEL OIL PUMP SET LEAK DETECTION ALARM (EACH PUMP SET)			X					
FUEL OIL PUMP STATUS (EACH PUMP)			X					
FUEL OIL PUMP ALARM (EACH PUMP SET)			3					
FUEL OIL PRESSURE AT BOILERS & GENERATORS (EACH)	X							
EXHAUST FANS (Typical for each fan)								
EXHAUST FANS START/STOP & STATUS			X	X			X	STATUS VIA ΔP SWITCH
DAMPER CONTROL AND PROOF			X	X			X	
CFM TRACKING AIR TERMINAL BOXES (Typical)								
SPACE TEMP.	X				X	X		
AIRFLOW VOLUME	X				X	X		
SUPPLY AIR TEMP. DOWNSTREAM OF REHEAT COIL	X				X			
MODULATE AIR TERMINAL VALVE		X			X	X	X	
MODULATE REHEAT		X					X	

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
MODULATE EXHAUST BOX/VALVE DAMPER		X						
EXHAUST BOX/VALVE ACTUAL CFM	X							
DIFFERENTIAL PRESSURE CONTROLS								
DIFFERENTIAL PRESSURE	X				X	X		ACROSS SUPPLY & RETURN
MODULATE ΔP CONTROL VALVE		X					X	
FIRE ALARM SYSTEM SIGNALS TO OCS								
FAS GENERAL ALARM (PER ZONE)		X					X	
FAS GENERAL TROUBLE ALARM		X					X	
ENERGY METERING								
ELECTRICITY DEMAND (KW)	2							TWO ELECTRIC SERVICES
ELECTRICITY CONSUMPTION (KWH)	2							TWO ELECTRIC SERVICES
COLD AND ENVIRONMENT ROOM MONITORING (TYP. PER ROOMS)								
HIGH TEMP. SENSOR	X				X			
TROUBLE ALARMS			X				X	
BOILER PLANT (B-1 AND B-2)								
BOILER STATUS (ON/OFF) (EACH BOILER)				X				
SYSTEM STEAM PRESSURE	2							EACH END OF MAIN STEAM HEADER
WATER SOFTENER SUPPLY WATER HARDNESS	X							
CONDENSATE RETURN WATER TEMPERATURE	X							
FEEDWATER TEMPERATURES TO BOILERS	X							
BOILER FLUE GAS TEMPERATURE (EACH BOILER)	X							
FEED WATER PUMP STATUS (EACH)			X					
DEAERATOR TRANSFER PUMP STATUS (EACH)			X					
BOILER FLAME FAILURE (EACH BOILER)			X			X		
BOILER LOW WATER (EACH BOILER)			X			X		
DEAERATORS								
LEVEL			X			X		LOW LEVEL
PRESSURE	X							

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
SURGE TANK								
LEVEL			X			X		LOW LEVEL
MISCELLANEOUS POINTS								
EXTERIOR SITE LIGHTING ON/OFF				X				COORDINATE LOCATION AND SIGNAL TYPE WITH ELECTRICAL CONTRACTOR
DUCT SMOKE DAMPER (EACH)			X	X				
COMPUTER ROOM AIR CONDITIONING UNITS (ALARM) (EACH)			X		X			
KITCHEN/FOOD SERVICE REFRIGERATION/FREEZERS TEMPERATURE (EACH)	X				X		X	
LABORATORY REFRIGERATION/FREEZERS TEMPERATURE (EACH)	X				X		X	
BAG-IN/BAG-OUT EXHAUST FILTERS – DIFFERENTIAL PRESSURE (EACH)	X				X		X	
GAS STORAGE ROOM & MRI ROOM OXYGEN DEPLETION (ALARM) (GAS) (EACH)			X			X		
SET BACK CONTROL W/OVERRIDE FOR OR'S & CATH LABS (EACH)			X	X				FOUR (4) OCCUPANCY SENSORS PER ROOM FOR OVERRIDE
PRESSURE REDUCING VALVE STATIONS (TYPICAL FOR EACH STATION)								
STEAM OUTLET PRESSURE (PSIG) (LOW PRESSURE-ALARM)	X				X	X		HIGH & LOW PRESSURE ALARMS
MECHANICAL AND ELECTRICAL ROOM VENTILATION (EACH ROOM)								
ROOM TEMPERATURE	X				X	X		
DAMPER CONTROL				2				
FAN (START/STOP)				X				
FAN STATUS (3 HP AND LARGER = AI) (UNDER 3 HP = DI)	X		X					
CONDENSATE PUMPS (TYPICAL OF EACH DUPLEX SET)								
HIGH WATER ALARM			X		X		X	
EACH ISOLATION ROOM (INFECTIOUS & PROTECTIVE), BRONCOSCOPY, OPERATING ROOMS, AUTOPSY ROOMS								
DIFFERENTIAL PRESSURE	X							
DOOR SWITCH CONTACT			X					TIME OUT ALARM
GENERAL FAILURE ALARM (LOCAL AND REMOTE)			X				X	

SYSTEM POINT	POINT				ALARMS			COMMENTS
	AI	AO	DI	DO	HI	LOW	OFF NORMAL	
PROCESS CHILLED WATER SYSTEM								
CHILLED WATER SUPPLY TEMP.	X							
CHILLED WATER RETURN TEMP.	X							
CHILLED WATER SUPPLY TEMPERATURE RESET	X							
CHILLER START/STOP STATUS			X	X			X	
CHILLER ALARM			X					
CHILLED WATER PUMP START/STOP				2			2	
CHILLED WATER PUMP STATUS				2				
CHILLED WATER DIFFERENTIAL PRESSURE	X							
CHILLED WATER BYPASS VALVE		X						
CHILLER CONTROL PANEL INTERFACE (GATEWAY)								
FLOW SWITCHES (HARDWIRED)								

1. The Contractor shall refer to the Plumbing and Fire Protection sections for additional points required. The Division 15 Contractors shall provide switches and sensors in piping system and terminal connections in Plumbing/Fire Protection equipment panels for connection to by the Contractor. The Contractor shall provide all conduit and wiring required to extend these points back to the DDC automation system. The Contractor shall review the Plumbing Drawings to determine the quantity of Plumbing equipment provided. The Contractor shall provide all integrating software required to incorporate these points into the automation system.

