SECTION 253000 - BUILDING AUTOMATION SYSTEM FIELD DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements, products, procedures, performance requirements, and methods of execution relating to the Building Automation System (BAS) terminal devices and field hardware.

2. Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.

B. Related Sections: Refer to Section 255000 - Building Automation System.

1.2 REFERENCES

A. Refer to Section 255000 - Building Automation System.

1.3 SYSTEM DESCRIPTION

A. Refer to Section 255000 - Building Automation System.

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 255000 - Building Automation System.

1.5 SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.6 CLOSEOUT SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.7 QUALITY ASSURANCE

A. Refer to Section 255000 - Building Automation System.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 255000 - Building Automation System.

1.9 SITE CONDITIONS

A. Refer to Section 255000 - Building Automation System.

1.10 WARRANTY

A. Refer to Section 255000 - Building Automation System.

PART 2 - PRODUCTS

2.1 TEMPERATURE SENSOR

A. Digital room sensors:

1. Temperature monitoring range: 55/95 degrees F.

2. Network jack.

3. Output signal: Changing resistance.

4. Accuracy at Calibration point: Plus or minus 0.5 degrees F.

5. Wall Mounted unit with finished cover:

a. Private offices and rooms:
1). LCD display, day/night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment.
2). Set Point and Display Range: 55 degrees to 95 degrees F.

b. Public Spaces: Blank Cover.

B. Liquid immersion temperature:

1. Temperature monitoring range: Minus 40/240 degrees F.

2. Output signal: Changing resistance.

3. Accuracy at Calibration point: Plus or minus 0.5 degree F.

4. Provide immersion sensor assembly as specified. Immersion sensors shall include a separate thermowell for sensor installation. Annular space between well and sensor shall be filled with heat conductive compound.

C. Duct (single point) temperature:

1. Temperature monitoring range: 20/120 degrees F.

2. Output signal: Changing resistance.

3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.

4. Sensing element shall be located a minimum of 25 percent across duct width.

D. Duct Average temperature:

1. Temperature monitoring range: 20/120 degrees F.

2. Output signal: 4-20 mA DC.

3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.

4. Sensor Probe Length: 25 feet.

E. Outside air temperature:

1. Temperature monitoring range: Minus 58/122 degrees F.

2. Output signal: 4-20 mA DC.

3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.

4. Provide NEMA3R rated mounting assembly (rain tight).

2.2 WALL MOUNTED SENSOR GUARD

A. Clear or opaque butyrate plastic guard, key lock, mounting plate.

2.3 ELECTRIC THERMOSTAT

A. Electric Room Thermostats: Low voltage, two position devices as indicated on the plans. Furnish standard manufacturing configurations of single or multi-stage as well as heating/cooling arrangements as required to provide an operable system. Thermostats shall be dual setpoint with deadband for heating and cooling.

B. Unit Heater Thermostat: Amperage capacity sufficient to cycle fan without need for contactor.

C. Remote Bulb Electric Thermostats: Precision snap acting, dust tight contacts; external adjustment by screwdriver slot or range adjusting knobs; operating temperature point in mid range of the instrument.

2.4 LOW TEMPERATURE DETECTION THERMOSTAT

A. Provide low temperature control thermostat, electric type manual reset, non-averaging 20 feet long sensing elements that switch whenever any 12-inch section or more of any portion senses a temperature as low as the thermostat setpoint as specified in sequences.

B. Provide with automatic reset with control system reset.

C. Provide with two sets of contacts, one for hardwired fan shutdown and one for remote monitoring.

2.5 HIGH AND LOW LIMIT THERMOSTATS

A. Provide electric, high or low limit thermostats as required by sequence of operation.

B. Freeze Protection Thermostats: Employ a 20 foot element. If any one foot section of the element is subjected to temperatures below 35 degrees F, the respective electric or pneumatic circuit opens, causing action to fans and dampers as required under the sequence of operations. Provide with automatic reset.

C. High Limit Thermostats (Fire Stats, etc.): Employ rod and tube type elements that extend approximately ten inches into the duct. If instrument is subjected to temperatures above 135 degrees F., action required by sequence of operation occurs.

2.6 DIGITAL STATUS POINTS

A. Digital status shall be monitored by sensing normally closed contacts (contact closed in alarm conditions). The addition of the monitoring relay shall not affect the operation of the systems involved.

2.7 DIGITAL COMMAND POINTS

A. Command relays shall be momentary, automatic, maintained, or magnetic latch fail/safe as required. Maintained contacts located in occupied spaces or plenum spaces shall be mechanically latched. Relays shall be plug in and field replaceable. Contact ratings shall be in accordance with service.

2.8 DIFFERENTIAL AIR STATIC PRESSURE SENSOR

A. Provide integral pressure transducer and transmitter in enclosure suitable for wall or panel mounting. 4-20ma output signal proportional to the input pressure span.

B. Transmitter range shall be selected so that the normal operating setpoint is midway between the upper and lower range of the transmitter. Transmitter range shall be bi-directional.

C. The following sensor locations with static pressure ranges are:

1. Supply duct static pressure: Plus or minus 2.0 inch W.C.

2. Filter bank static pressure drop: Plus or minus 1.5 inches W.C.

3. Air flow station: Varies based on manufacturer recommendations.

D. Temperature operating range: 32 to 122 degrees F.

E. Each transmitter shall have field adjustable span and zero adjustments for field calibration. Accuracy plus or minus 0.5 percent of full scale. Linearity plus or minus 0.1 percent.

2.9 EXTERIOR AIR STATIC PRESSURE REFERENCE HEAD

A. Provide parallel plate reference heads with mounting pipe, brackets, supports, and guys for complete installation.

B. Accuracy: Capable of sensing outside air pressure within 2 percent of actual value when subjected to radial wind velocities up to 40 mph with approach angles up to 30 degrees to the horizontal.

C. Provide a one-liter capacity volume chamber with restrictor between the exterior air static reference head and the pressure sensor.

2.10 ROOM PRESSURE MONITORS

A. Room Pressure Monitors shall be suitable for directly controlling supply and exhaust air to maintain a differential pressure setpoint relative to an adjacent room.

B. Provide a pressure sensor with the following features:

1. Through wall velocity sensor with integral algorithms to calculate temperature compensated differential pressure across wall with a range of minus 0.200 inch wg to plus 0.200, accurate to .0001 inch wg.

2. ANSI/UL 1479 listed for “Fire Tests of Through-Penetrations Firestops”.

C. Provide a monitor panel with following features:

1. Audible and visual alarm capability.

2. 24 VAC input power.

3. Keypad and display to program panel and display room pressure information.

4. The panel shall monitor room differential pressure to an adjacent room. The panel shall have the following points:

a. Zero to 10 V output suitable for controlling HVAC equipment.
b. Adjustable room pressure alarm contacts for high and low pressure.

D. Manufacturer: TSI Inc.

2.11 INTERIOR AIR STATIC PRESSURE PROBE

A. Provide shielded static air pressure probe with appurtenances for complete installation. Integral volume chamber, sensing ports engineered for quiet, steady operation.

B. Accuracy: Capable of sensing room air pressure within 1 percent of actual static pressure value.

2.12 DIFFERENTIAL FLUID PRESSURE SENSOR

A. Provide integral pressure transducer and transmitter with 4-20 mA output signal proportional to the input pressure span.

B. Provide NEMA 1 aluminum enclosure.

C. Transmitter range shall be selected so that the normal operating setpoint is midway between the upper and lower range of the transmitter. Transmitter range shall be unidirectional.

D. The range for the sensor serving the hydronic heating system is 0-10 psig.

E. Temperature operating range: Minus 40 to 175 degrees F.

F. Each transmitter shall have field adjustable span and zero adjustments for field calibration. Accuracy plus or minus 1.0 percent of full scale.

2.13 FLUID PRESSURE SENSOR

A. Provide integral pressure transducer and transmitter with 4-20 mA output signal proportional to the input pressure span.

B. Provide watertight enclosure.

C. Transmitter range shall be selected so that the normal operating setpoint is midway between the upper and lower range of the transmitter. Transmitter range shall be unidirectional.

D. The range for the sensor serving the hydronic heating system is 0-50 psig.

E. Temperature operating range: Minus 40 to 200 degrees F.

F. Each transmitter shall have field adjustable span and zero adjustments for field calibration. Accuracy plus or minus 1.0 percent of full scale.

2.14 AIRFLOW MEASURING STATION/DEVICE

A. One or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

B. Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors. The airflow rate of each sensor assembly shall be equally weighted and averaged

by the transmitter prior to output. Devices using less than two thermistors in each sensor assembly are not acceptable.

C. Devices using platinum wire RTDs are not acceptable.

D. Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.

E. Airflow accuracy shall be +/-2 percent of Reading over the entire operating airflow range.

F. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

G. Temperature accuracy shall be +/-0.15 degrees F over the entire operating temperature range of -20 degrees F to 160 degrees F.

H. The operating humidity range for each sensor probe shall be 0-99 percent RH (non-condensing).

I. Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter.

J. The number of sensor housings provided for each location shall be as follows:

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

K. Fan inlet sensors may be proposed where appropriate.

L. The transmitter shall communicate directly with the building automation system utilizing a LonWorks protocol.

M. Manufacturer: Ebron Gold Series or equal.

2.15 GAS DETECTION AND VENTILATION CONTROLS SYSTEM

A. Provide gas detection and ventilation control systems as scheduled on the drawings and specified herein.

B. Basis of Design: Toxalert, Model GVU-3 or GVU-6 as scheduled.

C. Sensors:

1. Carbon Monoxide (Gasoline Exhaust Engine):

a. Provide remote Carbon Monoxide (CO) sensors as located on the drawings. The remote CO sensor shall utilize a solid state sensing element, be microprocessor based and be both temperature and humidity compensated for long life and stability. Pilot lights or LED'S (light emitting diodes) shall indicate:
1). Unit normal operation/NOT in alarm.
2). High CO/unit in alarm.
3). Unit malfunction.

b. In the unit malfunction condition, the CO sensors output shall be fail-safe and indicate steady high CO condition. The CO sensor range shall be 0 to 250 parts per million (ppm) and shall be powered by low voltage from GVU control unit.

2. Nitrogen Dioxide (Diesel Engine Exhaust):

a. Provide Nitrogen Dioxide (NO2) sensors as located on the drawings. The remote sensor shall utilize an electrochemical element and have a range of 0-10 ppm. The sensor shall be housed in an impact-resistant, non-flammable, IP66 rated housing. The sensor response time shall reach 90% of level being sensed within 30 seconds. The sensor shall be powered by low voltage from the GVU control unit and have an LED to indicate sensor "OK".

D. System Controller:

1. The system controller shall continuously monitor its remote sensors. When an alarm condition is detected, the controller shall delay fan/damper contact closure for 30 seconds. If the high gas condition persists for more than 30 seconds, the fan/damper contacts shall close. The minimum contact closure time shall be field settable from one to eight minutes, in one minute increments. Should the alarm condition remain after the minimum run time has timed out, the contacts shall remain closed and a second "alarm" set of contacts shall close.

a. System controller shall interface with facility's BAS to implement ventilation equipment as specified elsewhere. See 25 9000 - Sequence of Operations.

2. The controller shall include separate internal LED's for each remote sensor to indicate which sensor is indicating a high gas condition. The controller shall be powered by 120VAC, 60Hz, 1Amp (fused) and provide all low voltage power to remote sensors. 24VAC, 2A resistive, 1.5 inductive auxiliary relay contacts shall be provided for remote control.

3. Provide the following control panel options:

a. Power "ON" indicator on face of controller to indicate power to system.
b. LED on face of panel to indicate high gas alarm condition. One for each sensor.
c. Fan/Damper "ON" indicator on face of controller to indicate fan/damper stage.

d. Audible and visual alarm with horn silence switch.
   1). Audible alarm with a minimum sound intensity of 68dB on the face of the control panel. Provide an "Audible Reset" push button switch to silence the audible alarm. Audible silence circuit shall be self resetting so that after alarm is cleared, the audible alarm with automatically resound on the next alarm activation.

e. Keyed panel lock.

2.16 CURRENT SENSOR

A. Provide current sensors that convert AC current to a proportional (4-20 mA) DC current.

B. Provide reverse voltage and high over current capacity.

C. Provide red LED light to indicated relay status and power.

D. Temperature operating range: 5 to 140 degrees F.

E. Provide UL Listed device.

2.17 CURRENT SENSING RELAY

A. Provide solid-state, self-calibrating, current operated relay suitable for equipment status monitoring. Provide a relay that changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.

B. Provide red LED light to indicated relay activation.

C. Temperature operating range: minus 30 to 140 degrees F.

D. Provide UL Listed device that is rated for plenum installation.

2.18 RELAYS

A. Applications: Relays external to the controls shall include (but not be limited to) the following:

1. Control relays for start/stop or open/close control of equipment.

2. Monitoring relays for electrical circuit on/off or open/closed status detection.

3. Interposing relays to provide interface between solid state circuitry and ac-driven control relays.

B. Requirements: Relays shall be housed in dust-tight cases conveniently located for wiring and inspection:

1. Control Relay: Control relays shall be suitable for continuous operation of 120 VAC and be able to interrupt the control circuits of various HVAC equipment. The number of

contacts required for the relay shall be determined from the number of independent equipment to be controlled. The number of control relays required for the motor start/stop circuit shall be determined from examination of the equipment to be controlled.

2. Monitoring Relay: Monitoring relays shall be suitable for continuous operation at the voltages of the circuits to be monitored. The monitoring relays shall be connected in such a way that the operation of the relay contact shall represent the change of status of the monitored circuit (i.e. ON/OFF, etc.) or duplicate the operation of the existing alarm circuit (i.e. high/low, etc.). The addition of the monitoring relay shall not affect the operation of the systems involved.

3. Interposing Relay: Interposing relays shall be DC driven and be utilized to provide interface between solid state circuitry and ac-driven control relays as required.

2.19 CONTROL VALVE

A. Control Valve: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Globe Valve 2 inch and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and sweat ends.

C. Globe Valve 2-1/2 inch and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

D. Hydronic system globe valve shall have the following characteristics:

1. Rating: ANSI Class 125 for service at 125 psig and 32/250 degrees F. operating conditions.

2. Internal Construction:

   a. Replaceable plugs and seats of stainless steel or brass.
   b. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
   c. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

3. Sizing: 3 psig maximum pressure drop at design flow rate.

4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.

5. Select heating valves shall fail to a Normally Open to heat position, unless otherwise indicated. Select cooling valves to normally closed to cooling position.

6. Three-way valves: Mixing type, unless otherwise indicated.

2.20 CONTROL DAMPER

A. Rectangular:

1. Frame: Five inches by one inch by minimum 0.125 inch 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.

2. Blades: Provide airfoil-shaped, single-piece blades made of heavy-duty 6063-T5 extruded aluminum. Maximum six inch blade width.

3. Bearings: Molded synthetic sleeve, turning in hole in frame.

4. Seals:

a. Blade: Extruded vinyl type for ultra-low leakage from minus 50 degrees F. to 350 degrees F. Mechanically attached to blade edge.
b. Jamb: Flexible metal compression type.

5. Linkage: Concealed in frame.

6. Axles: Minimum 1/2-inch diameter plated steel, hex-shaped, mechanically attached to blade.

7. Finish: Mill aluminum.

8. Performance Data:

a. Temperature Rating: Withstand minus 50 degrees F. to 350 degrees F.
b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions:
1). Closed Position: Maximum pressure of 13 inches W.C. at a 12-inch blade length.
2). Open Position: Maximum air velocity of 6,000 feet per minute.

c. Leakage: Maximum 2.0 cubic feet per minute per square foot at 1.0 W.C. for sizes 24 inches wide and above.
d. Pressure Drop: Maximum 0.03 inch W.C. at 1,500 feet per minute across 24 inch by 24 inch damper.

