SECTION 23 09 05 - SEQUENCE OF OPERATIONS – HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences. Sequence of operation is hereby defined as the manner and method by which various controls and systems function.

B. The requirements for the operation of each type of control system are specified in this section and/or on the contract drawings.

1.3 SUBMITTALS

A. The control system supplier/installer shall review all HVAC equipment shop drawings prior to their shop drawing submission. The supplier shall note in the submission that all relative shop drawings have been reviewed prior to submission to the engineer.

B. Shop Drawings: Submit shop drawings containing the following information:

1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and control devices.
2. Label each control device with setting or adjustable range of control.
3. Indicate difference between factory and field wiring.
4. Indicate each control panel required, with internal and external piping and wiring clearly indicated. Provide detail of panel face, including controls, instruments, and labeling.
5. Include verbal description of sequence of operation.
6. Maintenance Data: Include copy of all shop drawings in each maintenance manual.
7. When preparing submittals and programming, use a room number schedule generated by the architect and/or the owner, which indicates the actual room numbers that will be used when the building is occupied. If the schedule is not available, revise the initial submittal when a schedule is available, to reflect the proper room numbers.

PART 2 - PRODUCTS

2.1 Not Applicable

PART 3 - EXECUTION

3.1 BUILDING MANAGEMENT SYSTEM

A. The BMS shall include all hardware, software and programming required to fully execute all control sequences and monitor all control points described in this specification. The BMS shall have the capabilities to perform the control strategies, energy management functions, and building management functions. All BMS software shall reside on the Operator Workstation to be located within the building at a location to be determined.

1. Set Point Control: The BMS shall have full editing capabilities for any set point listed in these control sequences regardless of whether set point control logic resides in a local control unit or the building management software. All controls shall be capable of fully executing all control sequences in the event of a communication loss between the BMS operator workstation and any local control unit(s).
2. Operating Mode Control: The BMS shall have full 24-hour / 365-day scheduling capabilities for occupied/unoccupied modes of operation for all systems regardless of whether sequencing logic resides in a local control unit or the building management software. Provide programming that utilizes various global commands for zoning portions of the building as required by the owner. The control system shall be capable of fully executing all schedule sequences in the event of a communication loss between the operator workstation and any local control unit(s).
3. Control Offset: The BMS shall be capable of offsetting the control set points for any heating/cooling system equipment by an operator adjustable amount. This capability will allow for automatic set point changes based on system requirements, such as demand limiting.
4. Alarm Management: The BMS shall monitor, buffer, and direct alarm reports to operator devices and memory files. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three (3) priority levels shall be provided. Each local control unit as well as the BMS software shall be capable of performing distributed, independent alarm analysis and filtering based on priority level.

    a. The conditions under which alarms need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date shall be definable by the user.
    b. Report Routing: Alarm, reports, messages, and files will be directed to a user-defined list of operator devices for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.
    c. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.
    d. Auto-Dial Alarm: The user shall define which critical alarms shall initiate a call to a remote operator device.

5. Historical Data and Trending: The BMS shall be capable of automatically sampling, storing, and displaying system data and as a minimum do so in the flowing ways:

    a. Continuous Point Histories: A point history routine shall continuously and automatically sample the value of all analog and binary inputs and outputs at fifteen-minute intervals. Samples shall be stored for the past 72 hours to allow the user to immediately analyze equipment performance and all problem-related events. History files shall include a continuous record of the last ten status changes or commands for each point.
    b. Control Loop Performance Trends: Operator adjustable resolution sampling of 10-300 seconds in 1-second increments for verification of control loop performance.
    c. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting performance data over extended periods of time. Sample intervals of 1-minute to 2-hours, in 1-minute intervals, shall be provided.

d. Data Storage and Archiving: Trend data shall be uploaded from local unit controllers to the Operator Workstation at user-defined intervals or when the trend buffers become full. All trend data shall be available in disk file form for use in third party personal computer applications.