PART 5 - SEQUENCES OF OPERATION

5.1 GENERAL

A. NOTE: THIS IS A PARTIAL LISTING OF SEQUENCES.

B. Sequences

1. Air Handling Units - Recirculating - Dual Fans (AHU-1 & 2)
2. Air Handling Unit – 100% Outside Air Single Fan (AHU-3)
3. Exhaust Air Fans / Supply Air Fans
4. Differential Pressure Bypass Valve Arrangement
5. Variable Speed Pumping Systems (VFD)
6. Constant Volume Box with Reheat Coil
7. Constant Volume Box with Reheat Coil and Radiation/Radiant Panels
8. Variable Volume / Constant Volume Box with Reheat Coil

9. Variable Volume Box
10. Variable Volume / Constant volume Box with Reheat Coil and Radiation / Radiant Panels
11. Central VAV Return Air Units / Box Serving Multiple VAV Supply Boxes
12. Engineered Smoke Management System
13. Heat Exchanger Control (Reheat, Radiation/Radiant Panel)
14. Radiation and Radiant Panels (with No Airflow Box Interlock)
15. Cabinet Unit Heaters / Propeller Unit Heaters
16. In-Duct Hot Water Coils
17. Controllable Pressure Rooms
18. Fuel Oil Gauge and Alarm System
19. Mechanical & Electrical Room Heating & Ventilating
20. Steam Humidifiers
21. Chiller Plant
22. Ventilation / Refrigerant
23. Monitoring Pump & Smoke Exhaust
24. Variable Speed Drives
25. Optimized Start-Up After Power Failure
26. Infectious Isolation Exhaust Systems
27. Computer Room Units
28. Elevator Machine Room Control
29. Central Kitchen Occupied / Unoccupied Ventilation
30. Process Chiller System
31. OR's & Cath Labs Occupied / Unoccupied Control
32. Snow Melting System
33. Chemical Treatment
34. Normal / Emergency Power Monitoring System
35. MRI Emergency Exhaust Systems

5.2 SEQUENCE OF OPERATION

A. Air Handling Unit (Recirculation - Dual Supply and Dual Return Fans) – Variable Volume

1. The following units shall have this specified sequence: AHU-1 & AHU-2.

2. Unit shall normally be run continuously. Upon initial starting of AHU Supply and Return Air Fans, exhaust systems shall be directed to start prior to supply systems due to "exhaust" flow control basis of the pressurization control systems. When supply fans are started by the DDC panel, the following sequence shall occur:

   a. The duct mounted supply and return smoke dampers shall fully open.
   b. The minimum outside air damper shall open to full position and damper is verified open by its end switch, the fans shall be capable of starting.
   c. Unit shall be equipped with supply fan discharge isolation dampers/doors. The fans shall be ramp started to minimum fan speed of 15 Hz (adj.) via individual signal to each fan's VFD, both at the same rate. After both fans are at 15 hz, the fan isolation dampers/doors shall open and when both

damper/doors end switches prove the dampers/doors are open the fans will be allowed to increase in speed. If differential pressure across a fan has not reached 1.0" w.c. after 60 seconds, the fan shall be deactivated and its isolation dampers/doors closed. The rate of fan speed ramp-up shall be adjustable. When any fan is off, isolation damper/door shall close. If at any time during operation of fans, the differential pressure across a fan is sensed as less than 1.0" w.c. (adj.), that fan shall be deactivated, its isolation damper/door closed and alarm sent to the BAS (Building Automation System).

d. Upon start-up of one fan when other is running, reduce "ON" fan to 25% speed (adj.), then start "OFF" fan and ramp to match "ON" fan, then ramp speed to satisfy static setpoint.
e. Damper actuators shall be by ATC. Actuators shall be industrial grade electric. All dampers requiring proof must be wired with end switches.
f. When a fan is off, its discharge isolation damper/door shall be closed.
g. During startup, the supply fans and the return fans shall track without CFM off-set until an adjustable time delay has expired. The system shall then revert to its normal operation. During start-up, outside air dampers shall remain closed and the supply and return fans will run without offset until return air reaches a pre-set temperature. Then the minimum outside air damper shall open and the return air and exhaust air dampers shall take corresponding positions to initiate offset.

3. A temperature sensor sensing unit discharge temperature shall provide a signal to the DDC panel to control the cooling coil 2-way control valves, modulate the steam preheat coil control valves, the outside air dampers, return air dampers and exhaust air dampers in sequence to maintain an (adj.) discharge air temperature. Sensor shall be installed downstream of supply air fans. On a rise in unit discharge air temperature, the mid range and maximum outside air dampers, return air dampers and exhaust air dampers will modulate to the 100% outside air position. On a further rise in temperature, outside air dampers shall modulate to minimum position and the cooling coil control valve will be modulated open. On a drop in discharge temperature, the reverse sequence shall occur. The discharge control sequence shall maintain a constant temperature of 55°F. (adj.) in the cooling mode.
4. A mixed air low limit controller shall override the above discharge control sequence if the low limit sensor indicates a minimum mixed air temperature of 50°F (adj.).
5. An outside air sensor shall provide a signal to the DDC panel to modulate the mid range and maximum outside air dampers to closed position, the return air damper to its fully open position and the exhaust damper to its fully closed position whenever the outside air temperature rises above 70°F (adj.). At outside air temperature of 50°F (adj.) or lower, the cooling coil valve shall be shut.
6. Steam Heating Coil Sequencing

    a. The unit discharge temperature sensor shall modulate the preheat coil steam control valves to maintain the unit discharge setpoint as stated above.
    b. At no time shall the steam preheat coil and the cooling coil valves be open at the same time.

7. Provide a series of freeze protection thermostats in the entering air section of the cooling coils which shall stop the unit if the mixed temperature falls below 38°F (adj.). The sensor shall announce an alarm condition if the temperature falls below 42°F (adj.).
8. Smoke detectors in the supply and return air plenums and/or ducts shall be interlocked to subject fans only to shut down upon activation. Smoke detectors shall be furnished and wired to fire alarm by Electrical Contractor and mounted by HVAC. Provide smoke dampers and end switches and interlocking to close smoke control dampers in supply duct on smoke condition. Fans shall not be allowed to start until smoke control dampers are proven open. (Signal by Electrical Contractor, wiring by ATC Contractor).
9. When the supply fans stop (normal mode), the return fans shall stop, the outside air dampers and the exhaust air dampers shall close, the cooling and heating coils and humidifier shall be de-energized and the return air damper shall be open.
10. Humidifier Control: Refer to sequences below.
11. Air Volumetric Control
12. This portion of the specification includes the furnishing and installing of a complete air volume DDC control system, as herein described, for achieving air volume measurement for air handling unit supply and return air fans. The air volume control shall include all sensors for air volume, velocity and pressure as required. The supply air volume shall be controlled by varying the speed of fans through the associated VFDs. Where air handling units have multiple fans, the static pressure control signal shall be sent equally, but separately, to both fan VFDs.
13. The air volume control system shall be furnished and installed by the Contractor, except that the airflow measuring stations shall be installed by the Sheet Metal Contractor, but furnished, wired and controlled by the ATC Contractor who shall provide all control stations, selector relays, etc. Coordinate with the Sheet Metal Contractor. Mount station from floor. Duct mounted static pressure sensing stations (SPSS) shall be furnished by the ATC Contractor and installed from 2/3 to 3/4 of the way along the longest duct run for each unit, in the vertical duct riser. Provide access to the sensors.
14. It is the intent of this portion of the specification to provide for a fully synchronized control system between supply air volume and return air volume. The Contractor shall furnish, install and program software for fan volume control which shall include all arithmetic and logic functions required to maintain airflow conditions in accordance with job requirements.
15. The fan volume control components (variable speed drives) shall be equipped with operating features described herein and capable of performing the outlined performances. The direct digital control shall be capable of 3-mode control, proportional, integral, derivative. The velocity pressure sensors shall provide a signal to the DDC panel to provide for control functions, and shall be equal to the Setra #261 differential pressure transmitter.
16. The ATC Contractor shall provide all necessary fan volume control logic, programming, control devices and field labor for the complete installation and calibration, and shall be responsible to provide an operating sequence to the complete satisfaction of the Mechanical Engineer. In addition, the ATC Contractor shall guarantee the proper operation of the system and shall furnish all required service and maintenance from the local office to provide twelve (12) months, fully guaranteed