9. Manufacturer: Ruskin CD50, Louvers and Dampers, Air Balance, Pottorff, or equal.

B. Round:

1. Frame:

a. Under 6 inches Diameter: 2 inches by 1/2 inch minimum 12 gage galvanized steel tube.
b. 6 thru 12 inches Diameter: 2 inches by 1/2 inch by minimum 14 gage galvanized steel channel.
c. Above 12 thru 24 inches Diameter: 2 inches by 1/2 inch by minimum 1/8 inch galvanized steel channel.

d. Above 24 inches Diameter: 2 inches by 1 inch by minimum 3/16 inch galvanized steel channel.

2. Blade: Provide single-piece construction made of the following material:

a. 18 inches diameter and smaller: Minimum 12 gage galvanized steel.
b. Over 18 inches diameter: Minimum 10 gage galvanized steel, stiffeners as required.

3. Blade Seals: Closed cell polyethylene foam rubber fully encompassing and mechanically attached to blade edge.

4. Bearings: Self-lubricating stainless steel sleeve.

5. Axles:

a. 22 inches Diameter and smaller: Minimum 1/2 inch diameter, full length, plated steel, mechanically attached to blade.
b. Over 22 inches Diameter: Minimum 3/4 inch diameter, full length, plated steel, mechanically attached to blade.

6. Finish: Mill.

7. Performance Data.

a. Temperature Rating: Withstand maximum 250 degrees F.
b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
1). Closed Position: Maximum pressure of 10 inches W.C.
2). Open Position: Maximum air velocity of 4,000 feet per minute /min.

c. Leakage: Maximum 10 cubic feet per minute total at 1 inch W.C.
d. Pressure Drop: Maximum 0.05 inch W.C. at air volume of 7,000 cubic feet per minute through 24 inch diameter damper.

8. Manufacturer: Ruskin CDR25, Louvers and Dampers, Air Balance, Pottorff, or equal.

2.21 VALVE AND DAMPER ACTUATORS

A. General:

1. Provide electronic direct-coupled actuation for control valves and dampers.

2. Proportional actuators shall accept a 0-10 VDC or 0-20 mA control input and provide a 2-10 VDC or 4-20 mA operating range. Damper actuators and control valve actuators serving valves larger than 3/4” shall provide a 2-10 VDC position feedback signal. The feedback signal shall be independent of the input signal.

3. Actuators indicated by Normally Closed or Normally Open designation on drawings or in sequence of operation shall be spring return type.

4. The actuator shall have electronic overload circuitry to prevent damage to the actuator.

5. Provide actuators listed by Underwriters Laboratories Standard 873 Standard for Safety Temperature-Indicating and -Regulating Equipment.

B. Damper Actuator:

1. Provide damper actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage.

2. Spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.

3. 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 inch-pounds torque capacity shall have a manual crank for this purpose.

4. Provide actuators in sufficient size, quantity and type to match application. Provide a minimum of one damper actuator for each 24 square feet of damper area. Damper areas shall not exceed manufacturer's ratings.

5. Outside air and return air dampers on mixing boxes shall be linked such that one opens while the other closes. It shall not be possible to close both dampers simultaneously.

6. Dampers: Size for minimum running torque calculated as follows:

   a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
   b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
   c. Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. of damper.
   d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
   e. Dampers with 2 to 3 Inches W.C. of Pressure Drop or Face Velocities of 1000 to 2500 FPM: Multiply the minimum full-stroke cycles above by 1.5.
   f. Dampers with 3 to 4 Inches W.C. of Pressure Drop or Face Velocities of 2500 to 3000 FPM: Multiply the minimum full-stroke cycles above by 2.0.
   g. Values noted above do not include normally open or normally closed open spring return dampers. Provide additional torque as required.

7. Size operators with ample power to overcome friction of damper linkage and air pressure acting on the damper blades.

C. Valve Actuator:

1. Provide actuators with enough torque and force required for proper valve close-off against the system pressure.

2. The valve actuator shall be sized based on valve manufacturer's recommendations for flow and pressure differential.

2.22 INSTRUMENT ENCLOSURE

A. Steel construction with hinged and lockable doors.

B. NEMA 12 construction only in areas where panels are subject to moisture damage.

C. Wiring connections including I/O and power shall be extended to a numbered, color-coded, and labeled terminal strip for ease of maintenance and expansion.

D. Provide labeling and color coding for wiring. Wiring shall follow a common format typical for the entire facility. Terminal strip color coding and numbering shall follow a common format. Wiring shall be neatly installed in plastic trays or tie-wrapped.

E. Line voltage wiring shall be segregated from I/O wiring and shall be UL listed, 300-volt service and provide adequate clearance for field wiring.

F. Provide a convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers. Provide convenience receptacle for enclosures containing equipment that can be configured or adjusted with a portable computer.

2.23 POWER SUPPLY

A. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75 percent of the rated capacity of the power supply.

B. Input: 120 VAC plus 10 percent, 60Hz.

C. Output: 24 VDC.

D. Line Regulation: Plus 0.05 percent for 10 percent line change.

E. Load Regulation: Plus 0.05 percent for 50 percent load change.

F. Provide an appropriately sized fuse and fuse block shall be provided and located next to the power supply.

G. Provide a power disconnect switch shall be provided next to the power supply.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques:

1. Wiring:

a. The HVAC Control Contractor shall provide conduit, wiring, accessories, and wiring connections required for the installation of the control system, as herein specified, unless specifically shown in Divisions 26, 27 and 28.

b. Conduit and wiring shall comply with the requirements of applicable portions of Divisions 26, 27 and 28 and local and national electric codes, unless specified otherwise in this section.
c. System input wiring shall be twisted shielded pair, minimum 20 gauge wire. System analog output wiring shall be twisted shielded pair/3-wire as required, minimum 20 gauge wire. Preconfigured cables between Terminal Unit Controllers and Thermostats are acceptable, minimum 24 gauge.
d. Internal panel device wiring for binary outputs and pilot relay shall be minimum 16 gauge wire.
e. Provide separate conduit for control system power wiring including but not limited to 120 VAC and greater. I/O sensor wiring and data communication cabling shall be segregated from 120 VAC control system power wiring.
f. Wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size 3/4 inch. One half inch conduit may be used for thermostats and valve stub-ups where conduit contains only a single pair.

2. Temperature Sensors:

a. Temperature sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.
b. Outdoor installations shall be of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.
c. Wall Mounted Sensor and Thermostats:
   1). Install adjustable wall mounted room sensors at a height of 48 inches above finish floor level.
   2). Locate sensors as shown on the Drawings.
   3). Provide insulated base for sensors mounted on sheet metal, steel columns or exterior walls. Wire penetrations shall be caulked airtight to prevent thermal convection.
   4). Provide heavy-duty guards for sensors and thermostats in public areas and as shown on the Drawings.

d. Fluid Temperature Sensor: The sensor shall have a separable well suitable for insertion in a pipeline or vessel. Cable connections shall be suitable for the highest temperature expected and low temperature sensors shall be sealed to exclude condensation of atmospheric moisture.
e. Duct Temperature Sensor: The sensor shall measure the representative temperature of the entire cross-section of the duct or plenum. Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces. Ductwork shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.
f. Mixed Air Temperature Sensors: The sensor shall be of the averaging type. Mount sensors with consideration for stratification of warm and cold air streams. Minimum binding radius for averaging sensors is four inches. Provide a minimum of one foot of averaging sensor element for each square foot of ductwork. Sensing element shall be installed such that it crosses completely through stratified airflow with complete passes. Partial passes are not allowed. If averaging sensor is not available provide one sensor for every four square feet of duct cross section area.

g. Fluid Temperature Sensors: Provide sensors with thermal wells fabricated and installed for the intended service. Wells shall be non-corrosive to the medium being measured and shall have sufficient physical strength to withstand all pressures, (including test pressures) and velocities to which they are subjected. Well shall not restrict flow area to less than 70 percent of line-size-pipe normal flow area. Where piping is smaller than the length of the well or exceeds the area requirements, the well shall be installed at an elbow and installed to effect uniform flow across the well. Sensors installed in wells shall be installed in horizontal piping below the pipe centerline.
h. Low Temperature Detection Thermostats: Mount sensor element similar to Mixed Air Temperature Sensors.

3. Exterior Air Static Pressure Reference Head:

   a. Provide outside static reference heads and locate as shown on the Drawings.
   b. Mount reference heads above roof line and in accordance with manufacturer recommendations.

4. Interior Air Static Pressure Probe:

   a. Provide interior static pressure probes.
   b. Provide surface mount in mechanical spaces. Provide recessed mount in finished spaces.

5. Differential Fluid Pressure Sensor:

   a. Locate sensors as shown on the Drawings. Mount in accessible location.
   b. Controls subcontractor to furnish differential pressure sensor snubbers. Installation of snubbers by plumbing subcontractor.

6. Fluid Pressure Sensor:

   a. Locate sensors as shown on the Drawings. Mount in accessible location.
   b. Controls subcontractor to furnish fluid pressure sensor snubbers. Installation of snubbers by plumbing subcontractor.

7. Carbon Dioxide Sensors: Locate sensors as shown on the Drawings.

8. Current Sensors:

   a. Provide flow proof for constant volume fans and pumps with a current sensor connected to the motor wiring at the starter. Set upper alarm limit to the maximum rated current of the motor, or as advised by the TAB Agency. Set lower alarm limit at 1/2 the motor running amps.
   b. Provide flow proof for variable speed control system through utilization of the variable speed drive serial communication option. Drive will communicate directly with BAS system.

9. Digital Status, Digital Command Points, Lighting Controls:

a. Provide relays in a separate instrument enclosure or control panel adjacent to the monitored or controlled equipment. The relays shall mounted and connected in a manner that does not violate controlled equipment listing or code requirements.
b. Provide relays that operate in conjunction with the motor control system. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
c. Coordinate motor control requirements with Divisions 26, 27 and 28.
d. Coordinate lighting control requirements with Divisions 26, 27 and 28.

10. Identification:

a. Panel and Instrument Enclosure Identification: Panels and instrument enclosures shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.
b. Field Devices: Field devices shall be identified by a typed (not handwritten) securely attached tag label.
c. Panel or Instrument Enclosure Devices: Devices shall be identified by a typed label securely fastened to the backplane of the local control panel or instrument enclosure.
d. Wall Mounted Temperature Sensors: Device covers shall be identified by a typed label securely fastened to the front cover. The label shall indicate the terminal unit zone identification tag.
e. Raceway Identification: The covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating “Control System” affixed to the covers. This requirement includes control system tubing. Labels shall be typed, not hand written.
f. Wire Identification: Low and line voltage control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.

3.2 SYSTEM STARTUP

A. Commissioning: Perform tests and verification procedures required for the commissioning process as requested by the Owner and directed by the Owner's Commissioning Authority.

3.3 MAINTENANCE

A. Arrange work so that wherever possible serviceable or operable products are located within mechanical or electrical spaces and are accessible.

END OF SECTION 253000

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SECTION 254000 - VARIABLE SPEED DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. This section provides specification requirements for solid-state, pulse-width modulated (PWM) Adjustable Frequency Drives, herein referred to as AC Drives, for use with NEMA design AC motors. The term "VSD" (Variable Speed Drive) is also used in this specification.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200513 - Common Motor Requirements
4. 200553 - Mechanical Identification
5. 230593 - Testing, Adjusting and Balancing
6. 232123 - Hydronic Pumps
7. 233400 - HVAC Fans
8. 236400 - Packaged Water Chillers
9. 237323 - Central Air Handling Units
10. 253000 - Building Automation System Field Devices
11. 255000 - Building Automation System
12. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards:

1. ANSI/NFPA 70 - National Electrical Code (NEC).
2. Institute of Electrical and Electronic Engineers (IEEE): Standard 519, IEEE Guide for Harmonic Content and Control.
3. UL 508 - UL Standard for Safety Industrial Control Equipment.
4. UL 508C - UL Standard for Safety Power Conversion Equipment.

5. NEMA ICS 7.1 - AC Adjustable Speed Drive Systems.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.

2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.

3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements: This section describes specific requirements, products and methods of execution for variable speed drives.

B. Performance Requirements:

1. Provide product performance characteristics as specified or scheduled on drawings.

2. Operate variable speed drives in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

A. Coordinate installation of variable speed drives with trades responsible for portions of this and any other related sections of the Project Manual prior to installation of any components.

1.5 SUBMITTALS

A. Product Submittals: Submittals shall include the following information:

1. Outline dimensions, conduit entry locations and weight.

2. Customer connection and power wiring diagrams.

3. Complete technical product description including a complete list of options provided.

4. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).

a. The VSD manufacturer shall provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 5 percent.
b. Input line filters shall be sized and provided as required by the VSD manufacturer to ensure compliance with IEEE standard 519. VSDs shall include a minimum of 3 percent impedance reactors, no exceptions.

B. Quality Assurance:

1. Submit startup reports.

2. Submit syllabus of training for review and approval.

C. O&M Manuals:

1. Submit Operation and Maintenance Manuals to include all information necessary for the operation and maintenance of the system.

2. Furnish a minimum two complete sets to owner, or more as otherwise noted in Division 1.

1.6 QUALITY ASSURANCE

A. The manufacturer of the AC Drive shall be a certified ISO 9001 facility.

B. The AC Drive and associated optional equipment shall be UL Listed according to UL 508 C - Power Conversion Equipment. As verification, a UL label shall be attached on the inside of the combination enclosure. A UL508A panel builders label does not meet specification.

C. The AC Drive shall be designed, constructed and tested in accordance with UL, CSA, NEMA, and NEC standards.

D. Every power converter shall be tested with an AC induction motor while loaded and temperature cycled within an environment chamber at 40 degrees C (104 degrees F).

E. VSDs and options shall be UL listed as a complete assembly. VSDs that require the customer to supply external fuses for the VSD to be UL listed are not acceptable. The base VSD shall be UL listed for 100 KAIC without the need for input fuses.

F. The AC Drive supplier shall furnish, field test, adjust and certify installed AC Drives for satisfactory operation.

G. Any exceptions/deviations to this specification shall be indicated in writing and included with the submittal.

H. Acceptable Manufacturers:

1. Approval of manufacturer does not relieve supplier of specification requirements.

2. VSDs that are manufactured by a third party and “brand labeled” shall not be acceptable.

3. The drive manufacturer shall have an existing:

a. Sales representative exclusively for HVAC/Pumping products, with expertise in HVAC/Pumping systems and controls.
b. An independent service organization.

4. Factory trained application engineering and service personnel that are thoroughly familiar with the VSD products offered shall be locally available at the specifying location.

5. Service availability: The supplier shall have a fully equipped service organization capable of guaranteeing response time within 48 hours of service calls to service VSD.

6. There shall be 24/365 support available via a toll free phone number.

1.7 TRAINING

A. Provide two hours of Owner operator training on operation and service diagnostics at the time of the equipment commissioning.

B. Training shall be conducted by the manufacturer's start-up and commissioning agents.

C. Training shall utilize Operation and Maintenance Manuals submitted and approved for this specific project.

D. Coordinate with the Contracting Agency to schedule training sessions with Owner's personnel.

E. Submit training syllabus that describes topics to be addressed.

1.8 WARRANTY

A. Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include parts, labor, travel time and expenses.

PART 2 - PRODUCTS

2.1 BASIS OF DESIGN

A. The VSD Basis of Design is equipment from Square D by Schneider Electric to set a standard for quality. Equipment from ABB or alternative systems will be considered providing that sufficient documentation is provided to satisfy the Contracting Agency that the equipment meets the requirements of the specification.