6. Totalization: The BMS shall be capable of automatically sampling, storing, and displaying totals as follows:

a. Runtime: Automatically accumulate, store, and display runtime hours for binary input and output points as specified in sequence of operations specifications. The totalization routine shall have a sampling resolution of 1-minute or less. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
b. Analog/Pulse: Automatically sample, calculate, store and display consumption totals on a daily basis for user selected analog and binary pulse input-type points. The totalization routine shall have a sampling resolution of 1-minute or less. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
c. Event: Automatically count, store, and display event occurrences (such as the number of times a pump or fan system is cycled) on a daily basis for user selected events.

3.2 TEMPERATURE SETTINGS

A. All temperatures shown in the control sequences are indicated in degrees Fahrenheit. The temperature settings shall be fully adjustable through the use of simple key stokes on the operator work station.

B. Unless otherwise indicated in the sequences the initial settings are to be as follows:

1. Unoccupied heating: 60 degrees F.
2. Unoccupied cooling: 80 degrees F.
3. Occupied heating: 70 degrees F.
4. Occupied cooling: 75 degrees F.
5. Space humidity: 58%.

3.3 BOILER SYSTEM

A. The boilers and lead heating system pump will be enabled by the BMS when the outside air temperature is below 60 deg. F (adjustable) or manually enabled at through the BMS.

B. A Boiler Sequence Control System (BSCS) will be provided by the boiler manufacturer. Refer to the project's applicable Boiler Specification Section.

C. The BSCS will energize the lead system pump. The BMS shall modulate the system pump VFD to maintain system differential pressure. Utilize the electronic flow meter in the piping system to ensure the minimum flow is maintained to each operating boiler. The minimum flow rate will vary depending on the number of energized boilers and the flow rate required by the boiler manufacture. Verify the required minimum flow with the boiler manufacture.

D. The BSCS will control the leaving water temperature at each boiler and sequence the boilers to operate, as needed to optimize the efficiency of the system.

E. When the system pump is operating at the required minimum flow rate and the system pressure is above set point, modulate the differential pressure by-pass valve to maintain system differential pressure.

F. Provide controls to monitor and record make-up water flow from the domestic water system to the heating system.

G. Emergency Burner Control: Provide a complete operational system with shut-down switches, as required by the PA Labor and Industry Code, at all exit doors, to interrupt power to the controls feed and the appliances electric power feed to all fuel fired equipment located within the boiler room. This shall include both boilers and both existing water heaters.

H. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator work station:

1. Boiler status, each boiler: indication and alarm.
2. System pump status, each pump: indication and alarm.
3. System pump speed, each pump: indication and alarm.
4. Heating supply and return water temperature, each boiler: indication.
5. Common heating supply and return water temperature: indication.
6. Heating system flow in g.p.m - indication.
7. System bypass valve position: indication.
8. System differential pressure: indication, adjustment, and alarm.
9. Boiler room temperature: indication.
10. Boiler room temperature set point: indication and adjustment.
11. Make-up flow (gallons) from the domestic water system: indication.
12. Display all control points available through the BACnet interface furnished with the boiler control system.

3.4 CHILLER SYSTEM

A. The chilled water system consists of a new chiller (CHLR-1), an existing to remain chiller (CHLR-2), two sets of primary chilled water pumps (P-3A/B and P-4A/B), and a set of secondary chilled water pumps (P-2A/B).

B. The chillers and chilled water pumps will be enabled by the BMS when the outside air temperature is above a fully adjustable set point or when manually enabled at the operator workstation.

C. Primary chilled water pumps (P-3A/B and P-4A/B) shall operate at constant volume to provide required flow through their associated chiller. Secondary system pumps (P-2A/B) shall provide flow to all chilled water coils throughout the building and modulate based system differential pressure.

D. The chillers and system pumps shall operate to maintain a chilled water supply temperature of 42 deg. F (adjustable). The chillers shall stage in the flowing order.