system. Factory trained engineers and installers shall be located within a 75 mile radius of the job site so that proper service may be performed on this project.

17. Upon start-up of the supply and return fans, the fan volume control program shall place the supply and return fan Variable Frequency Drives in the minimum speed mode and as the DDC panel receives its static pressure signal, the VFDs speed shall increase to maintain static pressure setpoint. As the supply air volume increases, the flow synchronizing DDC system receiving signals from the velocity pressure transmitters sensing both the supply air velocity and the return velocity via flow measuring stations and through square root functions shall provide a linear signal enabling the synchronizing DDC system to gradually speed up the return fan VFDs to deliver the desired return air volume in accordance with supply air volume. On a decrease in supply air static or volume, the reverse sequence shall occur. All required auxiliary devices shall be provided by the ATC Contractor. Each fan shall receive the same signal from the DDC system, except during fan start-up and when a fan is off. Each fan VFD shall receive a separate speed signal from the DDC system. All required auxiliary devices shall be provided by the ATC Contractor. Provide DDC panel face indication to indicate each unit's supply air volume and system static pressure.

    a. The ATC system shall continuously monitor the quantity of return air and supply air and the ATC system shall modulate the outside air dampers, exhaust air dampers and return air dampers to maintain the minimum outside air quantity at or above the scheduled minimums.

18. Furnish and install duct mounted static pressure sensors.
19. The BAS shall continuously monitor the airflow readings and motor amperage readings (via the VFD's) of each pair of supply fans within each AHU. If the difference in flow/amperage of the fans vary by 15% (adj.) or more, an alarm shall be annunciated at the BAS.
20. For additional sequences, refer to humidifiers.
21. All control sequences as listed above shall fully function in either the hand or automatic modes as selected at the VFD drive control panel. The Contractor will provide all required hardware, programming, wiring, relays, coordination, etc., to provide a complete fully functional system that operates automatically with no intervention beyond switching the drive mode switch at the VFD panel.
22. VFD bypass mode of operation, if VFD drives have bypass mode installed as an optional feature the Contractor will provide "detailed" instructions as how the system, controls, VFD drives (s) etc., must be manipulated to allow system to operate in a safe manner. Instructions shall be attached to each affected VFD drive, printed and laminated for operators use.
23. For each air handling unit equipped with dual (2) supply and dual (2) return fans, the ATC Contractor shall provide a "lock-out" so that upon a loss of normal power, as sensed at the generator automatic transfer switch by the DDC system, only (1) supply fan and (1) return fan will be allowed to run. Coordinate these requirements with the HVAC Contractor, the Electrical Contractor and the air handling unit manufacturer.

B. Boiler Room Heating and Ventilation Control (AHU-3) (100% Outdoor Air) (Variable Volume)

1. AHU-3 shall be started/stopped by the DDC panel.
2. When unit is called to run, the outside air and exhaust air dampers shall open and upon proof of dampers open (via end switches), AHU-3 supply fan shall start. A discharge air temperature sensor shall send its signal to the DDC panel. The DDC panel shall signal the heating coil 2-way steam control valve to open and shall modulate the coil internal face and bypass dampers to maintain an adjustable discharge air setpoint. When the outside air temperature is above 55°F (adj.), the steam heating valve shall remain closed.

    a. AHU-3 shall be a variable speed unit which shall be interlocked with boiler operation (boilers B-1 through B-4). When AHU-3 is called to run, it shall start at low speed (6500 CFM) to satisfy boiler room and chiller room space conditions. As boilers are energized AHU-3 shall be sequence to higher speeds upon the start of additional boilers as follows:

Boilers in Operation	AHU-3 Airflow (CFM)
1	9,200
2	12,400
3 (Future)	15,600

    Note: Should the chiller plant emergency purge sequence be activated, AHU-3 supply air flow shall be indexed to an additional 3,000 CFM. Maximum AHU-3 supply with 3 boilers operating and emergency refrigerant purge = 18,600 CFM. Refer to Paragraph 5.2W for Refrigerant Purge Sequence.
3. Provide a freeze protection thermostat in the discharge to stop AHU-3 if the discharge temperature falls below 38°F (adj.). The sensor shall announce an alarm condition if the temperature falls below 42°F (adj.).
4. Smoke detectors in the supply plenum and/or ductwork shall be interlocked to supply fan to shut down upon activation. Smoke detectors shall be furnished and wired to the fire alarm by the Electrical Contactor and mounted by HVAC.

C. Boiler Plant Control

1. The ATC Contractor shall mount and wire all control and alarm devices furnished by the boiler manufacturer/HVAC Contractor. Coordinate requirements with the HVAC Contractor. ATC to wire Burner Management System including steam flow meters, stack sensors, fixed water regulation including providing any tubing required.
2. The central plant boilers (B-1 & B-2; B-1 through B-4 Future) shall be interlocked with the boiler plant ventilation air handling units. Refer to AHU-3 control sequence for interlocking requirements.
3. The ATC Contractor, in conjunction with the HVAC Contractor shall provide an expanded annunciation / communication interfacing module to provide

communications between the building DDC automation system and the boiler control panels.

D. Central Chilled Water System

1. Chilled water system shall be instrumented in accordance with the point list.
2. The Contractor shall provide all interlock wiring to the individual chiller control panels provided by the chiller manufacturer to activate/deactivate chillers and provide fully rotatable, controllable lead/lag control, as hereinafter specified. All remote sensors, differential pressure switches and other control devices furnished as part of this control system shall be provided by the ATC Contractor.
3. The chiller control system shall be capable to provide all sequences for the chillers and their respective chilled water and condenser water pumps. The Contractor shall interlock each chiller and associated pumps to the control system.

    a. The chiller plant is a VSD plant with all chillers, chilled water pumps and cooling tower fans utilizing VSD's. condenser water pumps are constant speed.
    b. Initial Phase I construction provides one (1) chiller. Future hospital phases shall include two (2) additional chillers and associated pumps, cooling towers and sequencing controls.