B. VSDs shall be Square D E-Flex enclosed drive controllers or approved equal.

2.2 GENERAL DESCRIPTION

A. The AC Drive shall convert the input AC mains power to an adjustable frequency and voltage.

B. The input power section shall utilize a full wave bridge design incorporating diode rectifiers. The diode rectifiers shall convert fixed voltage and frequency, AC line power to fixed DC voltage.

C. The output power section shall change fixed DC voltage to adjustable frequency AC voltage.

D. The adjustable frequency drive package shall consist of a circuit breaker disconnect, line reactor, EMI/RFI filter, 120V control transformer, control circuit terminal board for digital and analog field wiring. The base VSD shall be UL listed for 100 KAIC without the need for input fuses.

E. The drive door shall have mounted and wired, Hand-Off-Auto switch, Manual Speed Potentiometer and AFC-Off switch.

F. The entire drive package shall be UL508C listed and coordinated with NEMA ICS 7.1. A UL508A panel builders label does not meet specification.

2.3 CONSTRUCTION

A. The AC Drive power converter shall be enclosed in a NEMA Type 12 enclosure with a circuit breaker disconnect, and user terminal strip connections. The enclosure shall provide dedicated user terminals for power and control device connection.

B. Include provisions to lock the disconnect in the OFF position with a padlock.

C. Enclosure and heat sink fans shall be accessible from the front and shall not require the removal of the AC drive power converter for fan replacement.

2.4 APPLICATION DATA

A. The AC Drive shall be sized to operate a variable torque load.

B. The speed range shall be from a minimum speed of 1.0 Hz to a maximum speed of 72 Hz.

2.5 ENVIRONMENTAL RATINGS

A. The AC Drive shall meet IEC 60664-1 Annex A and NEMA ICS 1, UL, and CSA standards.

B. The AC Drive shall be designed to operate in an ambient temperature from -10 to 40 degrees C (14 to 104 degrees F).

C. The storage temperature range shall be -25 to 65 degrees C (-13 to 149 degrees F).

D. The maximum relative humidity shall be 95 percent, non-condensing.

E. The AC Drive shall be rated to operate at altitudes less than or equal to 3300 feet (1000 meters). For altitudes above 3300 feet (1000 meters), the AC Drive shall be de-rated per drive specifications.

F. The AC Drive shall meet the IEC 60721-3-3-3M3 operational vibration specification.

G. The AC Drive shall be Seismic Qualified to 2000 IBC Level 3 “Extreme” rating with an Importance Factor I_p=1.5.

2.6 RATINGS

A. The AC Drive shall be designed to operate at the input line voltage indicated on the equipment schedule.

B. The AC Drive shall operate from an input frequency range of 60 Hz (±) 5 percent.

C. The displacement power factor shall not be less than 0.98 lagging under any speed or load condition.

D. The efficiency of the AC Drive at 100 percent speed and load shall not be less than 97 percent.

E. The variable torque rated AC Drive over current capacity shall be not less than 110 percent for 1 minute.

F. The output carrier frequency of the AC Drive shall be programmable at 0.5, 1, 2, 4 or 8 kHz. In addition, the output carrier frequency shall be randomly modulated about the selected frequency.

2.7 PROTECTION

A. Upon power-up, the AC Drive shall automatically test for valid operation of memory, loss of analog reference input, loss of communication, DC-to-DC power supply, control power and pre-charge circuit.

B. The enclosure shall provide a fully coordinated 100,000 AIC current rating marked on the enclosure nameplate. Short circuit coordination to UL 508C Power Conversion Equipment and NEMA ICS 7.1.

C. The AC Drive shall be protected against short circuits, between output phases and to ground.

D. The AC Drive shall have a minimum AC under-voltage power loss ride-through of 200 milliseconds (12 cycles).

E. The AC drive shall have a programmable ride-through function, which shall allow the logic to maintain control for a minimum of one-second (60 cycles) without faulting.

F. For a fault condition other than a ground fault, short circuit or internal fault, an auto restart function will provide up to 6 programmable restart attempts. The time delay before restart attempts will be 30 seconds.

G. Upon loss of the analog process follower reference signal, the AC Drive shall be programmable to display a fault.

H. The AC Drive shall have a solid-state UL 508C listed overload protective device and meet IEC 60947.

I. The output frequency shall be software enabled to fold back when the motor is overloaded.

J. There shall be three skip frequency ranges that can be programmed to a bandwidth of ±2.5Hz.

2.8 ADJUSTMENTS & CONFIGURATIONS

A. The AC Drive will be factory programmed to operate specified optional devices.

B. The acceleration and deceleration ramp times shall be adjustable from 0.05 to 999.9 seconds.

C. The memory shall retain and record run status and fault type of the past eight faults.

D. The software shall have an energy economy function that, when selected, reduces the voltage to the motor when selected for variable torque loads. A constant volts/Hz ratio shall be maintained during acceleration. The output voltage shall then automatically adjust to meet the torque requirement of the load. Selectable volts/Hz ratio patterns do not meet specification; the function shall be automatically optimized.

2.9 KEYPAD DISPLAY INTERFACE

A. A keypad display interface shall offer the modification of AC Drive adjustments through a touch keypad. Electrical values, configuration parameters, I/O assignments, application and activity function access, faults, local control, and adjustment storage, and diagnostics shall be accessible.

B. The AC Drive model number, torque type, software revision number, horsepower, output current, motor frequency and motor voltage shall be listed on the drive identification portion of the LCD display.

C. The keypad display shall have a hardware selector switch that allows the keypad to be locked out from unauthorized personnel.

2.10 OPERATOR CONTROLS

A. The control power for the digital inputs and outputs shall be 24VDC.

B. The internal power supply shall incorporate automatic current fold-back that protects the internal power supply if incorrectly connected or shorted. The transistor logic outputs shall be current limited and shall not be damaged if shorted.

C. Pull-apart terminal strips shall be used on logic and analog signal connections in the power converter.

D. Two voltage-free relay output contacts shall be provided. One of the contacts shall indicate AC Drive fault status. The other contact shall indicate a drive run status.

E. The combination enclosure shall have the following dedicated operator controls:

1. Hand-Off-Auto switch.

2. Manual Speed Potentiometer.

3. AFC-Off switch.

F. The combination enclosure shall include terminal point connection for fire/freeze state interlock, to prevent drive operation. The interlock shall shut down the motor in the drive mode.

2.11 SERIAL COMMUNICATION

A. The AC Drive shall have BACnet communications capability. The BACnet communications card shall provide data communications with a host computer or other device via the existing BACnet network. Data exchanges shall give access to all drive functions:

1. Control: Start, stop, reset, and setpoint.

2. Monitoring: Status, current, voltage, thermal state, etc.

3. Diagnostics: Alarms.

B. The graphic display terminal or the integrated display terminal shall be used to access functions for communication configuration and diagnostics.

2.12 HARMONIC MITIGATION

A. Each drive shall include a minimum 3 percent line reactor mounted inside the drive enclosure to reduce power system harmonics and provide power quality protection for the drive. DC bus chokes do not meet specification and shall not be substituted.

B. EMI / RFI filters: VSDs shall include EMI/RFI filters. The onboard filters shall allow the VSD assemble to be CE Marked and the VSD shall meet product standard EN 61800-3 for the First Environment restricted level.

C. VSDs through 50HP shall be protected from input and output power mis-wiring. The VSD shall sense this condition and display an alarm on the keypad.

D. Additional Features: Furnished and mounted by the drive manufacturer. Additional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label:

1. A manual bypass system is not desired or required.

2. Provide a door interlocked, padlockable circuit breaker that will disconnect input power from the drive and internally mounted options.

3. Provide a fused disconnect (service switch).

4. The drive shall provide single-phase motor protection.

5. The following operators shall be provided:

   a. Hand-Off-Auto.
   b. Drive mode selector.

6. The following indicating lights (LED type) shall be provided. A test mode or push to test feature shall be provided:

a. Power-on (Ready).
b. Run enable (safeties) open.
c. Drive mode select damper opening.
d. Drive running.
e. Drive fault.
f. Safety open.
g. Damper opening.
h. Damper end-switch made.

7. The digital inputs for the system shall accept 24V or 115VAC (selectable).

8. Customer Interlock Terminal Strip: provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. External safety interlocks shall remain fully functional whether the system is in Hand or Auto modes.

9. The VSD shall include a "run permissive circuit" that will provide a normally open contact whenever a run command is provided (local or remote start command in VSD mode). The VSD system shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch. When the VSD system safety interlock (fire detector, freezestat, high static pressure switch, etc.) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.

10. Class 20 or 30 (selectable) electronic motor overload protection shall be included.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection: Cover drives to protect components from construction dirt and debris.

3.2 INSTALLATION

A. Verify that the location is ready to receive work and the dimensions are as indicated.

B. Do not install VSD until the building environment can be maintained within the service conditions required by the manufacturer. Before and during the installation, the VSD equipment shall be protected from site contaminants.

C. Details of the installation shall comply with the manufacturer's applicable instructions.

D. Minimize the length of conductors between the drive and the motor to avoid motor damage from reflected wave phenomenon.

E. Where the field conditions dictate long lengths of conductors between the VSD and motor, provide necessary measures to protect motors from reflected wave phenomenon. Measures may include coordination with the motor manufacturers to provide higher insulation voltage ratings, protection devices such as output reactors or special terminators, or BJT inverter output.

F. Mounting of VSD shall be suitable for seismic anchorage and/or restraints as required by International Building Code.

G. VSDs shall be furnished under Divisions 20, 21, 22, 23, 25 and installed under Divisions 26, 27 and 28. The contractor shall install the drive in accordance with the recommendations of the VSD manufacturer as outlined in the installation manual.

H. Power wiring shall be provided under Divisions 26, 27 and 28. The contractor shall complete wiring in accordance with the recommendations of the VSD manufacturer, as outlined in the installation manual.

3.3 CONTROL WIRING

A. Control wiring and control devices shall be provided under the specification section in which the controlled equipment is specified. Coordinate related work.

B. Control wiring shall be routed completely separately from power wiring.

3.4 NAMEPLATES

A. Provide a nameplate for each VSD in accordance with Section 200553 Mechanical Identification. Coordinate names with mechanical equipment lists.

3.5 FIELD QUALITY CONTROL

A. Start up: Certified factory startup shall be provided for each drive by a factory authorized service center. A certified startup form shall be filled out for each drive with copies submitted and included in the O&M Manuals, and a copy kept on file by the manufacturer.

B. Training: Onsite training shall be provided as part of the startup service. The training shall include installation, programming, and operation of the VSD and serial communication.

END OF SECTION 254000

SECTION 255000 - BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: This section describes requirements, products, and methods of execution relating to the building automation controls system for the project.

B. Related Sections: Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 230593 - Testing, Adjusting and Balancing
4. 232123 - HVAC Pumps
5. 233400 - HVAC Fans
6. 233600 - Air Terminal Units
7. 235223 - Cast Iron Boilers and Accessories
8. 236400 - Packaged Water Chillers
9. 237323 - Central Air Handling Units
10. 238123 - Dedicated Air-Conditioning Units
11. 238200 - Terminal Heating and Cooling Units
12. 238316 - Radiant Floor Heating Equipment
13. 253000 - Building Automation System Field Devices
14. 254000 - Variable Speed Drives
15. 259000 - Sequence of Operations
16. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards. Perform work in accordance with applicable national, state and local codes to include:

1. NFPA 70, National Electrical Code - NEC.

2. ANSI-C2, National Electrical Safety Code - NESC.

3. Underwriters Laboratory (UL) or approved equal.

4. Institute of Electrical and Electronics Engineers - IEEE.

5. National Electrical Manufacturers' Association - NEMA.

B. Abbreviations and Acronyms:

1. Building Automation System (BAS).

2. Direct Digital Control (DDC).

C. Definitions:

1. ASHRAE: The American Society of Heating, Refrigerating and Air-Conditioning Engineers.

2. BACnet: A Data Communication Protocol for Building Automation and Control Networks, ANSI/ASHRAE Standard 135-current edition, developed under the auspices of ASHRAE.

3. Bridge: A device that routes messages or isolates message traffic to a particular segment, sub-net or domain of the same physical communication media.

4. Building Automation System (BAS): Collection of sensors, operators, controllers, and interconnecting wiring that control the operation of the building mechanical and electrical systems as described in these specifications.

5. Field device or field control device: A physical component such as a temperature sensor, pressure sensor, contact, motor operated valve, and motor operated damper. Generally considered to bring only one point to a controller.

6. Gateway: A hardware/software package that allows communication between dissimilar ("foreign") systems and different protocols. Gateways are typically custom built, configured, and used only for transmitting and receiving data between different systems. System programming through gateways is not possible within the scope of this definition.

7. Operator workstation: The central personal computer for the user to implement day to day operation of the system.

8. Router: A device for connecting different local-area network segments within a network. Routers that are used between networks with different protocols are limited. Point mapping

in this type of router is automatic and requires less than one hour to configure. This device is not capable of storing point map information.

9. TCP/IP (Transmission Control Protocol/Internet Protocol): The communication language or protocol that defines the Internet. TCP/IP can also be used as a communication protocol in private networks.

10. Terminal Unit Controller: A device to control very specific applications such as a VAV box, cabinet unit heater, fan terminal unit and the like. These units may have predefined operating sequences with limited custom programming available. (Also called an "application specific controller").

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. The HVAC Control System will consist of a flat, open architecture based upon BACNet meeting the requirement of ANSI/EIA 709.1 and ASHRAE Standard 135. Provide necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.

2. The system shall operate as a low-voltage multiplexed data system. The controls and instrumentation specified herein shall be integrated and installed as a complete package by the Contractor.

3. The completed system shall be integrated such that graphics, reports, and system interfaces from the Operator's workstation appears as if there is one system.

4. No BAS system components requiring the use of gateways will be accepted.

5. To provide future flexibility, router domains shall not exceed nominally 75 percent of the maximum number of devices in the domain, unless specified otherwise.

B. Performance Requirements:

1. This section specifies the requirements for the BAS to be installed in conjunction with this project.

2. Controls contractor shall furnish and install an integrated building automation system, incorporating DDC for energy management, equipment monitoring and control, and subsystems as herein specified. Controls contractor will complete the temperature control system as specified herein.

3. Materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. Systems and components shall have been thoroughly tested and proven in actual use for at least two years.

4. Controls contractor shall be responsible for BAS and temperature control wiring for a complete and operable system. Wiring shall be done in accordance with Divisions 26, 27 and 28 of this specification and local and national codes.

5. Control and monitoring for mechanical systems installed under this Contract, including:

    a. Building ventilation systems.
    b. Building heating systems.
    c. Boiler monitoring.
    d. Chiller monitoring.
    e. Domestic hot water circulation systems.
    f. Domestic water heater monitoring.
    g. Fuel oil system monitoring.

6. The Work under this Section includes furnishing and installing wiring, conduit, connectors, terminal strips, and any other equipment required to interface each sensor or control point to the control system.

7. Provide control system and subsystem network cabling, routers, and other devices required for the systems shown and specified, except as specifically noted or shown on the drawings.

8. Providing sequences of operation described in Section 259000 - Sequence of Operations.

9. Installation of control instrumentation and hardware specified in Section 253000 - Building Automation System Field Devices, necessary for a complete system of controls.

10. Commissioning support activities as required in 019100 - Commissioning, including requirements in development of commissioning checklists, phased commissioning, trend data gathering, installation examination and performance test activities, training and IO&M requirements.