1. Stage 1: CHLR-1 only.
2. Stage 2: CHLR-2 only.
3. Stage 3: CHLR-1 and 2.

E. On a call for cooling, start primary chilled water pump (P-4A/B) and secondary chilled water pump (P-2A/B). When flow is proven start the chiller CHLR-1. If this chiller is unable to maintain the chilled water system setpoint for a period of 10-minutes (adj.), start primary chilled water pump (P-3A/B). When flow is proven start the chiller CHLR-2 and commanded off CHLR-1. After a brief delay, primary chilled water pump (P-4A/B) can be commanded off. If additional chilled water capacity is required, repeat the startup procedure to operate CHLR-1 simultaneously with CHLR-2.

F. The BMS shall display the following monitoring points on a custom graphic at the operator work station:

1. Chiller status, each chiller: indication and alarm.
2. Primary system pump status, each pump: indication and alarm.
3. Secondary system pump status, each pump: indication and alarm.
4. Secondary system pump speed, each pump: indication and alarm.
5. Chilled water flow in G.P.M: indication
6. Chilled water supply and return temperature, each chiller: indication and adjustment.
7. Secondary chilled water supply and return temperature: indication.
8. System bypass valve position: indication.
9. System differential pressure: indication, adjustment, and alarm.

3.5 HVAC SYSTEM PUMPS

A. The HVAC system pumps shall be controlled by the BMS.

B. Provide The HVAC system heating pumps shall be controlled by the BMS.

C. Provide lead / standby controls for all redundant pumps. In the event the led pump fails, start the lag pump and alarm the system. Provide for a fully adjustable schedule to alternate the lead and standby pumps.

D. Provide the required number of sensors in the piping loop to control the pump VFD's and control the system by-pass valve as necessary for the heating and cooling systems.

E. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator workstation:

1. HVAC pump status: indication, adjustment, and alarm.
2. Lead / Stand-by pump status - indication, adjustment, and alarm.
3. System by-pass valve position: indication.
4. System differential pressure: indication, adjustment, and alarm.

3.6 MODULAR AIR HANDLING UNITS: AHU-1, 2, 3, AND 4

A. The system is a single zone variable air volume system. The air handling unit contains a variable speed supply, chilled-water cooling coil, hydronic pre-heat coil, hydronic reheat coil, filters, air flow monitoring, and bipolar ionization air purification, as well as other components.

B. The unit shall be controlled by the BMS and shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start/stop programming.

C. Provide a temperature/humidity sensor with adjustable set points. The minimum and maximum set points shall be set through the BMS.

D. Freeze Protection: Provide a freeze stat, with manual reset, serpentined across the leaving air side of the heating coil and provide programming per the following sequence if the leaving air temperature falls below 35 deg. F. (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers and open the return air damper.
3. Fully open the heating coil control valve.
4. Stop the fan.

E. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

F. Provide fully modulating heating valves that are to fail in the open position. Control valves on the duct mounted reheat coils shall fail in the last position. Provide fully modulating cooling valves that are to fail in the last position. Outdoor air dampers and relief vent dampers are to fail in the closed position with return dampers failing in the open position.

G. Provide a transducer to monitor and record pressure drop across the MERV 13 filters in the air-handling unit. An alarm will be activated at the BMS workstation if the actual filter pressure drop exceeds the dirty filter pressure drop established by the TAB Contractor.

H. Provide CO2 Control. Use standard factory calibrated CO2 sensors in locations shown on the drawings or as indicated in sequence of operations.

I. Unoccupied heating cycle:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature falls below the unoccupied set point temperature of 60 deg. F. (adjustable) start the supply fan at full speed and open the preheat coil control valve to provide a 95 deg. F. leaving air temperature.
3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.

J. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off and the outside air damper closed. The second choice is for a higher space cooling set point, which is described as follows:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature rises above the unoccupied set point of 80 deg. F. (adjustable) start the supply fan at the minimum speed and open the cooling coil control valve to supply a 54 deg. F. leaving air temperature. If required to maintain space temperature slowly increase the fan speed and simultaneously modulate open the cooling coil control valve to maintain a 54 deg. F. (adjustable) leaving air temperature.
3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.
4. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). Close the chilled water coil control valve when the system is in an economizer mode.