4. Provide flow switches for the chilled water and condenser water pumps and interlock to the chiller and lead/lag panel to prevent chiller operation until both the chilled water and condenser water pumps are operating to provide flow through the individual chillers.
5. Provide all sensors, relays and other control devices necessary for a complete and workable chilled water system. Coordinate the entire chilled water control installation with the chiller manufacturer.
6. Chiller shall be controlled as follows:

    a. The chilled water pump of the lead chiller and the associated condenser water pump shall start via the DDC. When flow is established in both circuits by differential pressure switches, the chiller shall start. Pressure switches shall be installed across each chiller and wired to the local DDC and chiller control panel to provide proof of flow.
    b. The packaged chiller control system shall maintain supply water temperature of 42°F (adj.) which can be reset from the BAS.

7. Chiller and condenser system as specified below shall be controlled by a dedicated DDC controller. Control of any other systems on this DDC controller shall not be acceptable.

    a. The VSD chiller plant control system shall modulate (via the pump VSD's) the primary chilled water flow (gpm) and the water temperature entering the chiller in proportion to the chiller loading. The following table shall establish the base operating parameters for system operation. The actual valves shall

be coordinated with the chiller manufacturer based on the operational limits and part-load efficiency characteristics of the actual chillers provided.

		Chilled Water	
Chiller Loading (%)	Capacity (tons)	Lvg CHWT (°F)	Minimum Flow (GPM)
100	650	42	1000
90	585	42	880
80	520	42	780
75	485	42	730
70	455	42	685
67	435	42	655
66	430	42	650
50	325	42	650
40	260	42	650
30	195	42	650
20	130	42	650
15	100	42	650

8. The following information shall be displayed at the DDC without the requirement of manual data retrieval. Gauges, auto-scroll or portable operator station is acceptable. Display shall include but not be limited to:

    a. Chilled Water Supply Temperature
    b. Chilled Water Return Temperature
    c. Chilled Water Pump Status, Variable Frequency Drive Speed and Status (CHP- 1 & CHP-2) (CHP-2 & Standby)
    d. System CHS/CHR/CWS/CWR Temperatures
    e. Variable Frequency Drive Chiller Speed and Status

E. Condenser Water System

1. Provide a condenser water temperature sensor to control the variable speed drive of the cooling tower fan and the linked tower bypass butterfly valves in sequence, to maintain condenser water temperature.
2. On a rise in temperature, the valves shall modulate open to the full tower position. On a continued rise in temperature, the tower fan VFDs shall be indexed to minimum speed. On a further rise in temperature, the tower fan VFDs shall increase fan speed to maintain condenser water temperature.

    a. When outdoor ambient wet bulb temperatures are below 38°F (adj.), the tower basin heating system shall be energized to maintain basin water temperature. Basin heating system shall be interlocked with the cooling tower fans to prevent operation of the tower fans when the basin heating system is operating.

b. When basin water temperature falls below 38°F (adj.) the tower basin heaters shall be energized to maintain a 38°F minimum (adj.) basin water temperature.

1) Provide temperature sensors in the condenser water return piping and cooling tower basin reporting to the DDC panel.

3. On a drop in water temperature, the reverse sequence shall occur.

a. Vibration switches shall shut down the tower fans and signal an alarm.

4. Cooling tower fan and associated condenser water pump shall be interlocked to the chiller start/stop sequence, as hereinbefore specified.
5. The following information shall be displayed at the DDC:

a. Condenser Water Pump Status, (CWP- 1 & CWP-2) (CWP-2 = Standby))
b. Cooling Tower Fan Speed and Status
c. Condenser Water Piping Heat Trace Status
d. Condenser Water Supply Temperature (Tower Basin Sump)
e. Condenser Water Return Temperature

F. Exhaust Air Fans/Supply Air Fans

1. For exhaust and supply fans, as hereinafter specified, furnish for installation by the HVAC Contractor, automatic supply and/or discharge air dampers and interlock with fans to "open/close" when fans are "on/off". For fan designations and areas served by each fan, see schedule on drawings.
2. Legend

E	=	Electric
FCC	=	Fire Command Center
N	=	None
S	=	Start/Stop by DDC Panel
T	=	Start/Stop by ATC Thermostat
24	=	Continuous Operation - Manual Start/Stop
SW	=	Remote Switch
•	=	To Be Provided
BDD	=	Gravity Back Draft Damper (Furnished by HVAC Contractor)

3. Schedule

Unit Number	Service	Exhaust Damper	Supply/Intake Damper	Interlock	Remarks	Start/Stop	Status
SF-1	Penthouse Ventilation	---	E	EX-21	S	•	•
SF-2	Penthouse Ventilation	---	E	EX-21	S	•	•
EX-1	Toilet	BDD	N	---	S	•	•
EX-2	Lab	BDD	N	---	24	•	•

Unit Number	Service	Exhaust Damper	Supply/Intake Damper	Interlock	Remarks	Start/Stop	Status
EX-3	Isolation	E	E	---	24	•	•
EX-4	Isolation	E	E	EX-3	S	•	•
EX-5	Clean Room	BDD	N	---	24	•	•
EX-6	Infectious Waste	BDD	N	---	24	•	•
EX-7	Cartwash	E	N	Cartwash	S	•	•
EX-8	Sterilizer	E	N	---	24	•	•
EX-9	Body Holding	BDD	N	---	24	•	•
EX-10	Kitchen Hood	E	N	Kitchen Hood	SW	•	•
EX-11	Servery	E	N	---	S	•	•
EX-12	MRI Emergency Exhaust	E	N	MRI Quench	S	•	•
EX-13	Hazmat	BDD	N	---	24	•	•
EX-14	Lab	BDD	N	---	24	•	•
EX-15	Battery Storage	BDD	N	---	24	•	•
EX-16	Dishwasher	E	N	Dishwasher	SW	•	•
EX-17	Fire Pump Room	E	E	---	T	•	•
EX-18	Chiller Room Ventilation	BDD	N	AHU-3	S	•	•
EX-19	Boiler Room Ventilation	BDD	N	AHU-3	S	•	•
EX-20	Anesthesia Exhaust	BDD	N	---	24	•	•
EX-21	Penthouse Ventilation	E	N	---	T	•	•
EX-22	General	BDD	N	---	S	•	•
EX-23	Tank Storage	BDD	N	---	24	•	•
EX-24	Refrigerant Purge	E	E	Chiller Purge	S	•	•
RF-1A	AHU-1	E	N	AHU-1	S	•	•
RF-1B	AHU-1	E	N	AHU-1	S	•	•
RF-2A	AHU-2	E	N	AHU-2	S	•	•
RF-2B	AHU-2	E	N	AHU-2	S	•	•

4. All air flow switches, sensors, relays, dampers, etc., required to achieve the above sequence shall be provided by the ATC Contractor.