11. System functional requirements include, but are not limited to:

    a. BAS system shall provide all normal and off-normal control functionality without reliance upon PC file server or workstation.
    b. Programming information, graphics, databases, and other information required to restore the entire system in the event of equipment failure or malfunction, or human error shall be protected with a centralized back-up system.
    c. Systems shall be designed to maximize multiple-vendor flexibility to replace or modify any portion of the system.

12. Software upgrades for PC and control network operating systems, the supervisory system, web browser, programming/binding tools, etc., without limitation shall be provided at no additional charge for a period of one year after Substantial Completion of the BAS.

13. A training program shall be provided to include: Data acquisition and report generation on the Operator's workstation.

14. The cost of providing power from the building electrical system shall be included in the bid. Power sources are subject to submittal requirements, and review and approval.

1.4 PREINSTALLATION MEETINGS

A. Coordinate installation of the building automation system with trades responsible for portions of this and any other related sections of the Project Manual prior to installation of any components.

1.5 SUBMITTALS

A. Refer to Section 200000 - Mechanical General Requirements for general submittal requirements.

B. Product Data:

1. Provide manufacturer's literature that demonstrates compliance with the manufacturing methods, appurtenances and salient features specified.

2. Equipment tagging method specifically listing each device and the identification tag to be applied.

3. Sequence of Operations.

4. Riser Diagrams.

5. Control Diagrams.

6. Panel layouts.

7. Valve and Damper schedules.

8. Point Summary Report.

9. Blank (Reserved for Enhanced Alarm Report).

10. Blank (Reserved for Commented PPCL).

11. Blank (Reserved for Trend Logs).

12. Blank (Reserve for Electronic Plans Room file).

C. Shop Drawings:

1. Riser Diagrams.

2. Control Diagrams.

3. Panel layouts.

4. Valve and Damper schedules.

D. Quality Control Submittals:

1. Pre-functional Installation (PC) and Functional Performance Test (FT) Checklists in accordance with Section 019100 - Commissioning.

2. Incorporate BAS control requirements into the applicable equipment PC/FT checklists, including Graphic User Interface (GUI) features (provide submittal showing screen shots).

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data. The O&M Manuals will consist of the following (Progression from Submittal to O&M Manual takes place using the same binders):

1. Sequence of Operations.

2. Riser Diagrams.

3. Control Diagrams.

4. Panel layouts.

5. Valve and Damper schedules.

6. Point Summary Report.

7. Enhanced Alarm Report.

8. Commented PPCL (Program Code).

9. Trend Logs.

10. Product Data including items reused from existing control system as noted.

11. Electronic Plans Room file.

B. Warranty Documentation.

C. Record Documentation.

1.7 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturers: Companies specializing in manufacturing the products specified in this section with a minimum of three years' documented experience.

2. Installers: Minimum three years' experience in the installation, programming and start-up of building automaton systems.

3. Testing Agencies: Regulatory requirements for products requiring electrical connection – Listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the SOA.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:

1. Verify equipment and associated appurtenances are delivered in original factory packaging/crating and are free from damage and corrosion.

2. Replace equipment delivered to job site that does not comply with above requirements at no expense to the Owner.

B. Storage and Handling Requirements:

1. Store products in covered storage area, protected from the elements, outside the general construction area until installed.

2. Handle items carefully to avoid breaking, chipping, denting, scratching, or other damage.

3. Replace damaged items with same item in new condition.

1.9 WARRANTY

A. Manufacturer Warranty:

1. Provide in accordance with Section 200000 - General Mechanical Requirements.

2. Provide maximum 4 hour response time to service/warranty calls from the Owner during the warranty period.

B. Special Warranty:

1. The warranty shall consist of a commitment by controls contractor to provide, at no cost to the Owner, parts and labor as required to repair or replace such parts of the control system that prove inoperative due to defective materials or installation practices.

2. The warranty expressly excludes routine service such as instrument calibration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Distech Controls.

B. Siemens Building Technology (SBT).

C. Johnson Controls.

2.2 APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:

1. Application Specific Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.

2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.

3. The ASC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.

4. ASC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement.

B. ASC Interface Software:

1. General: ASC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of ASC shall not be required for configuration.

2. ASC shall provide a selection of control applications performable through configuration of the device. Download of new application should not be required for one of these applications.

C. ASC Device Software:

1. General: An ASC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.

2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage network communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.

2.3 APPLICATION GENERIC CONTROLLER (AGC)

A. General Requirements:

1. Application Generic Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.

2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.

3. The AGC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.

4. AGC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. Network and power wiring shall allow for 'pass-thru' of signal when electronic boards are removed.

B. AGC Interface Software:

1. General: AGC shall be configured, not programmed, via PC based interface software. This software shall be a program applet that runs within the network management tool chosen. Intimate knowledge of operation of AGC shall not be required for configuration.

2. AGC shall provide a selection of control applications performable through configuration of the device. Download of new applications from network management tool shall be possible, but not required.

2.4 CUSTOM APPLICATION CONTROLLER (CAC)

A. General Requirements:

1. Custom Application Controllers shall be equipped with a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.

2. Operating system software, custom operating sequence software and application programs shall be stored in programmable, non-volatile memory.

3. CAC unit may be equipped with a dedicated software clock battery. If included, the battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a two-week period. Include an integral calendar with automatic leap year compensation.

4. CAC packaging shall be such that complete installation and checkout of field wiring can be performed prior to the installation of electronic boards. Make board terminations by means of plug-in connectors to facilitate troubleshooting, repair and replacement. The complete CAC including accessory devices such as relay, transducers, power supplies, etc. shall be factory-mounted, wired and housed in a NEMA 1 enclosure or as required by the location and local code requirements.

5. Equip CAC's with diagnostic indicators for the following:

a. Transmit.
b. Receive.

c. Power up test.
d. Power up fail.
e. Power up test okay.
f. Bus error.

B. CAC Software:

1. General: A CAC shall operate in standalone mode as needed for specified control applications if network communication fails. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.

2. Operating system software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage CAC to OI communications, and scan inputs and outputs. The operating system shall also contain built in diagnostics.

3. Input/Output Point Processing Software shall include:

   a. Continuous update of input and output values and conditions. Connected points are to be updated at a minimum of one-second intervals.
   b. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32 bit floating point format. Both the maximum and minimum values sensed for each analog input are to be retained in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.
   c. A reasonability check on analog inputs against the previously read value and discard those values falling outside pre-programmed reasonability limits.
   d. Assignment of proper engineering units and status condition identifiers to analog and digital input and outputs.
   e. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and actual alarm) to an input or to assign a set of floating limits (alarm follows a reset schedule or control point) to the input. Each alarm shall be assigned a unique differential to prevent a point from oscillating into and out of alarm. Alarm comparisons shall be made each scan cycle.
   f. Debounce of digital inputs to prevent nuisance alarms. Debounce timing shall be adjustable from two seconds to two minutes in one second increments.

4. Alarm lockouts:

   a. Alarm lockout software shall be provided to prevent nuisance alarms. On initial start-up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period is to be programmable on a per point basis from 0 to 90 minutes in one minute increments.
   b. A “hard lockout” shall also be provided to positively lock out alarms when equipment is turned off or when true alarm is dependent on the condition of an associated point. Hard lockout points and lockout initiators are to be operator programmable.

c. Design the power supply to accommodate the power requirements of all components (or nodes) connected, plus 50 percent.

5. Run Time Totalization or Point Trending:

a. Run time shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Run time counts shall be resident in non-volatile memory and have CAC resident run time limits assignable through the operator's terminal.
b. Totalized run time or trended data shall be batch downloaded using FTP to the SS on a daily or weekly basis. Trended data shall reside on the SS database server. The automatic update of this data shall be determined by the SS and facility management application requirements.

6. Transition Counting:

a. A transition counter shall be provided to accumulate the number of times a device has been cycled on or off.
b. Counter is to be non-volatile and be capable of accumulating 600,000 switching cycles.
c. Limits shall be assignable to counts to provide maintenance alarm printouts.

7. Custom Direct Digital Control (DDC) Loops:

a. Custom DDC programs are to be provided to meet the control strategies as called for in the sequence of operation sections of these specifications.
b. Each CAC shall have residential in its memory and available to the programs a full library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences:
   1). Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning): The adaptive control algorithm shall be used on control loops, as indicated in I/O summary, where the controlled medium flow rate is variable (such as VAV units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that on system shutdown and restart, the learning process starts from where it left off and not from ground zero. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.
   2). DDC setpoints, gains and time constants associated with DDC programs shall be available to the operator for display and modification via the SS operator interface.
   3). The execution interval of each DDC loop shall be adjustable from 2 to 120 seconds in one-second increments.
   4). DDC control programs shall include an assignment of initialization values to outputs to assure that controlled devices assume a fail-safe position on initial system start-up.

2.5 VAV CONTROLLERS

A. Provide manufacturer's thermostat matched to controller. Refer to Section 253000 - Building Automation System Field Devices, for requirements.

B. Coordinate with Section 233600 - Air Terminal Units to have VAV controllers factory mounted on the VAV terminal unit.

2.6 ROUTERS, BRIDGES, REPEATERS AND TRANSCEIVERS

A. Routers, Bridges and Repeaters:

1. Equip each router and bridge with a network transceiver on each network port (inbound and outbound) as dictated by the network type (Type 1 - FTT, Type 2 - TP, Type 3 - PL, Type 4 - LP, Type 5 - RF).

2. The network router shall be designed to route messages from a segment, sub-net, or domain in full duplex communication mode.

3. Routers with TCP/IP capability shall be provided where TCP/IP backbone is used.

4. Routers, bridges and repeaters shall be fully programmable and permit a systems integrator to define message traffic, destination, and other network management functions.

5. The routers, bridges, and repeaters shall be capable of DIN rail or panel mounting and be equipped with status LED lights for Network traffic and power.

B. Transceivers:

1. Type 1 Network Transceiver, Free Topology, Twisted Pair: Provide a transformer isolated, twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:

   a. Differential Manchester encoded signaling for polarity insensitive network wiring.
   b. Transformer isolated for common mode rejection.
   c. 78 Kbps network bit rate up to distances of 2000m.
   d. Free topology supports star, home run, multi drop and loop wiring topologies.
   e. Complies with FCC and VDE requirements.
   f. UL recognized component.

2. Type 2 Network Transceiver, Twisted Pair: Provide a transformer isolated twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:

   a. Differential Manchester encoded signaling for polarity insensitive network wiring.
   b. Transformer isolation for common mode rejection.
   c. 1.25 Mbps network bit rate up to distances of 1000 meters.
   d. Unpotted construction.
   e. Less than 1 mA power consumption with +5VDC input voltage.
   f. FCC and VDE Level B requirements compliance.

g. UL Listed.

3. Type 3 Network Transceiver, Power Line:

   a. Provide a direct sequence, spread spectrum power line transceiver which is equipped with the following signal processing and error correction capabilities to provide robust and error free communications.
      1). Forward Error Correction (FEC) to enable the system to read and reconstruct corrupted packets without sacrificing throughput. The FEC shall require only six percent overhead for error correction.
      2). Automatic sensitivity adjustment algorithm that dynamically changes the receiver sensitivity based on noise characteristics.
      3). Oversampling correlation filter and adaptive data recovery algorithm to synchronize instantaneously to incoming packets.
      4). Tri-state power amplifier/filter combination to provide a powerful output signal with a minimum number of components.

   b. The transceiver shall be able to operate using the controller power supply and coupling circuit. Provide the following general features as a minimum:
      1). Packaged in a rugged, potted module.
      2). Programmable clock output (1.25, 2.5, 5 or 10 Mhz).
      3). 10 Kbps network transmission rate.
      4). Packet detect output to drive a status indicator LED.
      5). Minus 20 to plus 85 degrees C. operating temperature range.
      6). UL Listed.

4. Type 4 Network Transceiver, Link Power: Provide a twisted pair transceiver that utilizes the twisted pair communication media to provide power for Controller(s). The transceiver shall meet the following specifications:

   a. Free single-in-line package (SIP) construction.
   b. Send both network data and power on a twisted wire pair.
   c. Differential Manchester encoded signaling for polarity insensitive network wiring.
   d. 78 Kbps network bit rate up to distances of 320 meters.
   e. Supports star, home run, multidrop, and loop wiring.
   f. Supplies +5VDC @ 100 mA maximum for node power.
   g. Compliance with FCC and VDE requirements.
   h. UL Listed.

5. Type 5 Network Transceiver, Radio Frequency: Provide a direct sequence, spread spectrum RF transceiver that meets the following specifications:

   a. 100 meter open field range.
   b. Wireless communications extends network between buildings and to vehicles and portable devices.
   c. FCC type certifiable, 48 MHz.
   d. Low-cost miniature circuit board, SMT components.
   e. Carrier detect output to drive a status indicator LED.
   f. Plus 7 to plus 15VDC input voltage.
   g. Minus 20 to plus 60 degrees C. operating temperature range.

2.7 OPERATOR WORKSTATION

A. Laptop computer for the user to implement day to day operation of the system. The laptop is generally capable of allowing the operator to accomplish the following functions:

1. Operate in a network environment.
2. Monitor the entire control system.
3. Change set points.
4. Maintain, set, and monitor alarms.
5. Maintain and monitor operating schedules.
6. Control interactively using graphical representations of the system.
7. Manually command points.
8. Trend the behavior of selected points.
9. Archive history.
10. Backup data.
11. Print results.
12. Modify custom programs and sequences of operation.

2.8 LAPTOP COMPUTER (OPERATOR WORKSTATION) HARDWARE

A. A new graphical laptop computer (operator workstation) shall be provided as specified in this section. The new workstation shall communicate directly with the existing controls database server. Communication shall take place over the Owner's existing Wide Area Network. Programming, graphics and databases created as part of this project shall be incorporated into the existing controls system. Provide a complete, secure backup of the host database at the completion of this project.

B. Provide one graphical laptop computer for command entry, information management, network alarm management and database management functions. The laptop shall communicate seamlessly with the existing controls system.

1. Provide one workstation of equal or greater capability, with the ability to connect to the network in each mechanical space in the building.
2. Workstation shall consist of a laptop computer with minimum 16GB RAM, 15" screen, hard drive with minimum 1 TB available space and wireless mouse. Laptop computer shall be Windows compatible.

2.9 WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description:

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

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

2. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device and “point and click” approach to menu selection.

3. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information.

4. Operator specific password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall “follow” the operator to any workstation logged onto (up to 999 user accounts shall be supported).

5. Scheduling and Override: Provide a calendar type format for simplification of time-of-day scheduling and overrides of building operations. Schedules reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection or function key.

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

B. Dynamic Color Graphic Displays:

1. Create at least one color graphic display for each piece of mechanical equipment, including air handling units, hot water boiler systems, and room level terminal units. Provide floor plans to facilitate navigation. Point information to be displayed on the graphics shall be provided by the BAS contractor to optimize system performance and analysis and to speed alarm recognition.

2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of submittal AutoCAD drawings and scanned pictures for use in the system.

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

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

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

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

C. System Configuration and Definition:

1. Network wide control strategies shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.

2. Provide automatic backup and restore of DDC controller databases on the workstation hard disk. In addition, database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

D. Alarm Management:

1. Alarm Routing shall allow the user to send alarm notification to selected PC locations based on time of day, alarm severity, or point type.

2. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.

3. Alarm messages shall be customizable for each point to display detailed instructions to the user regarding actions to take in the event of an alarm.

2.10 NETWORKING COMMUNICATIONS

A. The design of the BAS shall network an operator workstation(s) and stand-alone DDC Controllers. The network architecture shall consist of three levels; a Management Level Network (MLN) Ethernet network based on TCP/IP protocol, a high performance peer-to-peer building level network (BLN) and DDC Controller floor level local area networks (FLN). Access to the system shall be totally transparent to the user when accessing data or developing control programs.