K. Occupied heating cycle:

1. Warm-up: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain the space temperature. Modulate the preheat coil control valve in unison with the supply fan VFD, to maintain a leaving air temperature of 95 deg. F. (adjustable).

3. Provide ventilation control per the CO2 sequence.

L. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain space temperature. The cooling coil control valve shall modulate in unison with the supply fan to maintain a 54 deg. F. (adjustable) leaving air temperature.
3. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). Close the chilled water coil control valve when the system is in an economizer mode.
4. Provide ventilation control per the CO2 sequence.

M. CO2 Ventilation Control: Provide ventilation control during the occupied cycles. When the space is indexed to the occupied cycle open the outdoor air damper to minimum outdoor airflow as indicated on the drawings. If the space CO2 controller senses an increased CO2 level above 800 p.p.m. slowly modulate open the outside air damper to maintain the space CO2 level below 1000 p.p.pm. At any time during the occupied cycle the outdoor air damper shall not open past the position to allow more than the scheduled amount of design outside air, as indicated on the drawing schedule, unless the unit is in an economizer cycle. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable).

N. Makeup Air Ventilation Control (AHU-1 and 2 only): Anytime the kitchen cooking hood exhaust fan (KEF-1) is operating, provide ventilation at the design outdoor airflow indicated on the schedule in order to provide makeup air for the kitchen.

O. Dehumidification: At any time the space humidity is above 60% RH, run the supply fan at cooling airflow, open the cooling coil control valve to provide a 54 deg. F. (adjustable) leaving air temperature and modulate open the duct-mounted reheat coil control valve to maintain the space temperature set point. When the space humidity level falls below 55% RH, reverse the sequence. Dehumidification shall be available during unoccupied cycles with the outdoor air damper closed.

P. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator work station:

1. System status (Occupied / Unoccupied): indication and adjustment.
2. Supply fan status: indication, adjustment, and alarm.
3. V.F.D. status: indication and alarm.
4. Preheat coil control valve position: indication and adjustment.
5. Cooling coil control valve position: indication and adjustment.
6. Reheat coil control valve position: indication and adjustment.
7. Supply air temperature: indication and adjustment.
8. Return air temperature: indication.
9. Mixed air temperature: indication
10. Outdoor air c.f.m.: indication.
11. Smoke detector status: indication and alarm.
12. Freezestat status: indication and alarm.
13. Filter differential pressure: indication and alarm.

14. Building pressurization: indication and adjustment.
15. Space temperature set point: indication and adjustment.
16. Space temperature: indication and alarm.
17. Space humidity set point: indication, adjustment.
18. Space humidity level: indication and alarm.
19. Space CO2 set point: indication and adjustment.
20. Space CO2 level: indication and alarm.
21. Bipolar Ionization generator status: indication, and alarm.
22. Economizer: indication.

3.7 PACKAGED ENERGY RECOVERY UNITS (DOAS): ERU-1 THRU 10

A. The roof mounted energy recovery units and systems provide ventilation air to various areas in the building. Each unit contains compressors, DX cooling coil, hot-gas reheat coil, hydronic heating coil, energy recovery wheel, supply fan, exhaust fan, filters, and other components.

B. Control of the units will be through the BMS system with all controls furnished by the BMS supplier / Installer. The units shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start/stop programing.

C. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

D. Provide a modulating heating control valve that fails in the open position. Outdoor air dampers are to fail in the closed position with return dampers failing in the open position.

E. Provide an analog pressure transducer to monitor and record pressure drop across the final filters in the air-handling unit. An alarm will be activated at the BMS workstation if the actual filter pressure drop exceeds the dirty filter pressure drop established by the TABC.