G. Differential Pressure Bypass Valve Arrangement ([1] Per Water System)

1. Provide a differential pressure sensor, reporting to the DDC panel and valve to maintain constant pressure differential between supply and return piping mains, to automatically bypass water and compensate for pressure fluctuations in the systems. Pressure sensor shall have sensing tips in the supply and return water lines. See plans for quantity.

    a. Central Chilled Water System (For backup use only upon full speed override of VFD): One (1) Valve
    b. Hot Water System (For backup use only upon full speed override of VFD): One (1) Valve
    c. Process Chilled Water System: One (1) Valve

H. Variable Speed Pumping Systems (VFD)

1. VFD's shall be furnished and installed by HVAC Contractor. ATC Contractor shall provide power to each VFD. The ATC Contractor shall provide all control wiring for each VFD.
2. Provide two (2) pair differential pressure sensors for each VFD controlled pumping system. The ATC Contractor shall furnish and the HVAC Contractor shall install all sensors.
3. The VFD shall vary the speed of the pump to maintain the differential pressure setpoint at the D.P. sensor in each of the two (2) major piping branches (control to maintain pressure at lowest of the pressure at the [2] sensors).
4. Each VFD controlled pumping system shall also have a differential pressure bypass assembly provided to operate only in the event of a VFD malfunction. When full speed VFD bypass is selected. All VFD's on pumps shall have automatic full speed bypass enabled whenever a fault is sensed in the VFD or the pump motor.

I. Constant Volume Box (Supply/Exhaust)

1. Space sensor will modulate and control the normally open 2-way heating coil valve to maintain desired space temperature. Air volume shall be constant.
2. The associated exhaust airflow control terminal shall track the supply box CFM, with CFM offset as noted on the drawings. Provide necessary software to allow single exhaust box to track multiple supply boxes.
3. The ATC Contractor shall coordinate with the terminal box manufacturer to obtain the proper velocity pressure signal multiplier for each box size, which shall be input into the DDC box controller for proper calibration of sensed vs. actual CFM airflow. Each box shall be field verified and adjusted such that "sensed flow" matches actual flow as measured by the Independent Testing & Balancing Contractor.

J. Constant Volume Box with Radiation/Radiant Panels

1. Sequence of Operation shall be as specified above for the CV box except on a continued drop in space temperature and after the reheat valve is modulated 80% open

the space thermostat shall modulate and control the radiation 2-way control valve to satisfy the room temperature.

2. When space temperature setting is satisfied, the reverse sequence shall occur.

K. Variable Volume/Constant Volume Box

1. Space DDC sensor shall modulate the box damper operator and heating 2-way normally open coil control valve in sequence to maintain space temperature.
2. On space temperature drop, box damper operator shall be modulated to a fixed minimum setting. On continued drop in space temperature heating coil valve will be modulated open.
3. As space temperature rises, the reverse sequence shall occur.
4. The associated exhaust airflow control terminal shall track the supply box CFM, with CFM offset as noted on the drawings. Refer to 2.12. Provide necessary software to allow single exhaust box to track multiple supply boxes.
5. The ATC Contractor shall coordinate with the terminal box manufacturer to obtain the proper velocity pressure signal multiplier for each box size, which shall be input into the DDC box controller for proper calibration of sensed vs. actual CFM airflow. Each box shall be field verified and adjusted such that "sensed flow" matches actual flow as measured by the Independent Testing & Balancing Contractor.

L. Variable Volume Box (Supply/Exhaust)

1. Space sensor shall modulate the box controls to open and close box to maintain setpoint. Specifically, as space temperature rises, box shall modulate from closed towards the fully open position. The reverse shall occur on a space temperature decreases.
2. Where indicated on the drawings, the associated exhaust airflow control terminal shall track the supply box CFM, with CFM offset as noted on the drawings. Refer to Section 2.12. Provide necessary software to allow single exhaust box to track multiple supply boxes, such as typical floor office areas.
3. The Contractor shall coordinate with the terminal box manufacturer to obtain the proper velocity pressure signal multiplier for each box size, which shall be input into the DDC box controller for proper calibration of sensed vs. actual CFM airflow. Each box shall be field verified and adjusted such that "sensed flow" matches actual flow as measured by the Independent Testing & Balancing Contractor.

M. Variable Volume/Constant Volume Box with Radiation/Radiant Panels

1. Sequence of operation shall be same as specified above for VCV box, except on continued drop in space temperature and after reheat valve is modulated 80% open, the radiation 2-way control valve shall be modulated open.
2. When space temperature setting is satisfied the reverse sequence shall occur.

N. Central VAV Return Air Unit/Box Serving Multiple VAV Supply Boxes

1. The VAV return box manufacturer shall provide an airflow control damper and an airflow measurement station array. The ATC Contractor shall provide a normally open electric actuator and a DDC unit controller.
2. The central VAV return air unit cfm shall control the total return air flowing through the flow measuring stations in direct proportion to supply air boxes in the same zone, less a numerical offset CFM to account for direct exhaust and pressurization requirements.
3. For each grouping of supply air terminals with (1) variable volume return box, the ATC Contractor shall furnish, install and program software to totalize the individual airflow for each grouping of supply air terminals. The installation shall be complete with field wiring, panels, software programming, and memory to obtain a CFM tracking between the supply and return terminals.
4. All devices required to read the CFM return volume (at the FMS) shall be by the ATC Contractor.

O. Heat Exchanger Control

1. The reheat and radiation systems share a common heat exchanger system which shall generate constant temperature (190° adj.) hot water year-round. Piping to the building is a year-round constant temperature loop which has VFD-driven pumps.
2. Heat Exchanger Hot Water Loop

    a. Provide temperature monitoring sensors at each heat exchanger hot water supply and return piping connection, reporting to the DDC panel. The common hot water supply and return piping temperatures shall be sensed. Hot water pumps shall be activated by the DDC system and shall run continuously.
    b. The DDC panel shall modulate the 1/3 and 2/3 capacity steam valves to maintain common hot water supply temperature of 190°F (adj.). 1/3 Valve shall be normally open, 2/3 valve shall be normally closed.
    c. When the hot water pump is off, the steam valves shall be closed.
    d. Provide start/stop and status for each pump from the DDC panel.
    e. Provide a lead/lag control sequence which shall be automatically activated upon shutdown of each pump.
    f. Provide a pressure sensor, reporting to the DDC panel and valve to control the VFDs to compensate for pressure fluctuations in the systems. Pressure sensor shall have sensing tips in the supply and return water lines.
    g. Heat exchanger pair (primary/standby) will need only one (1) pair of steam control valves. Systems employing more than two (2) heat exchangers shall include additional steam control valve stations with no more than two HEX per pair of steam control valves.
    h. Provide a flow switch to indicate flow through heat exchanger. Steam valves shall be closed unless flow is proven.