B. Management Level Network:

1. PCs shall simultaneously direct connect to the Ethernet and Management Level Network without the use of an interposing device.

2. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.

3. Simultaneous user access to network limited to number of sight licenses issued to user.

4. When appropriate, any DDC controller residing on the peer-to-peer building level network shall connect to Ethernet network without the use of a PC.

5. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet as well as directly connected building level networks. Any PC shall be able to interrogate any controller on the building level network in addition to being able to download program changes to individual controllers.

6. The Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.

7. Access to the system database shall be available from any client workstation on the Management Level Network.

C. Peer-to-Peer Building Level Network (BLN):

1. The system shall have the ability to support integration of third party systems (fire alarm, security, lighting, variable speed drives, PLCs, condensers, boilers) via a panel mounted open protocol processor. This processor shall exchange data between the two systems for inter-process control. Exchange points shall have full system functionality as specified herein.

2. Data transfer via Ethernet.

D. Floor Level Network (FLN):

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

2.11 CONTROL PANELS

A. Terminal Equipment Controllers will be mounted in enclosed control panels with screwed, removable covers.

B. Control devices located in exposed areas subject to outside weather conditions or near circulator pumps (spray due to shaft seal failures) shall be mounted inside weatherproof enclosures. Location of each panel shall be convenient for adjustment service.

C. Nameplates shall be provided beneath each panel face mounted control device describing the function of each device. Nameplates shall have white letters engraved on blue Lamicoid, or approved equal.

D. Control panels shall bear a UL label compatible with the application.

E. Electrical devices within the panel shall be pre-wired to terminal strips, with inter-device wiring within the panel completed prior to installation of the system.

F. BLN level controllers shall be provided with standby/emergency power to provide power quality and minimum 15 minutes operation.

2.12 UNINTERRUPTIBLE POWER SUPPLY

A. Acceptable manufactures are limited to the following:

1. Powerware.

2. Alternate Brand Request or Substitution Request required.

2.13 ACCESS PANELS

A. Access panels provided by Division 08.

B. Coordinate access panel location with the Owner's Representative and Division 08. Provide access to concealed control devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques:

1. Mount damper operators and other control devices secured to insulated ductwork on brackets such that the device is external of the insulation. See Section 200529 - Hangers and Supports.

2. Do not install control devices in locations where they are subject to damage or malfunction due to normally encountered ambient temperatures.

3. Identification: Permanently tag controllers, switches, relays, thermostats and actuators for identification using the tagging format shown on the BAS control drawings.

4. Sensors and Switches:

   a. Pump flow or fan flow, etc., shall be sensed using current switch unless indicated otherwise. Calibrate current switch to distinguish between loaded or unloaded motor condition due to belt or coupler breakage.
   b. Protect averaging or capillary tubes where they penetrate duct with rubber grommet and seal with clear silicon. Support with capillary clips and maintain minimum 1 inch tubing bending radius.

5. Wiring:

   a. Install, connect and wire the items included under this Section. This work includes providing required conduit, wire, fittings, and related wiring accessories. Install wiring in exposed or inaccessible areas in EMT conduit. Plenum-rated cable may be used in concealed, accessible areas only.
   b. Provide wiring between thermostats and unit heater motors, and control and alarm wiring.
   c. Provide conduit and wiring between the BAS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit or plenum-rated cable.
   d. Provide conduit and control wiring for devices specified in this Section.
   e. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BAS panels located in the vicinity of motor control centers.
   f. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contactors, and BAS panels, as shown on the drawings or as specified.
   g. Wiring shall be compliant with the Divisions 26, 27 and 28 requirements and the NEC.
   h. Provide electrical wall boxes and conduit sleeves for wall-mounted devices. Mount thermostats at 48 inches AFF unless otherwise noted.

B. Interface with Other Work:

1. The Contractor is responsible to furnish and install complete and operational systems. The following breakdown is recommend; carefully coordinate work between subcontractors.

2. Products furnished by BAS contractor for installation by the mechanical contractor:

   a. Control valves.
   b. VAV box controllers.
   c. Wells for hydronic temperature sensors.

3. Products furnished and installed by mechanical contractor:

   a. VAV boxes: BAS contractor shall furnish VAV box controls to the VAV box manufacturer for factory installation at the expense of the box manufacturer.
   b. VAV box controller enclosures will be provided by box manufacturer.

c. Gauges, thermometers and thread-o-lets for BAS contractor furnished control sensor wells.
d. Airflow measuring stations.
e. Control and balancing dampers.
f. Smoke and fire/smoke dampers actuators.

4. Electrical contractor (Div. 26, 27, 28) provides:

a. Wiring of power feeds through disconnect starters to electrical motors.
b. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by controls contractor.
c. Duct smoke detectors including installation and wiring.
d. Power wiring of smoke/fire dampers provided by Divisions 20, 21, 22, 23, 25.
e. Stand-alone packaged controls and wiring of stand-alone packaged controls to their remote sensors and devices.
f. Ethernet drop at or near designated BAS control panel(s).
g. Mounting and wiring of Variable Speed Drives (VSDs) furnished by the Mechanical Contractor per Divisions 20, 21, 22, 23, 25.

C. System Integration. Products to receive integration under this section:

1. Variable Speed Drives:

a. Connect directly to the BAS through three twisted pair for Start/Stop, speed control and remote communications.
b. Factory-furnished with the appropriate communication hardware and software to allow communication.
c. Connections to VSD provided under this section.

2. Fire Alarm/Life Safety System:

a. The BAS shall communicate with the fire alarm/life safety system via an alarmable point in the form of a dry contact.
b. The device will be provided and terminated by Divisions 26, 27 and 28. This section will provide wiring to the termination device.

3.2 PROGRAMMING

A. Programming and graphics shall be included to implement the controls sequences specified in Section 259000 - Sequence of Operations, and to implement the systems and features included in Facility Services Divisions 20-28. It shall not be necessary for the Contracting Agency to further program the system.

B. Provide licensed copies of software tools and programming aids used to install, develop and troubleshoot the controls system to the Contracting Agency. Assist the Contracting Agency in registering the software in Contracting Agency's name.

C. Implement the control sequences for the equipment on this project as contained in Section 259000 - Sequence of Operations.

D. Point identifiers shall be chosen for easy identification of the actual equipment being controlled or monitored. They shall include equipment tag identifiers shown on the drawings, and may

include additional characters to identify floor, area, etc. Maintain a listing of identifiers used in this project, with their plain English names. Submit the listing for review and information.

3.3 GRAPHICS

A. Graphical Mechanical Displays: Create graphical displays of major mechanical equipment for this project and install graphics on the PC-based workstations. At a minimum, these graphical displays shall include building floor plans derived from architectural AutoCAD representations and graphical representations of the equipment controlled under this contract.

1. Plans:
   a. Provide a central site plan for the entire facility and immediate surroundings. As a minimum indicate the following:
      1). Area designation.
      2). Number of levels on each area.
      3). Adjacent street names.
      4). North arrow.
   b. Provide floor overall floor plans for each level of the facility. As a minimum indicate the following:
      1). Area designation and level.
      2). Mechanical and electrical rooms.
      3). Control panel locations.
      4). North arrow.
   c. Provide individual floor plans for the facility. As a minimum indicate the following:
      1). Walls, doors, and general floor plan arrangement.
      2). Mechanical and electrical rooms.
      3). Temperature sensors.
      4). Temperature control zones.
      5). Control panel locations.
      6). North arrow.
      7). List of major HVAC systems serving the area including but not limited to the following:
         a) Air handling systems.
         b) Exhaust fans.
         c) Toilet exhaust fans.
         d) Heating systems.
         e) Cooling systems.
   d. As a minimum provide the following functional links on for each floor plan:
      1). Provide links back and forth between the plan screens noted above.
      2). On floor plan with temperature sensor, provide dynamic color coding for each sensor as follows:
         a) Blue indicates space temperatures less than 65 degrees F.
         b) Green indicates space temperatures between 66 degrees and 74 degrees F.
         c) Red indicates space temperatures above 75 degrees F.
      3). Provide a link to each VAV terminal unit from the associated temperature sensor.
      4). Provide a link to each major mechanical system serving the temperature sensor.

2. Room Reheat coils:
   a. Indicate the following information for each unit:

1). Room Temperature.
2). Coil valve position percent.
3). Terminal heating unit valve position percent.

3. Air Handling: Indicate the following information for each AHUs/MAUs, relief/exhaust fans, and toilet exhaust fans:
   a. Put control points and adjustable set points on the screen.
   b. Define action of dampers and valves (N/O or N/C);
   c. Fan schedule override commands.
   d. Reset schedules.
   e. Outside air CFM and minimum requirement.
   f. Duct static set point.

4. Building static pressure: Provide a common screen for the building and fan room static pressure sensors for the entire facility. Put control points, adjustable set points, and reset schedules on the screen.

5. Boiler Room: Indicate the following information for the heating pumps, boiler room ventilation equipment, and other boiler room equipment:
   a. Put control points and adjustable set points on the screen.
   b. Define action of dampers and valves (N/O or N/C).
   c. Pump override commands.
   d. Boiler override commands.
   e. Reset schedules.
   f. GPM flows.
   g. Outside air temperature.

B. Graphical Electrical Displays: Create graphical displays of electrical equipment specified for connection to this system. Coordinate with Divisions 26, 27 and 28 and provide graphics on the PC-based workstations. At a minimum, these graphical displays shall include building floor plans utilized for Graphical Mechanical Displays.

1. Emergency/Standby Generating System:
   a. Operating parameters, generation equipment and ATS status, and alarm information.
   b. Refer to Section 263213 - Diesel Engine Driven Generator Sets, for additional information.

2. Building Lighting Control:
   a. Status information.
   b. Put control points and adjustable set points on the screen.
   c. Lighting override commands.

3. Site Lighting Control:
   a. Status information.
   b. Put control points and adjustable set points on the screen.
   c. Lighting on/off override commands.

C. Use approved designations for room names, spaces, equipment tags, etc.

3.4 SITE QUALITY CONTROL

A. Document each installation and operational step utilizing the approved PC/FT checklists in accordance with Section 019100 - Commissioning.

B. Programming BAS to provide system operation and monitoring in accordance with Section 259000 - Sequence of Operation and other referenced sections.

C. Trend Logs:

1. Prepare trend logs for all points required to demonstrate BAS calibration, control and stability.

2. Trend logs shall document building operation after applicable PC/FT checklists are completed and building site commissioning is satisfactorily completed.

3. Set points, valve positions, etc. may be temporarily adjusted to artificially induce the intended sequences to occur.

3.5 CLOSEOUT ACTIVITIES

A. Demonstration:

1. Provide demonstrations in accordance with Section 017900 - Demonstrations and Training.

2. Demonstrate the proper operation and control of systems controlled and monitored by the BAS.

3. The demonstration shall include, but not necessarily be limited to, the following:

a. Review of the Trend Logs.
b. Complete and proper operation of control systems including simulations.
c. Access to devices for required maintenance.
d. Review of associated graphics on Host.

B. Training:

1. Provide training in accordance with Section 017900 - Demonstrations and Training.

2. In addition, provide 40 hours of on-site instruction by BAS contractor to familiarize operating personnel with the control system. Instructions will include:

a. A brief description of the controls' sequence of operation.
b. A discussion and explanation of alarms, switches and gauges.
c. A summary and explanation of steps to be taken in response to specific alarms or control malfunctions.
d. Building walk-through to physically locate and examine control devices and demonstrate control setpoint adjustment procedures.

e. Instructions regarding adjustment procedures shall emphasize methods for continual building "fine-tuning".

END OF SECTION 255000

SECTION 259000 - SEQUENCE OF OPERATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. This section describes the building automation system (BAS) control sequences for the heating, ventilating and air-conditioning (HVAC) systems, electrical systems and plumbing systems provided for this project.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 211000 - Water Based Fire Suppression Systems
4. 230593 - Testing, Adjusting and Balancing
5. 232123 - Hydronic Pumps
6. 233100 - Ducts and Accessories
7. 233400 - HVAC Fans
8. 233600 - Air Terminal Units
9. 235223 - Cast Iron Boilers and Accessories
10. 236400 - Packaged Water Chillers
11. 237323 - Central Air Handling Units
12. 238123 - Dedicated Air-Conditioning Units
13. 238200 - Terminal Heating and Cooling Units
14. 238316 - Radiant Floor Heating Equipment
15. 253000 - Building Automation System Field Devices
16. 254000 - Variable Speed Drives
17. 255000 - Building Automation System
18. 281600 - Security Alarm and Detection

19. 283100 - Addressable Fire Alarm

1.2 SUBMITTALS

A. Refer to 200000 – Mechanical General Requirements.

B. Product Data:

1. Provide BAS manufacturers' product literature, clearly annotated to indicate performance criteria to include the following:

   a. Building level to floor level network controller riser diagrams. Include building locations and equipment controlled by each controller.
   b. Sequences of operation for HVAC, electrical and plumbing systems.
   c. Process control diagrams to support each sequence of operation. Show field mounted control device locations and circuit routing.
   d. Complete electrical BAS points list.

C. Quality Assurance/Control Submittals:

1. Installation and Functional Performance Test Letter.

   a. Provide a letter certifying that the building automation system hardware is completely installed and sequences of operation have been programmed, operationally tested, with physical verification, to comply with the sequences of operation as specified. The installer(s), sub-contractor(s) and the Contractor must sign the letter.
   b. Include as an attachment, a list of programming deviations from the specified sequences of operation with justification to support each deviation.
   c. Include as an attachment, a table of final adjustable setpoint values for each applicable control point.

D. Installation, Operation and Maintenance Data:

1. Refer to Section 200000 – Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.

2. Provide approved submittal information, revised to reflect the actual installation as addressed in the attachments provided with the Installation and Functional Performance Test Letter, for inclusion within the project IO&M Manual.

1.3 QUALITY ASSURANCE

A. Qualifications of Installers/Programmers: Minimum 3 years' experience in the installation and programming of direct digital control systems.

B. Pre-Installation Meetings: Conduct coordination meetings, as necessary, to evaluate and coordinate the connection of the BAS to each piece of HVAC, electrical and plumbing equipment. Where the BAS is to be connected to packaged, stand-alone controllers, coordinate

BAS remote control and monitoring capabilities with the specific features of the packaged controller to maximize remote operability and monitoring of each packaged controller through the BAS.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 GENERAL

A. Setpoints, schedules, offsets, and delays described in the sequences of operations shall be adjustable.

B. Electrical Load Sequencing:

1. Limit starting surge on emergency generator by sequencing controlled motors “ON”, one at a time at not less than five second intervals.

2. Limit motors controlled by variable speed drives to 80 percent of full load when operating on generator power.

C. Emergency Generator Monitoring:

1. Run status.

2. Total run time.

3. Common pre-alarms (any alarm condition that does not prevent the generator from running.

4. Common alarms (any alarm condition that prevents the generator from running).

5. Battery charger fault.

D. Emergency Generator Alarm: Provide alarm if generator runs more than 60 minutes at any one time.

3.2 FIRE ALARM PANEL MONITORING

A. Monitor the building fire alarm panel alarm status output.

3.3 VENTILATION SYSTEMS (AHU-1 THROUGH AHU-3)

A. General Ventilation System Description:

1. The forced air ventilation system for the clinic consists of 4 centralized air handling units (AHU) located in 2 second floor Fan Rooms (201 and 211). The air handling units serve the following areas.

   a. AHU-1: Clinic Areas.
   b. AHU-2: Wellness Area.
   c. AHU-3: Administration Areas.
   d. AHU-4: Dental Area (See Article 3.4).