P. Radiation/Radiant Heating Panels (with no airflow box interlock)

1. Space thermostat will modulate the 2-way normally open control valve to maintain space temperature.
2. When radiant heating panels are employed with an air terminal unit/box, the sequence shall be similar to the radiation and box, as specified above.

Q. Cabinet Unit Heaters/Propeller Unit Heaters

1. At each hot water or steam unit heater, the ATC Contractor shall provide remote mounted thermostats and interlocking to modulate the 2-way steam or hot water normally open control valve and energize the fan to satisfy the room temperature setting. When heat is not available, the fan will remain off by reverse acting aquastat.
2. For electric unit heaters, the ATC Contractor shall furnish, install and wire the thermostat.

R. Engineered Smoke Management Systems

1. On-Floor/Smoke Partitions/Smoke Zones

a. Smoke management for the new building shall consist of floor smoke control dampers. All in duct smoke dampers shall be equipped with 120V electric actuators furnished and installed by the HVAC Contractor. The Electrical Contractor shall supply 120V emergency power to various locations on the floor as shown on the drawings. The Electrical Contractor shall supply a control module and a supervised relay for each smoke control zone, and wire these into the Fire Alarm intelligent loop.

b. Upon sensing a smoke condition via the fire alarm panel located at the Fire Command Center, all associated area supply smoke control dampers shall close to a preset adjustable minimum position (±10% open) and all associated return air terminal boxes or smoke control dampers shall fully open to cause a negative pressure in the alarm zone. The box dampers of the area of incident shall be positioned to provide a differential pressure of 0.05" w.g. with adjacent smoke zones. All other zones/floors will operate in the "normal" mode. Wiring shall be by the Contractor. In addition, the DDC supply air terminal boxes within each smoke zone in alarm shall be addressable via the DDC/BAS and shall be reset to predetermined CFM values (supply boxes ±10% open and return/exhaust boxes 75% open) to achieve the smoke control function and be repeated as many times as required during the building commissioning process to achieve satisfactory smoke control system operation.

c. Upon sensing smoke at the return air fan detector, the associated air handling units will be indexed to 100% outside air, 0% return air mode and 100% exhaust mode (smoke mode). Activation of an air handling unit return air duct smoke detector shall index the associated air handling unit to this mode. Prior to going to 100% outside air, through a hardwired two-position outside air thermostat, preheat steam valve shall open 100% if outside air is below 40°F.

d. The ATC Contractor shall wire from the on-floor supervised relay, to the 120V damper operator. The ATC Contractor shall be responsible for the 120V power wiring, between the subject dampers and the on-floor emergency power. Junction boxes provided by the Electrical Contractor. (Refer to Electrical drawings for junction box locations.) The DDC panel shall provide contact closures for output to the Fireman's Override Panel to indicate fan status (ON/OFF).

e. When any automatic device is activated, the FCC shall be programmed to send a signal to the control module(s) associated with the zone in alarm. This signal shall close the contacts on the control modules(s), pull in the supervised relay and put 120V on the smoke damper actuators, closing the dampers supplying air to the zone in alarm, and any adjacent zone.

S. In-Duct Hot Water Coils

1. Space sensor shall modulate 2-way normally open control valve to maintain space temperature.

T. Controllable Pressure Rooms (Infectious Isolation Rooms/Ante Room**;** Protective Isolation Rooms/Ante Room; Operating Rooms; Bronchosopy; Autopsy Rooms, Clean Room, Laboratories, etc.)

1. Provide alarm/monitoring wiring interface to remote annunciation via the BAS for the room pressurization pressure monitors provided by the Mechanical Contractor under Section 15856.

U. Fuel Oil Gauge and Alarm System

1. All interlocking wiring between tank gauge transducer systems to indoor gauge panel and alarm point shall be provided by the ATC Contractor.
2. The ATC Contractor shall mount and wire all components as furnished by the HVAC Contractor, including high and low level alarms and tank monitoring alarms and the fuel system package as supplied by the HVAC Contractor.
3. For additional work including all automatic control valves and leak alarm sensors, refer to fuel oil system specification Sections 15190 and fuel oil flow diagrams and the DDC Points Schedule.
4. All calibration shall be done by gauge system manufacturer and the ATC Contractor together.

V. Mechanical and Electric Room Heating and Ventilating

1. When space temperature rises above 85°F db (adj.), the outside air intake and exhaust dampers shall fully open. Upon proof that dampers have opened, the room supply and exhaust fans shall start. When room temperature falls below 83°F (adj.), fans shall stop and dampers fully close.
2. When room temperature falls below 55°F (adj.), the room unit heaters shall start to maintain room temperature.

W. Steam Humidifiers

1. Provide an electronic DDC humidistat and interlock to electric actuated/DDC controlled steam control valve so that the humidifier valve is modulated, as required, to maintain the desired relative humidity in the room, subject to the high limit action of the duct humidistat, which shall override the signal to the steam valve to assure duct relative humidity does not exceed 85% RH (adj.). When there is no flow, the flow switch provided by the ATC Contractor shall close the valve by spring action.

    a. A two-position (open/closed) control valve shall be provided in the LPS supply main serving the AHU humidifiers. This control valve shall serve to isolate the humidifiers from the steam supply during the summer months when additional humidification is deemed unnecessary as determined by the Owner.

2. The humidistat shall be a room/space mounted humidistat for all in-duct applications, while the humidistat shall be duct mounted for in-unit humidifiers.
3. Refer to the drawing schedules for quantities of humidifiers located in air handling units. Humidifiers shall be interlocked with associated fans so that when the fan is "off" (i.e, no airflow), the humidifier will be de-energized.
4. High limit humidistat (adjustable via the DDC system) shall be provided by the ATC Contractor to override and take control when high limit is exceeded.
5. The in-duct humidifiers shall be similar, with electronic actuators.