2. AHUs utilize a variable air volume (VAV) control strategy incorporating variable speed drive motor controllers to modulate supply fan speed. During periods of low system demand, supply fans automatically reduce speed, minimizing fan horsepower and conserving electrical energy.

3. Supply air from AHUs is transferred to their respective variable air volume (VAV) terminal units through a system of medium pressure ductwork. Each VAV terminal unit, with hydronic reheat coil, controls supply airflow rate (CFM) and temperature to maintain zone setpoint temperature. Auxiliary fintube or radiant ceiling panel heating is provided for each perimeter zone to improve comfort.

4. Return air from AHU's flows back through return ducting to the AHUs. Once back at the AHUs, return air is either re-circulated through the building, or is relieved from the building through relief dampers in the AHU.

B. Typical AHU Ventilation System Operation:

1. Full Shutdown Mode:

   a. AHU:
   b. Supply fans off.
   c. Return fans off.
   d. Mixing box outside air damper shut.
   e. Mixing box return air damper fully open.
   f. Return fan relief damper shut.
   g. Heating coil circulation pumps (PMP-7A/-7B, PMP-8A/-8B, PMP-9A/-9B) enabled and heating coil hydronic control valve modulating to maintain 55 degrees F minimum mixing box air temperature.
   h. Cooling coil hydronic three-way control valves shut (no flow through coil).

2. Start Sequence:

   a. Provide independent, adjustable, automatic start/stop sequence for each air handling system based on time-of-day schedule.
   b. Provide a minimum 5-second time delay between the start of each AHU supply fan and return fans.

c. AHU-1 to operate 24/7 to maintain required room pressure relationships and allow adequate indoor air quality for medical staff staying overnight in bunk area on the second level.

3. Supply Fan Speed Control:

   a. Locate duct static pressure sensors in main supply air duct, approximately 3/4 the distance between the AHU supply outlet and most remote zone variable air volume (VAV) terminal unit branch duct connection. In systems with multiple supply air duct branches, provide a separate static pressure sensor in each main branch duct, located approximately 3/4 of the distance between the AHU supply outlet and the most remote zone terminal unit branch connection. Suggested locations are shown on the drawings.
   b. Utilizing the fan variable speed drive (VSD) controller, modulate supply fan speed to maintain the lowest branch duct static pressure at 1.5 inches WC setpoint pressure.
   c. Program AHU to go into Full Shutdown Mode in the event of VSD failure. Require manual restart of the system.

4. Return Fan Speed Control:

   a. Locate static pressure sensor in return fan discharge plenum upstream of the mixing box.
   b. Modulate the return fan speed through the variable speed drive (VSD) controller to maintain a discharge pressure of 0.2 inches WC setpoint pressure.

5. Building Static Pressure Control:

   a. Provide two outdoor ambient pressure sensors on the roof on opposite corners of the building as shown on the drawings.
   b. Provide indoor static pressure reference heads in the following locations:
      1). Circulation (120) - AHU-1
      2). Breakroom (212) - AHU-1
      3). Circ Wellness (112) - AHU-2
      4). Circulation (104) - AHU-3
      5). Waiting (200B) - AHU-3

   c. Compare indoor static pressure reference heads for each AHU with the average reading from the outdoor ambient pressure sensors. Modulate each AHU relief damper to maintain a positive 0.03 inches WC building pressure as measured by its respective indoor static pressure head(s).

6. Supply Temperature Control:

   a. Pre-Occupancy Warm-Up/Cool-Down Mode:
      1). Initial Conditions: The ventilating system is in Full Shutdown Mode.
      2). Initiate pre-occupancy warm-up/cool-down cycle one hour prior to scheduled Occupied Mode operation.
      3). Start AHU using the start sequence.
      4). Control AHU fan speeds using fan speed control sequence.

5). Warm-Up: Enable heating coil circulation pumps (PMP-7A/-7B, PMP-8A/-8B, PMP-9A/-9B) and modulate heating coil hydronic control valve to maintain 55 degrees F supply air setpoint temperature as measured downstream of supply fan. The outside air damper remains shut, the return air damper remains fully open, and the relief damper remains shut. The building pressure control sequence is disabled.
6). Economizer Cool-Down: If outdoor air temperature is greater than 45 degrees F and less than 65 degrees F, modulate outside air damper open and modulate return air damper shut to maintain 55 degrees F supply air setpoint temperature. The relief damper modulates to maintain an approximately neutral building pressure.
7). Mechanical Cool-Down: If outdoor air temperature is greater than 65 degrees F, the outside air damper remains shut, the return air damper remains fully open, and the relief damper remains fully shut. Modulate open hydronic cooling control valve to maintain supply air setpoint temperature.

b. Occupied Mode:
1). System has completed Pre-Occupancy Warm-Up/Cool-Down Mode and zones are at Occupied Mode temperature setpoints.
2). Command outside air damper to occupied mode from the BAS. Outside air damper modulates open and controls minimum outside air volume flow rate (CFM) to scheduled value as measured by the airflow measuring station.
3). Return air damper modulates proportionally to outside air damper.
4). Relief damper modulates to maintain building static pressure.
5). Measure mixing box mixed air temperature using duct averaging flexible sensors. If mixed air temperature is less than 55 degrees F setpoint shift to Heating Mode. Enable heating coil circulation pump and modulate heating coil hydronic control valve to maintain 55 degrees F supply air setpoint temperature measured downstream of supply fan.
6). If mixed air temperature is greater than 55 degrees F setpoint, and the heating coil hydronic control valve has been shut for 3 minutes, shift to Economizer Cooling Mode. Modulate open outside air damper and modulate shut return air damper proportionally to maintain supply air temperature setpoint. Modulate relief damper to maintain building static pressure.
7). If the outside air damper is fully open and return air damper is fully shut for 5 minutes, supply air temperature is greater than setpoint temperature, and the outside air temperature increases to 5 degrees F greater than return air temperature, shift to Mechanical Cooling Mode. Modulate the outside air damper to the minimum outside air position. Modulate return air damper open and modulate relief damper to maintain building static pressure setpoint. Modulate cooling coil hydronic control valve to maintain supply air temperature setpoint.

c. Unoccupied Mode:
1). AHUs are initially operating in Occupied Mode.
2). Shift ventilation systems to Full Shutdown Mode.
3). The hydronic heating system operates to maintain 65 degrees F night setback temperature setpoint plus 3, minus 0 degrees F using perimeter heat only.
4). If any zone falls below setback temperature setpoint, operate the applicable ventilating system using Pre-Occupancy Warm-Up Mode sequences.

5). Provide 15-minute minimum supply fan run time and 5-minute minimum system off time.
6). If any thermostat occupancy override button is pushed, operate that ventilation system in Occupied Mode for a 2-hour period.

C. Typical Zone VAV Temperature Control with Reheat:

1. Zone Sensors: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.

2. Occupied Mode Operation:

a. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Modulate VAV reheat coil control valve in parallel with control damper.
b. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day setpoint temperature, plus or minus 1-degree F. Reheat coil control valves remain shut.

3. Unoccupied Mode Operation:

a. Heating Mode: When AHU is operating, modulate VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone night setpoint temperature plus 0, minus 3 degrees F. Modulate VAV reheat coil control valve in parallel with control damper.
b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

D. Typical Zone VAV Temperature Control with Reheat and Auxiliary Heat (Fintube or Radiant Panel):

1. Zone Sensors: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.

2. Occupied Mode Operation:

a. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Modulate reheat coil and auxiliary heat control valves in parallel with control damper.
b. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Reheat coil and auxiliary heat control valves remain shut.

3. Unoccupied Mode Operation:

a. Heating Mode: When AHU is operating, modulate VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone night setpoint temperature plus 0, minus 3 degrees F. Modulate VAV reheat coil and fintube control valves in parallel with control damper.
b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

E. Laundry - Clean (152) VAV Temperature and Room Pressure Control:

1. Zone Sensors:

   a. Zone Thermostat: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.
   b. Zone Pressure Sensing: Provide ceiling-mounted static pressure reference heads and differential pressure transmitter as shown on the drawings, with input to zone VAV terminal equipment controller.

2. Occupied Mode Operation:

   a. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Modulate reheat coil control valve in parallel with control damper.
   b. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Reheat coil control valve remains shut.

3. Unoccupied Mode Operation:

   a. Heating Mode: When AHU is operating, modulate VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone night setpoint temperature plus 0, minus 3 degrees F. Modulate VAV reheat coil control valve in parallel with control damper.
   b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

4. Room Pressure Control:

   a. Room is required to be positively pressurized with respect to adjacent corridor. Room contains a commercial clothes dryer with periodic exhaust ventilation. Make-up air for the commercial clothes dryer is provided by the room VAV box.
   b. Dryer not in use: Operate VAV box in Occupied Mode to maintain zone temperature setpoint and to maintain a minimum positive 0.03 inches WC pressure.
   c. Dryer in use: Modulate VAV box control damper open to maintain a minimum positive 0.03 inches WC. Modulate reheat coil control valve to maintain the zone temperature setpoint.
   d. Coordinate with testing, adjusting, and balancing contractor to provide supply and exhaust airflow offset to maintain room differential setpoint, with and without dryer operating.
   e. If room differential pressure setpoint drops below 0.01 inches WC for more than 30 seconds, generate “Clean Room Low Pressure” alarm to the BAS.

F. Safety Shutdowns:

1. General:

   a. “Hardwire” system safety shutdowns to provide safe, reliable operation in the event of Building Automation System (BAS) failure.

b. Where equipment is provided with packaged stand-alone controls, capable of operating the equipment independently from the BAS, provide control logic which shifts the equipment to stand-alone operation in the event of BAS failure.

2. Return Duct Smoke Detector Shutdown:

a. Hardwire return air duct smoke detectors directly to the building's fire alarm panel. Refer to Section 283100 - Addressable Fire Alarm System for sequence of operation.
b. Monitor fire alarm panel "General Alarm" status from BAS system.
c. On "General Alarm" from fire alarm panel, the BAS shall:
1). Verify AHU supply and return fans are off. If fans are operating, stop supply and return fans.
2). Shut outside air dampers.
3). Open return air dampers.
4). Shut relief dampers.
5). Stop exhaust fans and shut exhaust fan dampers.

3. High Duct Static Pressure Shutdown:

a. If ventilating system duct supply static pressure increases to 3.0 inches WC:
1). Command applicable ventilating system to Full Shutdown Mode.
2). Provide "AHU-X High Static Pressure" alarm.
3). Require manual restart of the ventilation system through the BAS.

4. Low Temperature Shutdown:

a. If supply air temperature decreases to 45 degrees F:
1). Command applicable ventilating system in Full Shutdown Mode.
2). Provide "AHU-X Low Temperature Shutdown" alarm.
3). Require manual restart of the ventilation system through the BAS.

G. Maintenance and Alarm Monitoring:

1. Air filter replacement monitoring:

a. Provide analog differential pressure sensor at each pre-filter bank:
1). Normal filter (MERV-8) differential pressure range is 0.27 inches WC (clean) to 0.90 inches WC (dirty) at 500 feet per minute.
2). Generate "AHU-X High Filter Differential Pressure" maintenance alarm at 0.80 inches WC.

b. Provide analog differential pressure sensor at each final filter bank:
1). Final filter (MERV-14) differential pressure range is 0.32 inches WC (clean) to 1.00 inches WC (dirty).
2). Generate "AHU-X High Filter Differential Pressure" maintenance alarm at 0.90 inches WC.

2. Zone Temperature Monitoring:

a. Generate "AHU-X Zone Temperature High/Low" maintenance alarm if any zone temperature is not being maintained within setpoint band tolerance as described in Occupied Mode and Unoccupied Mode sequences.
b. During optimized start period, generate "AHU-X Zone Temperature High/Low" maintenance alarm if any zone temperature fails to meet occupied temperature setpoint.
c. Generate "AHU-X Zone Low Temperature" critical alarm if any zone temperature falls below 55 degrees F.

3. Duct Static Pressure Monitoring:

a. Generate "Duct Static Pressure High/Low" maintenance alarm if duct pressure falls outside setpoint tolerance, plus or minus 0.05 inches WC.
b. Provide 3-minute alarm time delay to prevent spurious alarms.

4. AHU Flow Monitoring:

a. Provide BAS monitoring of variable speed drive enable/disable contacts, analog speed controller, and trouble contacts.
b. Generate "VSD Fault" alarm if the VSD fan motor controller goes into fault.

3.4 VENTILATION SYSTEM (AHU-4)

A. General Ventilation System Description:

1. The forced air ventilation system for the dental area within the clinic consists of a single once-through centralized air-handling unit (AHU) located in the second floor Fan Room 211.

2. AHU-4 utilizes a variable air volume (VAV) control strategy incorporating variable speed drive motor controllers to modulate supply and exhaust fan speeds. During periods of low system demand, supply and exhaust fans automatically reduce speed, minimizing fan horsepower and conserving electrical energy.

3. Supply air from AHU-4 is transferred to its respective variable air volume (VAV) terminal units through a system of medium pressure ductwork. Each VAV terminal unit, with hydronic reheat coil, controls supply airflow rate (CFM) and temperature to maintain zone setpoint temperature. Auxiliary radiant ceiling panel heating is provided for each perimeter zone to improve comfort.

4. Exhaust air is controlled by exhaust air valves within the dental area in order to maintain proper room pressure relationships. Exhaust air from the zones flows back through exhaust ducting to the AHU. Once back at the AHU, exhaust air passes through a heat recovery coils (RC-4A and RC-4B) to transfer heat from the exhaust air (RC-4B) to the incoming outside air (RC-4A) and is then relieved from the building by the exhaust fan.

B. Ventilation System Operation:

1. Full Shutdown Mode:

a. Supply fan off.
b. Exhaust fan off.
c. Outside air damper shut.
d. Exhaust air damper shut.
e. Heating coil hydronic control valve modulating to maintain 55 degrees F minimum discharge air temperature.
f. Cooling coil hydronic three-way control valves shut (no flow through coil).

2. Start Sequence:

a. Provide independent, adjustable, automatic start/stop sequence for AHU-4 system based on time-of-day schedule.
b. Provide a minimum 5-second time delay between the start of AHU supply fan and exhaust fan.
c. AHU-4 to operate at a significantly reduced airflow in Unoccupied Mode in order to maintain negative pressure relationships in specific zones.

3. Supply Fan Speed Control:

a. Locate duct static pressure sensor in main supply air duct, approximately 3/4 the distance between the AHU supply outlet and most remote zone variable air volume (VAV) terminal unit branch duct connection. Suggested location is shown on the drawings.
b. Utilizing the fan variable speed drive (VSD) controller, modulate supply fan speed to maintain duct static pressure at 1.5 inches WC setpoint pressure.
c. Program AHU to go into Full Shutdown Mode in the event of VSD failure. Require manual restart of the system.

4. Exhaust Fan Speed Control:

a. Locate duct static pressure sensor in main exhaust air duct, approximately 3/4 the distance between the AHU exhaust inlet and most remote zone exhaust air valve (EAV) terminal unit branch duct connection. Suggested location is shown on the drawings.
b. Utilizing the fan variable speed drive (VSD) controller, modulate exhaust fan speed to maintain exhaust duct static pressure at -1.5 inches WC setpoint pressure.
c. Program AHU to go into Full Shutdown Mode in the event of VSD failure. Require manual restart of the system.

5. Supply Temperature Control:

a. Pre-Occupancy Warm-Up/Cool-Down Mode:
   1). Initial Conditions: The ventilating system is in Full Shutdown Mode.
   2). Initiate pre-occupancy warm-up/cool-down cycle one hour prior to scheduled Occupied Mode operation.
   3). Start AHU using start sequence.
   4). Control fan speeds using fan speed control sequence.
   5). Operate heat recovery system per heat recovery system control sequence.
   6). Warm-Up: Modulate heating coil hydronic control valve to maintain 55 degrees F supply air setpoint temperature as measured downstream of supply fan.

7). Mechanical Cool-Down: If outdoor air temperature is greater than 65 degrees F, modulate open hydronic cooling control valve to maintain supply air setpoint temperature.

b. Occupied Mode:
1). System has completed Pre-Occupancy Warm-Up/Cool-Down Mode and zones are at Occupied Mode temperature setpoints.
2). Measure supply air temperature downstream of heat recovery coil using duct averaging flexible sensors. If supply air temperature is less than 55 degrees F setpoint shift to Heating Mode. Modulate heating coil hydronic control valve to maintain 55 degrees F supply air setpoint temperature measured downstream of supply fan.
3). If supply air temperature downstream of the heat recovery coil is greater than 55 degrees F setpoint, the heating coil hydronic control valve has been shut for three minutes, and the heat recovery system has been disabled for three minutes, shift to Cooling Mode. Modulate cooling coil hydronic control valve to maintain supply air temperature setpoint.

c. Unoccupied Mode:
1). AHU is initially operating in Occupied Mode.
2). Shift ventilation system to Unoccupied Mode.
3). The hydronic heating system operates to maintain 65 degrees F night setback temperature setpoint plus 3, minus 0 degrees F using perimeter heat only.
4). If any zone falls below setback temperature setpoint, operate the applicable ventilating system using Pre-Occupancy Warm-Up Mode sequences.
5). Provide 15-minute minimum supply fan run time and 5-minute minimum system off time.
6). If any thermostat occupancy override button is pushed, operate the ventilation system in Occupied Mode for a two hour period.

C. Heat Recovery System: See Article 3.16 Heat Recovery System.

D. Typical Zone VAV Temperature Control with Reheat and Exhaust Air Valve (EAV):

1. Zone Sensors: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller:

2. Occupied Mode Operation:

a. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Modulate VAV reheat coil control valve in parallel with control damper. Modulate the EAV between minimum CFM and maximum CFM to maintain the zone supply and exhaust offset as determined during testing, adjusting and balancing.
b. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Reheat coil control valves remain shut. Modulate the EAV between minimum CFM and maximum CFM to maintain the zone supply and exhaust offset as determined during testing, adjusting and balancing.

3. Unoccupied Mode Operation:

   a. Heating Mode: When AHU is operating, modulate VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone night setpoint temperature plus 0, minus 3 degrees F. Modulate VAV reheat coil control valve in parallel with control damper.
   b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

E. Typical Zone VAV Temperature Control with Reheat and Auxiliary Heat (Radiant Panel) and EAV:

1. Zone Sensors: Provide wall-mounted zone thermostat with input to zone VAV terminal equipment controller.

2. Occupied Mode Operation:

   a. Heating Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Modulate reheat coil and auxiliary heat control valves in parallel with control damper. Modulate the EAV between minimum CFM and maximum CFM to maintain the zone supply and exhaust offset as determined during testing, adjusting and balancing.
   b. Cooling Mode: Modulate the VAV terminal unit control damper between Minimum CFM and Maximum Cooling CFM to maintain zone day setpoint temperature plus or minus 1-degree F. Reheat coil and auxiliary heat control valves remain shut. Modulate the EAV between minimum CFM and maximum CFM to maintain the zone supply and exhaust offset as determined during testing, adjusting and balancing.

3. Unoccupied Mode Operation:

   a. Heating Mode: When AHU is operating, modulate VAV terminal unit control damper between Minimum CFM and Maximum Heating CFM to maintain zone night setpoint temperature plus 0, minus 3 degrees F. Modulate VAV reheat coil and auxiliary heat control valves in parallel with control damper.
   b. Cooling Mode: Ventilation system remains off regardless of zone temperature.

F. Safety Shutdowns:

1. General:

   a. “Hardwire” system safety shutdowns to provide safe, reliable operation in the event of Building Automation System (BAS) failure.
   b. Where equipment is provided with packaged stand-alone controls, capable of operating the equipment independently from the BAS, provide control logic which shifts the equipment to stand-alone operation in the event of BAS failure.

2. Fire Alarm Shutdown:

   a. Monitor fire alarm panel “General Alarm” status from BAS system.
   b. On “General Alarm” from fire alarm panel, the BAS shall:

1). Verify supply and exhaust fans are off. If fans are operating, stop supply and exhaust fans.
2). Shut outside air damper.
3). Shut exhaust damper.

3. High Duct Static Pressure Shutdown.

a. If ventilating system duct supply static pressure increases to 3.0 inches WC:
1). Command AHU-4 system to Full Shutdown Mode.
2). Provide "AHU-4 High Static Pressure" alarm.
3). Require manual restart of the ventilation system through the BAS.

4. Low Temperature Shutdown:

a. If supply air temperature decreases to 45 degrees F:
1). Command AHU-4 system in Full Shutdown Mode.
2). Provide "AHU-4 Low Temperature Shutdown" alarm.
3). Require manual restart of the ventilation system through the BAS.

G. Maintenance and Alarm Monitoring:

1. Air filter replacement monitoring:

a. Provide analog differential pressure sensor at each pre-filter bank:
1). Normal filter (MERV-8) differential pressure range is 0.27 inches WC (clean) to 0.90 inches WC (dirty) at 500 feet per minute.
2). Generate "AHU-X High Filter Differential Pressure" maintenance alarm at 0.80 inches WC.

b. Provide analog differential pressure sensor at each final filter bank:
1). Final filter (MERV-14) differential pressure range is 0.32 inches WC (clean) to 1.00 inches WC (dirty).
2). Generate "AHU-X High Filter Differential Pressure" maintenance alarm at 0.90 inches WC.

2. Zone Temperature Monitoring:

a. Generate "AHU-4 Zone Temperature High/Low" maintenance alarm if any zone temperature is not being maintained within setpoint band tolerance as described in Occupied Mode and Unoccupied Mode sequences.
b. During optimized start period, generate "AHU-X Zone Temperature High/Low" maintenance alarm if any zone temperature fails to meet occupied temperature setpoint.
c. Generate "AHU-4 Zone Low Temperature" critical alarm if any zone temperature falls below 55 degrees F.

3. Duct Static Pressure Monitoring:

a. Generate "Duct Static Pressure High/Low" maintenance alarm if duct pressure falls outside setpoint tolerance, plus or minus 0.05 inches WC.
b. Provide three-minute alarm time delay to prevent spurious alarms.

4. AHU Flow Monitoring:

    a. Provide BAS monitoring of variable speed drive enable/disable contacts, analog speed controller, and trouble contacts.
    b. Generate “VSD Fault” alarm if the VSD fan motor controller goes into fault.

3.5 GENERAL EXHAUST FAN OPERATION (EF-1 THRU 3)

A. Each exhaust fan unoccupied/occupied mode shall be set to match its associated air handling unit (AHU) mode.

B. Unoccupied Mode:

1. Exhaust fan is disabled.

2. Two-position motor operated damper with end-switch is closed.

C. Occupied Mode:

1. Two-position motor operated damper with end-switch opens.

2. Once damper is fully open, exhaust fan is enabled.

D. Monitoring and Alarms:

1. Monitor exhaust fan motors and generate a fan specific “EF-X Trouble” alarm when any exhaust fan fails to start during Occupied Mode operation.

2. Monitor motor operated dampers and generate a fan specific “EF-X Motor Operated Damper Trouble” alarm if damper fails to open/close when commanded.

3.6 MORGUE EXHAUST FAN OPERATION (EF-4)

A. Exhaust fan is scheduled to operate 24/7.

B. Full shutdown mode:

1. Exhaust fan is disabled.

2. Two-position motor operated damper with end-switch is closed.

C. Enabled mode:

1. Two-position motor operated damper with end-switch opens.

2. Once damper is fully open, exhaust fan is enabled.

D. Monitoring and Alarms:

1. Monitor exhaust fan motor and generate “EF-4 Trouble” alarm if the exhaust fan fails to start when enabled.

2. Monitor motor operated damper and generate “EF-4 Motor Operated Damper Trouble” alarm if damper fails to open/close when commanded.

3.7 EXAM ISOLATION (124) EXHAUST FAN OPERATION (EF-5)

A. Exhaust fan is scheduled to operate 24/7.

B. Full shutdown mode:

1. Exhaust fan is disabled.

2. Two-position motor operated damper with end-switch is closed.

C. Enabled mode:

1. Two-position motor operated damper with end-switch opens.

2. Once damper is fully open, exhaust fan is enabled.

D. Room Pressure Monitoring:

1. Provide room pressure monitor for the Airborne Infection Isolation (AII) room named Exam Isolation (124); locate static pressure reference heads, differential pressure transmitter, and wall-mount digital display as shown on the drawings.

2. Coordinate with testing, adjusting, and balancing contractor to provide supply and exhaust airflow offset to maintain a room differential setpoint of -0.05 inches WC.

3. If room differential pressure setpoint drops below -0.01 inches WC for more than 30 seconds, generate “Isolation Room Low Pressure” alarm on the BAS and on the local wall-mount digital display.

4. Provide door contacts for door into Isolation Room. Indicate door open/closed status on BAS graphics. Disable pressure alarm if door is in the open position. Generate local alarm if door is held open for more than 90 seconds.

E. Additional Monitoring and Alarms:

1. Monitor exhaust fan motor and generate “EF-5 Trouble” alarm if the exhaust fan fails to start when enabled.

2. Monitor motor operated damper and generate “EF-5 Motor Operated Damper Trouble” alarm if damper fails to open/close when commanded.

3.8 GARAGE VENTILATION (EF-6)

A. The garage is provided with minimum required ventilation through outside air make-up for the morgue exhaust. The garage exhaust fan (EF-6) is enabled and provides required ventilation to "purge" the garage when concentrations of carbon monoxide (CO) or nitrogen dioxide (NO2) get too high. Make-up air for the exhaust fan is provided by a make-up air louver.

B. Disabled mode:

1. Exhaust fan is disabled.

2. Exhaust fan and make-up air louver two-position motor operated dampers with end-switches are closed.

C. Purge mode:

1. High CO or NO2 levels are sensed by the gas detection sensors for more than 30 seconds.

2. Exhaust fan and make-up air louver two-position motor operated dampers with end-switches are opened.

3. Once dampers are fully open, exhaust fan is enabled.

4. Once CO or NO2 levels return to normal levels for more than one minute, garage ventilation system goes into disabled mode.

5. Exhaust fan minimum run time of 10 minutes.

D. Monitoring and Alarms:

1. Monitor gas detection sensors and provide "Garage High Gas Concentration" alarm if either gas has high concentration.

2. Monitor exhaust fan motor and generate "EF-6 Trouble" alarm if the exhaust fan fails to start when enabled.

3. Monitor fan motor operated damper and generate "EF-6 Motor Operated Damper Trouble" alarm if damper fails to open/close when commanded.

4. Monitor make-up air motor operated dampers and generate "Make-up Air Motor Operated Damper Trouble" alarm if damper fails to open/close when commanded.

3.9 DRYER BOOSTER FAN (EF-7)

A. Dryer booster fan utilizes packaged pressure controls to enable and modulate fan speed to maintain the desired exhaust pressure setpoint to provide the required exhaust airflow when the dryer is operational.

B. No monitoring provided by BAS.

3.10 MECHANICAL ROOM VENTILATION SYSTEM (SCF-1)

A. Description:

1. Mechanical room ventilation system SCF-1 provides ventilation cooling for the boiler room whenever heat gain from the boilers exceeds room heat loss and combustion air heating requirements.

2. The fan includes an outside air intake louver, mixing box, small cabinet fan with medium efficiency filter section, and discharge air temperature sensor.

3. A direct combustion air wall opening with associated louver and insulated duct elbow provides combustion air to fuel oil fired equipment when SCF-1 is not operating.

4. Excess air from the SCF-1 ventilation system is relieved through the combustion air intake louver when SCF-1 is operating.

B. Zone Thermostat: Provide wall mounted thermostat with output signal to BAS system.

C. Cooling Mode:

1. Start fan SCF-1 when mechanical room temperature increases above 75 degrees F setpoint temperature.

2. Modulate mechanically linked mixing box outside air and return air dampers to maintain 55 degrees F supply air discharge temperature.

3. When mechanical room temperature falls to 70 degrees F, stop SCF-1. Shut outside air damper and fully open return air damper.

D. Low temperature shutdown.

1. Stop fan, close outside air damper and fully open return air damper if discharge supply temperature is less than 45 degrees F.

2. Provide “SCF-1 Low Temperature” alarm to BAS.

3. Allow system to automatically restart via the BAS after minimum system off time.

E. Minimum Run Timer: Provide 10-minute minimum system run time and 5-minute minimum system off time.

F. Filter Monitoring:

1. Provide analog differential pressure sensor across filter bank. Normal filter (MERV-8) differential pressure range is 0.28 inches WC (clean) to 0.90 inches WC (dirty) at 500 feet per minute.

2. Generate “SCF-1 High Filter Differential Pressure” alarm at 0.80 inches WC.

G. Fan Monitoring: Monitor supply fan motor and generate “SCF-1 Trouble” alarm if fan fails to start when it has been enabled.

3.11 TELECOMMUNICATIONS ROOM (232) AIR-CONDITIONING SYSTEM (AC-1)

A. General System Description: The Telecommunications Room air-conditioning system consists of an evaporator unit located within the Telecommunications Room and a condensing unit located in the Garage for waste heat recovery. The dedicated air-conditioning system has packaged controls to maintain zone temperature.

B. Operate dedicated air conditioning system utilizing packaged microprocessor control system. Monitor general fault alarm through BAS.

3.12 HYDRONIC HEATING SYSTEM OPERATION

A. General System Description:

1. The hydronic heating system consists of two identical cast iron hydronic boilers (BLR-1 and BLR-2) each sized for approximately 60 percent of the building's design heating load. The boilers are arranged in a primary/secondary piping arrangement. Each boiler has a dedicated primary loop circulator (PMP-1, PMP-2).

2. One set of secondary heating loop variable speed pumps (PMP-3A and PMP-3B), arranged in parallel, and each sized for 100 percent system zone flow provide circulation to AHU coils, VAV boxes, perimeter fintube, radiant panels, cabinet unit heaters and unit heaters throughout the facility.

3. AHU-1, 2, and 3 heating coils have primary/standby pumps (PMP-7A/-7B, PMP-8A/-8B, PMP-9A/-9B) to continuously circulate the heating coils during heating mode in order to provide uniform heat distribution over the entire coil and help prevent freezing the coil during cold outside air conditions.

B. Coordination with Packaged Boiler Controls:

1. Coordinate connection of the BAS to the packaged burner controllers.

2. Provide boiler enable/disable and sequencing, circulator pump operation and secondary loop temperature reset utilizing the BAS.

C. Full Shutdown Mode (Initial conditions):

1. Boilers off.

2. Boiler circulator pumps off.

3. Secondary heating loop circulator pumps off.

4. AHU heating coil recirculation pumps off.

D. Operating Mode:

1. System Enable:

a. Manual Mode: Provide three-position on/off/auto switch located on each burner control cabinet to allow local manual enable, disable or automatic burner control from the BAS (normal condition).

2. Lead/Lag Control:

a. Provide lead/lag control for boilers (BLR-1 and BLR-2). Alternate lead boiler monthly during the heating season.
b. Provide lead/lag control for secondary loop circulators (PMP-3A and PMP-3B). Alternate lead loop pump monthly during the heating season.