X. Chiller Plant Ventilation/Refrigerant Monitoring, Purge and Smoke Exhaust

1. Chiller plant ventilation AHU-3 and EX-18 shall run continuously.
2. If at any time the space refrigerant sensor/detector is activated, the emergency purge fan EX-24 shall be automatically indexed on, AHU-3 airflow shall increase by 3000 CFM and an alarm (audio-visual) shall be activated (one inside and one directly outside the chiller room). This alarm shall also be reported back to the BAS. Audio-visual alarms with silencing switches shall be furnished and installed by the ATC Contractor.
3. If at any time the space smoke detector(s) is activated, exhaust fan EX-24 shall be automatically indexed on to provide space smoke evacuation.
4. Provide refrigerant monitor system with at least two sensors located near chillers 12” above floor level. The ATC Contractor to provide the interlocking between sensors, BAS and purge fan EX-24. Control sequencing shall be as described above.
5. The ATC Contractor shall furnish, install and wire the refrigerant detection system.
6. The central refrigerant monitor system panel shall consist of the following:

    a. Fully electronic
    b. Simplicity of keypad programming
    c. Battery back-up
    d. Microprocessor based 7-day clock
    e. Capacity of (1) to (10) sensors
    f. Automatic fan start-up on power restoration
    g. Continuous monitoring of each point

h. Integrated test switch
i. Multiple panel capability
j. 2-stage control
k. (5) Refrigerant detectors
l. (5) Oxygen sensors

7. The following functions shall be field programmable for each refrigerant sensor or zone:

a. Sensor input to fan output activation.
b. Different delay time before activation (1-99 seconds).
c. Different adjustment levels.
d. Different adjustable delay time from 1st to 2nd stage.
e. Adjustable run time of fan (1-99 minutes).

8. The remote sensors shall be low voltage adjustable dual chamber transducers. They shall have (2) separate electronically matched sensors for added stability. The sensors shall be solid state rather than electrochemical. Each sensor shall have its own adjustable setpoint.

Y. Variable Speed Drives

1. For each VFD, provide the following through the DDC system:

a. Motor run feedback points to provide run status in both VFD and bypass mode.
b. Provide mode feedback (VFD and bypass mode).
c. Speed control output signal to VFD.
d. Feedback indicating speed (Hz) and amperage.
e. General alarm from VFD.
f. Start/stop output to VFD.

Z. Optimized Start-Up After Power Failure

1. The Contractor shall start systems and equipment in a staggered manner after a power failure such that systems and equipment do not start all at once and overload electrical service nor create an excess negative or positive pressure in the building. Provide a 5 second (adj.) delay between start-up of each system.
2. All equipment - any piece of equipment or system that is stopped for any reason other than loss of normal or emergency power must be alarmed and may only reset manually via the BAS. Power failure shall be as sensed by the undercurrent relays and normal/emergency power relays at the electrical automatic transfer switches.

AA. Infectious Isolation Exhaust System

1. The Infectious Isolation Exhaust System shall consist of two exhaust fans on the roof ([1] primary/[1] standby). The fans shall be controlled by a single VFD with

automatic switchover from one fan to the other upon sensing of a fan failure via fault sensed at motor or loss of signal from a duct mounted flow switch.

2. Each isolation fan shall be provided with an industrial grade very low leakage isolation damper equal to Ruskin RD-102 with end switches and electric actuators at the fan inlet and outlet ducts to isolate the fans. When a fan is off, its inlet and outlet isolation dampers shall be closed.

BB. Computer Room Units

1. The computer room units shall be equipped with self-contained controls provided by the unit manufacturer.
2. The ATC Contractor shall mount and wire all auxiliary controls furnished with the unit, (i.e., thermostat, humidistat, remote indicator panel). In addition, provide common alarm point from each unit to the BAS.

CC. Elevator Machine Room Control

1. Provide a temperature sensor into the DDC system to alarm space high or low temperature at the Graphic Central.
2. The DDC system shall modulate the variable volume supply air and hot water reheat coil in sequence to maintain a maximum space setpoint of 80°F (adj.).
3. Upon a drop in space temperature (below 60°F, adj.), the hot water reheat coil control valve shall be modulated open to maintain space temperature at 60°F (adj.).

DD. Central Kitchen Occupied/Unoccupied Ventilation

1. The ATC Contractor shall provide all interlocking, wiring and control logic required for the Central Kitchen occupied/unoccupied ventilation scheduling of the associated HVAC equipment.
2. Unoccupied Mode

Equipment Tag	On/Off	Airflow (CFM)
Supply Box - TBD	On-Low	TBD
Supply Box – TBD	On-Low	TBD
Return Box – TBD	On-Low	TBD
Exhaust Fan – TBD	On-Low (2 speed)	TBD
Supply Box – TBD	On-Low	TBD
Return Box – TBD	On	TBD
Exhaust Fan – TBD	On-Low (VFD)	TBD
Supply Box – TBD	On-Low	TBD
Supply Box – TBD	On	TBD
Exhaust Fan EF-TBD	On-Low (VFD)	TBD

Refer to Drawings TBD for location of air terminal boxes.

3. Occupied Mode

Equipment Tag	On/Off	Airflow (CFM)	Interlocking
Supply Box - TBD	On-High	TBD	TBD
Supply Box - TBD	On-High	TBD	TBD
Return Box – TBD	On-High	TBD	---
Exhaust Fan EF- TBD	On-High (2 speed)	TBD	Dishwasher
Supply Box – TBD	On-High	TBD	TBD
Return Box – TBD	On	TBD	---
Exhaust Fan EF- TBD	On-High (VFD)	TBD	Kitchen Hood
Supply Box – TBD	On-High	TBD	EF- TBD
Supply Box – TBD	On	TBD	TBD
Exhaust Fan EF- TBD	On-High (VFD)	TBD	Kitchen Hood

Refer to Drawings TBD for location of air terminal boxes.

4. The ATC Contractor shall coordinate occupied/unoccupied hours of operation (weekday/weekend/holiday) with Mercy Hospital.
5. Kitchen Hood Variable Volume Controls – Occupied Hours

   a. Kitchen hood exhaust fans EF-(TBD) are provided with VFD's. The kitchen hoods include variable volume exhaust hood controls (Refer to Paragraph TBD) to vary the hood exhaust air flow during occupied hours in direct relation to actual cooking operations and room thermostat setpoints.
   b. During cooking operations, the exhaust fan and associated supply terminal boxes shall be sequenced to the high speed/maximum airflow mode as indicated in the "occupied mode" table in Paragraph 17000 – TBD above.
   c. Each of the kitchen hood exhaust fan systems shall operate independently, with fan exhaust and associated supply terminal box airflows reduced during non-cooking occupied hours. Exhaust fan and associated terminal box airflows shall track in direct proportion to maintain the room air balance. Terminal box thermostats shall control the actual airflows between the maximum and minimum positions (supply boxes and exhaust fan) to maintain room setpoints.
   d. Occupied, non-cooking airflow range shall be as follows:

      1) Exhaust Fan EF- TBD system

Equipment	Maximum CFM	Minimum CFM
TBD	TBD	TBD

      2) Exhaust Fan EF- TBD System

Equipment	Maximum CFM	Minimum CFM
TBD	TBD	TBD

3) Exhaust Fan EF-TBD System

Equipment	Maximum CFM	Minimum CFM
TBD	TBD	TBD

6. Hood/Fan Maintenance

   a. When EF-TBD is manually turned off during occupied hours to facilitate dishwasher or fan maintenance, supply box TBD airflow shall be automatically sequenced down to TBD CFM and supply box TBD shall be sequenced to the unoccupied mode of TBD CFM.
   b. When EF-TBD is manually turned off during occupied hours to facilitate washdown of hoods or fan maintenance, air terminal boxes TBD shall be sequenced off and terminal box TBD airflow shall be sequenced down to TBD CFM.
   c. When EF-TBD is manually turned off during occupied hours to facilitate wash down of hoods or fan maintenance, air terminal boxes TBD shall be sequenced off.