3. System Start-up:

a. Start lead secondary loop circulator pump. Operate secondary circulator pumps with lead pump in "run" and standby pump in "standby." If lead pump fails to start as determined by analog current sensor, disable lead pump and start standby pump.
b. After secondary loop flow has been established for 10 minutes, enable boiler operation.

4. Boiler Operation:

a. Calculate "secondary loop water temperature setpoint" in accordance with the following linear reset schedule:

Hydronic System Temperature Reset Schedule	
Outside Air Temperature	Secondary Loop Water Temperature Setpoint
60 Degrees F	160 Degrees F
0 Degrees F	190 Degrees F

b. Compare actual secondary loop temperature (sensor located upstream of air separator AS-1) with computed secondary loop water temperature as determined by reset schedule.
c. If actual water temperature is lower than water temperature required by reset schedule:
   1). Start lead boiler circulator pump.
   2). Command lead boiler to "Low Fire" mode from the BAS system utilizing packaged burner control start-up sequence.

d. Track the actual secondary loop water temperature rate-of-rise. If one time constant elapses and rate-of-rise is insufficient to achieve "computed water temperature setpoint," modulate burner to achieve the "computed water temperature setpoint."
e. If lead boiler is modulated to "High Fire" and rate-of-rise is still insufficient to achieve "computed water temperature":
   1). Start lag boiler circulator pump.
   2). Command lag boiler to "Low Fire" mode from the BAS system utilizing packaged burner control start-up sequence.

f. Continue boiler sequence until secondary loop temperature setpoint is reached or both boilers are operating in "High Fire" mode.
g. Reverse sequence if actual secondary loop water temperature is greater than computed secondary loop water temperature setpoint.
h. Boilers must modulate to "Low Fire" mode prior to full shutdown. After a boiler is commanded to shut down, operate associated circulator pump for 5 minutes utilizing a time delay relay.
i. Coordinate with boiler manufacturer's representative and adjust setpoints and time constants in accordance with manufacturer's recommendations.

5. System Shutdown:

a. Initiate Full Shutdown Mode in the following events:
1). Manual "off" mode.
2). Low water cutoff shutdown of either boiler.

E. Variable Speed Hydronic Pump Control (PMP-3A and PMP-3B):

1. Provide a separate hydronic system pressure sensor in each main hydronic header branch line (see plans for approximately locations). Locate each sensor approximately 3/4 the distance between the secondary loop circulator pump combined discharge and the most remote terminal heating unit control valve in each branch.

2. Adjust VSD controller output to modulate pump speed between 35 percent and 100 percent flow to maintain the lowest reading hydronic header pressure sensor at setpoint pressure with a minimum of one terminal heating unit control valve at 95 percent open. Set initial header pressure setpoint to 5 PSIG. Setpoint to be adjusted during testing, adjusting and balancing.

3. In the event of VSD failure, enable and run standby pump.

F. AHU Heating Coil Recirculation Pumps (PMP-7A/-7B, PMP-8A/-8B, PMP-9A/-9B) Control:

1. When outside air temperature is 35 degrees F and decreasing, and associated AHU heating coil control valve opens greater than 0 percent, start applicable heating coil circulator pump:

a. Start lead circulator pump. Operate circulator pumps with lead pump in "run" and standby pump in "standby."
b. If lead pump fails to start as determined by analog current sensor, disable lead pump and start standby pump.

2. See ventilation system sequences for additional requirements.

G. Hydronic System Monitoring and Alarm:

1. Boiler safeguard alarms (BLR-1 and BLR-2):

a. Generate a separate "BLR-X Flame Failure" alarm if either boiler is shut down by its flame safeguard control system.

b. Generate a “Low Water System Shutdown” alarm upon a low water condition as sensed by the low water cut-off.

2. Boiler circulator pump (PMP-1 and PMP-2) trouble alarms:

a. Provide current sensing (analog) for each pump.
b. Disable applicable flame safeguard circuit and generate a “PMP-X Trouble” alarm if either pump fails to run when its respective boiler is enabled.

3. Secondary loop pump trouble alarms (PMP-3A and PMP-3B):

a. Provide current sensing (analog) for each pump.
b. Generate “Secondary Loop Pump Failure” alarm if lead pump fails to run when enabled by the BAS.
c. Generate “Secondary Loop Pump Critical Failure” alarm if standby pump fails to run when enabled by the BAS after a lead pump failure.
d. Generate “Secondary Loop Pump Trouble” alarm if both pumps are running.

4. AHU heating coil circulation pump trouble alarms (PMP-7A/-7B, PMP-8A/-8B, PMP-9A/-9B):

a. Provide current sensing (analog) for each pump.
b. Generate a separate “PMP-X Trouble” alarm if any pump fails to operate when outside air temperature is below setpoint.

5. Hydronic System Low Pressure Alarms:

a. Monitor the heating system pressure with an analog pressure sensor.
b. Generate a “Hydronic Heating System Low Pressure” alarm if the system pressure falls below 5 PSIG.

3.13 RADIANT SLAB HEATING

A. Description:

1. The saunas utilize a radiant floor hydronic heating system to maintain zone temperature control when the saunas are not in operation.

2. The radiant floor heating system operates to maintain a constant floor setpoint temperature utilizing slab floor temperature sensors. Floor temperature is reset based on outside air temperature.

B. System Shutdown:

1. Zone circulator pump is off.

2. Zone three-way valve is open (full recirculation of radiant floor loops).

C. Typical System Operation:

1. When outside air temperature decreases to 60 degrees F start zone circulator pump.

2. Operate circulator pump for one hour to allow slab temperature to stabilize.

3. After slab temperature stabilization period, measure floor slab temperature. Modulate three-way valve to maintain scheduled floor slab temperature based on outside air temperature as follows:

Floor Slab Temperature Reset Schedule	
Outside Air Temperature	Slab Floor Temperature Setpoint
Greater than 60 Degrees F	System off
60 Degrees F	65 Degrees F
0 Degrees F or less.	85 Degrees F

4. Control three-way valve to limit maximum supply water temperature to 120 degrees F, as measured by supply water temperature sensor located downstream of zone circulator.

5. When outside air temperature increases to 65 degrees F and increasing, stop zone circulator and open three-way valve (full recirculation of radiant floor loops).

D. Radiant Floor Heating System Monitoring and Alarm:

1. Zone circulator pump trouble alarms:

   a. Provide current sensing (analog) for pump.
   b. Generate “PMP-6 Failure” alarm if pump fails to operate when command to start from the BAS.

2. High Temperature Alarms:

   a. If zone supply temperature water exceeds 130 degrees F, generate a “Radiant Floor High Supply Water Temperature” alarm.
   b. If any slab temperature sensor exceeds 90 degrees F, generate a “Radiant Floor High Floor Temperature” alarm.

3.14 HYDRONIC HEATING SYSTEM DEVICES

A. AHU Heating Coils (AHU-1 through AHU-4): See ventilation system control sequences.

B. Zone VAV Terminal Reheat Coils (AHU-1 through AHU-4): See ventilation system control sequences.

C. Finned Tube Radiators: See ventilation system control sequences.

D. Radiant Ceiling Panels:

1. Radiant ceiling panel included with zone VAV terminal unit control: See ventilation system control sequences.

2. Stand-alone radiant panel:

   a. Occupied Mode: Modulate radiant ceiling panel control valve to maintain the zone occupied space temperature setpoint plus or minus 1-degree F.
   b. Unoccupied Mode: Modulate radiant ceiling panel control valve to maintain the zone unoccupied space temperature setpoint plus or minus 1-degree F.

E. Cabinet Unit Heaters:

1. At 65 degrees F and decreasing, start recirculating fan and open hydronic control valve.

2. At 68 degrees F and increasing, stop recirculating fan and shut hydronic control valve.

F. Hydronic Unit Heaters:

1. At 65 degrees F and decreasing, start recirculating fan and open hydronic control valve.

2. At 68 degrees F and increasing, stop recirculating fan and shut hydronic control valve.

3.15 HYDRONIC COOLING SYSTEM OPERATION

A. Description:

1. The hydronic cooling system consists of a chiller (CH-1) sized for 100 percent of the building's design cooling load. The cooling distribution system is arranged in a primary only piping arrangement.

2. One set of constant speed circulation pumps (PMP-4A and PMP-4B), arranged in parallel and each sized for 100 percent system zone flow, provide circulation to AHU cooling coils. AHU cooling coils have three-way valves to modulate fluid flow through the coil in order to maintain the supply air temperature setpoint.

3. The hydronic cooling system utilizes a 40 percent propylene glycol/water mixture to transfer heat. A packaged glycol make-up tank (GM-1) maintains system pressure and automatically makes up any fluid lost.

B. Full Shutdown Mode (Initial conditions):

1. Chiller (CH-1) is disabled.

2. Circulation pumps (PMP-4A and PMP-4B) are disabled.

C. Operating Mode:

1. System Start-up:

   a. When one AHU calls for mechanical cooling by modulating its cooling coil three-way valve partially open (flow to coil), enable cooling system circulation pump.

b. Allow pump to operate for 3 minutes to equalize system temperature.
c. After three minutes, enable chiller to operate to maintain cooling system supply temperature setpoint.

2. Lead/Lag Control:

a. Provide lead/lag control for cooling loop pumps.
b. Alternate lead loop pump monthly during the cooling season.

3. Chiller Operation: The chiller utilizes packaged controls to maintain the chilled glycol supply temperature setpoint of 44 degrees F.

4. Coil Operation: See ventilation system control sequences.

D. Hydronic System Monitoring and Alarm:

1. Chiller alarm:

a. Monitor chiller dry contact.
b. Generate "Chiller Trouble" general alarm if the chiller goes into an alarm condition.

2. Circulation pump trouble alarms:

a. Provide current sensing (analog) for each pump.
b. Generate "Cooling Loop Pump Failure" alarm if lead pump fails to run when enabled by the BAS.
c. Generate "Cooling Loop Pump Critical Failure" alarm if standby pump fails to run when enabled by the BAS after a lead pump failure.
d. Generate "Cooling Loop Pump Trouble" alarm if both pumps are running.

3. Hydronic Cooling System High Temperature Alarm:

a. Monitor the glycol supply temperature with an analog temperature sensor.
b. Generate a "Hydronic Cooling System High Temperature" alarm if the system temperature increases 3 degrees F above the setpoint temperature for more than 60 seconds.

4. Hydronic Cooling System Low Pressure Alarm:

a. Monitor the cooling loop system pressure with an analog pressure sensor.
b. Generate a "Hydronic Cooling System Low Pressure" alarm if the system pressure falls below 10 PSIG.

3.16 HEAT RECOVERY SYSTEM

A. General System Description:

1. A runaround coil loop energy recovery system removes energy from the dental area's exhaust air stream (heat recovery coil RC-4B). This energy is used to preheat AHU-4 incoming outdoor air (heat recovery coil RC-4A). In addition, heat exchanger HX-1 can

add energy into the runaround loop to provide additional preheat capability when the heat recovery alone is insufficient, and to provide freeze protection.

2. Primary/standby pumps (PMP-5A and PMP-5B) circulate fluid through the loop, varying speed to match load conditions. Fluid makeup and pressure control is provided by glycol makeup unit GM-2 and expansion tank ET-3. Fluid is 40 percent ethylene glycol / 60 percent water.

B. Pump speed control (PMP-5A and PMP-5B):

1. Provide lead/lag control for heat recovery loop circulators. Alternate lead loop pump monthly during the heating season.

2. Start lead heat recovery circulator pump at full speed whenever AHU-4 supply and exhaust fans are operating.

3. Operate circulator pumps with lead pump in "run" and standby pump in "standby." In the event of VSD failure, enable and run standby pump.

4. Run pump at full speed except during conditions described below.

5. During warmer weather, modulate pump speed to maintain RC-4A leaving air temperature (LAT) of 55 degrees F. Stop pump if pump is at minimum speed and LAT rises above setpoint.

C. Preheat temperature and frost protection control (HX-1):

1. Modulate hydronic heating 3-way control valve for HX-1 to maintain minimum RC-4B coil entering fluid temperature (EFT) of 30 degrees F to avoid frost buildup on the coil. The intent is to maximize recovery potential by keeping EFT as low as possible without frosting coil.

2. Provide operator override ability to change control of HX-1 to meet RC-4A LAT setpoint listed above. This will have the effect of reducing the amount of heat recovery and increasing the HX-1 load, but will provide additional heating capacity if needed.

D. Monitoring and Alarms:

1. Monitor the following points:

   a. Coil RC-4A Entering Air Temperature (EAT) and LAT. NOTE: Coil RC-4A EAT is the outdoor air temperature and may be mapped in from the outdoor air temperature sensor.
   b. Coil RC-4B EAT, LAT, and EFT.

2. Heat recovery system pump trouble alarms (PMP-5A and PMP-5B):

   a. Provide current sensing (analog) for each pump.
   b. Generate "Heat Recovery System Pump Failure" alarm if lead pump fails to run when enabled by the BAS.

c. Generate "Heat Recovery System Pump Critical Failure" alarm if standby pump fails to run when enabled by the BAS after a lead pump failure.
d. Generate "Heat Recovery System Pump Trouble" alarm if both pumps are running.

3. Generate alarms for the following conditions:

a. Coil RC-4A:
1). LAT less than or equal to 34 degrees F.
2). Alarm message to read "Heat recovery coil RC-4A low air temperature, check operation of frost protection controls".

b. Glycol makeup system (GM-2):
1). Provide low level alarm.
2). Alarm message to read "Check heat recovery system glycol tank level".

c. Heat Recovery System Low Pressure Alarms:
1). Monitor system pressure with an analog pressure sensor.
2). Generate a "Heat Recovery System Low Pressure" alarm if the system pressure falls below 5 PSIG.

3.17 PLUMBING

A. Domestic Water Heater (WH-1A and WH-1B):

1. Utilize packaged water heater controls.

2. Set aquastat to 140 degrees F.

3. Monitoring and Alarms:

a. Provide fluid temperature sensors in discharge piping on both water heaters to monitor domestic hot water supply temperature.
b. If hot water supply temperature increases above 140 degrees F for a period of 5 minutes, provide "High Domestic Hot Water Temperature" alarm.
c. If hot water supply temperature decreases below 130 degrees F for a period of 5 minutes, provide "Low Domestic Hot Water Temperature" alarm.

B. Domestic Hot Water Circulation Pump (PMP-P1):

1. Provide hot water circulation temperature sensor in return piping located outside of the level 1 Mechanical Room.

2. If return water temperature decreases below 115 degrees F, enable circulation pump.

3. If return water temperature increases above 120 degrees F, disable circulation pump.

C. Elevator Sump Pump (PMP-P2).

1. The elevator sump pump operates automatically on high elevator sump water level utilizing a packaged float switch.

2. Provide BAS alarm monitoring point for the sump pump controller (utilizing controller relay connection).

3. Provide "Elevator Sump Pump High Water" alarm upon activation of high level float.

4. Provide "Elevator Oil Detection" alarm upon activation of sump pump oil sensing probe.

3.18 FUEL OIL

A. The fuel oil transfer system utilizes packaged controls to transfer fuel from the above ground storage tank (AST-1) to the interior day tank (DT-1) using a remote fuel oil transfer pump (RFP-1).

B. Monitoring and Alarms:

1. Provide "Underground fuel oil leak" alarm upon detection of fuel in either containment sump by leak detector sensors.

2. Provide BAS alarm monitoring point for the day tank controller. Provide "Day Tank Trouble" alarm upon activation of any day tank alarm.

END OF SECTION 259000