EE. Process Chiller System

1. The process chilled water system shall be instrumented in accordance with the point list.
2. The Contractor shall provide all interlocking wiring to the individual chiller control panel provided by the chiller manufacturer to activate/deactivate chillers. All remote sensors, differential pressure switches and other control devices furnished as part of this control system shall be provided by the Contractor.
3. The chiller control system shall be capable to provide all sequences for their respective chilled water pumps and isolation valves. The Contractor shall interlock each chiller and pump to the control system.
4. Provide flow switches for the chilled water pump and interlock to the chiller to prevent chiller operation until the chilled water pumps are operating to provide flow through the individual chillers.
5. Provide all sensors, relays and other control devices necessary for a complete and workable chilled water system. Coordinate the entire chilled water control installation with the chiller manufacturer.
6. Chillers shall be controlled as follows:

   a. The process chilled water system shall start via the DDC.
   b. The packaged process chiller system shall maintain supply water temperature of 45°F (adj.) which can be reset from the DDC system.

      1) Sequence of Operation (Refer to Dwg. TBD for system flow diagram)
      2) Normal Mode

         a) Process chiller shall supply a continuous flow of minimum 45°F chilled water. Medical equipment chilled water control valves shall regulate actual flow through equipment. A

system pressure sensor shall modulate the differential pressure bypass valve as required to maintain flow thru the chiller.

3) Back-Up Mode

a) Control valves V-1, V-2 and V-3 shall be interlocked with chiller. In the event of chiller failure, valve V-1 shall close and valves V-2 and V-3 shall open. Non-potable "city water" shall flow through the medical equipment and be discharged to sanitary waste. "City Water" flow shall be proven via a water flow switch. ATC remote alarm indicating chiller failure and successful switchover to the "City Water" back-up mode shall be annunciated at the central computer.

7. Chiller system shall be controlled by a dedicated DDC(s). Control of other major systems on this DDC(s) shall not be acceptable. Provide chiller run/not run status input and chiller safety alarm input to the central DDC system. Provide demand limiting, chilled water reset and chiller enable/disable output signals from central DDC system to chiller controller.
8. The following information shall be permanently displayed at the DDC without the requirement of manual data retrieval. Gauges or auto-scroll are acceptable.

a. Chilled water supply temperature
b. Chilled water return temperature
c. Chilled water pump status
d. System CHS/CHR system temperature

FF. OR's & Cath Labs Occupied/Unoccupied Control

1. The ATC Contractor shall provide all interlocking, wiring and control logic for an integrated HVAC and lighting occupied/unoccupied control scheduling for each individual Operating Room and Cath Lab.
2. The ATC Contractor shall coordinate occupied/unoccupied hours of operation (weekday/weekend/holiday) for each OR and Cath Lab with Mercy Hospital. The user adjustable schedules shall additionally include override capability of the unoccupied mode via computer input and via in-room occupancy sensors (4 per room). Occupancy sensors shall be provided by the ATC Contractor.
3. Occupied Mode

a. The room 2-position supply and return terminal boxes shall be indexed to the 100% open ("high") position. Room thermostat and humidistat shall sequence reheat coil and humidifier to maintain setpoints.
b. ATC system shall provide digital signal to the individual room lighting control panel to initiate the occupied lighting mode. Lighting control panel/system shall be provided by the Electrical Contractor.

4. Unoccupied Mode

a. The room 2-position supply and return boxes shall be indexed to the "low" setpoint position. Room thermostat shall maintain temperature at 72°F (adj.).
b. ATC system shall provide digital signal to the room lighting control panel to initiate the unoccupied lighting mode.

GG. Snow Melting System

1. The snow melting system shall be energized manually on a seasonal basis. When energized, the DDC system shall provide snow melting pump SMP-1 start/stop and status and snow melting heat exchanger (HE-3) control. When the outdoor ambient temperature is below 40°F dB (adj.), the snow melting system shall run in a stand-by/idling mode to maintain the sidewalk surfaces at a minimum temperature of 32°F dB (adj.).
2. During the stand-by mode operation, the heat exchanger shall provide 120°F (adj.) supply hot water and pump shall be cycled on/off to maintain the surfaces at the 32°F (adj.) minimum. At periods of extreme cold, the system water temperature shall be adjusted, as needed, to a maximum of 160°F dB to maintain the surfaces at the 32°F minimum. Pump SMP-1 shall remain off at ambient temperatures above 40°F dB (adj.).
3. Provide weather sensing controls including snow/ice and moisture (SIM) sensors embedded in the sidewalks. The quantity and installed location of the temperature and SIM sensors shall be in accordance with the snow melting system manufacturer's recommendation.
4. When the ambient temperature is below 40°F dB (adj.) and upon sensing SIM surface snow or ice, the DDC system shall raise the sidewalks and ramp thermal mass temperature to 40°F (user adjustable between 35°F and 45°F). The system shall continue to operate until all presence of moisture is removed. System hot water supply temperature shall be modulated between 120°F and 160°F as needed to maintain the 40°F (adj.) thermal mass setpoint. Once moisture is no longer present, the snow melting system shall be returned to the stand-by mode.

HH. Chemical Treatment

1. Chemical treatment systems shall be provided by HVAC Contractor for all water systems. The ATC Contractor shall provide wiring between all components of the chemical treatment systems.

II. Normal/Emergency Power Monitoring System

1. Provide DI points to sense the transfer of building power from normal-to-emergency and emergency-to-normal, plus the loss of power and normal testing. Each automatic transfer switch requires three (3) digital inputs as follows:

a. DI Undercurrent relay

b. DI Loss of normal power
c. DI Loss of emergency power

JJ. MRI Emergency Exhaust Systems

1. Normal HVAC system operation for the MRI Rooms shall include the return of room air back to the Central Air Handling Unit.
2. Upon activation of the MRI cryogenic purge mode/failure signal from MRI controller or alarm annunciation from the room oxygen depletion monitor and signal via the DDC system, the MRI emergency exhaust mode shall be activated.
3. Upon activation of the emergency exhaust mode, the normally closed exhaust air damper shall open; the associated MRI exhaust fan shall start; and the normally open return air damper shall close.
4. The MRI purge event shall be annunciated both locally at the MRI Room and remotely via the DDC system.

END OF SECTION