F. The unit(s) will be off during the unoccupied cycle and will not operate under any conditions.

G. Freeze Protection: Provide a freeze stat, with manual reset, serpentined across the leaving air side of the heating coil. Provide programming per the following sequence if the leaving air temperature falls below 35 deg. F (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers.
3. Fully open the heating coil control valve.
4. Stop the fans.

H. Provide controls to detect and eliminate frost accumulation on the energy recovery wheel.

I. Occupied cycle:

1. At an adjustable predetermined time, the BMS will index the respective unit to an occupied status.
2. When the outdoor air temperature is below 40 degrees F. (adjustable) at the start of this cycle the unit will operate in a warm-up mode as follows:

    a. The supply fan will energize and the exhaust fan will remain off. The outdoor air damper will remain closed with the unit's return bypass damper open. The energy recovery wheel will remain off.

b. The hydronic heating valve shall modulate to maintain provide a 95-degree F. (adjustable) leaving air temperature. When the space temperature reaches the fully adjustable occupied set point the unit will operate in the occupied cycle.

3. When the outdoor air temperature is above 80 degrees F. (adjustable) at the start of this cycle the unit will operate in a cool down mode as follows:

   a. The supply fan will energize and the exhaust fan will remain off. The outdoor air damper will remain closed with the unit's return bypass damper open. The energy recovery wheel will remain off.
   b. The DX cooling shall modulate to maintain 54-degree F (adjustable) leaving air temperature. When the return air temperature unit reaches 75 degrees F. (adjustable) the unit will operate in the occupied cycle.

4. During the occupied cycle the supply and exhaust fans shall run continuously.
5. The DX cooling and hydronic heating shall each modulate to maintain the required leaving air temperature. The leaving air temperature will be fully adjustable, through simple key strokes at the operator work station, and shall be based on outside air temperature. Provide a temperature sensor located in the supply duct to monitor the leaving air temperature. The initial settings for leaving air temperature shall be as follows:

   a. O A temperature higher than 80 degrees F. - 70-degree F. leaving air temperature.
   b. O A temperature 50 to 79 49 degrees F. - 73 degree leaving air temperature.
   c. O A temperature lower than 49 degrees F. - 75 degree leaving air temperature.

6. Energy Recovery: During occupied cycles, energize the energy recovery wheel when the outdoor air temperature is below 50 deg. or above 75 deg. F. The temperature set points are to be adjustable. When the wheel is on, all outdoor air will flow through the energy recovery wheel.
7. Energize the hot gas reheat when necessary to maintain the required leaving air temperature/humidity.
8. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor spaces, allow the unit to operate in an economizer mode. The exhaust fan shall modulate to maintain a set building differential pressure with relationship to the atmosphere of +0.02" w.c. (adjustable). Fully open the energy recovery wheel (ERW) bypass dampers, configure the ERW to operate in a stop/jog sequence, stop the wheel for 30 minutes, then restart the wheel and run it for 5 minutes. Continue to repeat this sequence while unit remains in economizer cooling. Once conditions are no longer acceptable to operate in economizer cooling, fully close the ERW bypass dampers, and return the unit back to mechanical unoccupied cooling.

J. The BMS shall display the following monitoring points on a custom graphic at the operator workstation:

1. System status - indication and adjustment.
2. Supply fan status - indication and alarm.
3. Exhaust fan status – indication and alarm.
4. V.F.D. status (both fans): indication and alarm.
5. Cooling coil supply air temperature (d.b. and w.b.) - indication and adjustment.
6. Unit supply air temperature (d.b. and w.b.) - indication and adjustment.
7. DX cooling status - indication and alarm.
8. DX cooling modulation - indication and alarm.
9. Heating coil control valve position: indication and adjustment.
10. Hot-gas reheat status – indication.
11. Energy recovery wheel status – indication.
12. Energy recovery wheel mixed-air-temperature: indication.
13. Energy recovery wheel leaving air temperature: indication.
14. Outdoor air damper position: indication.

15. Energy recovery wheel bypass damper position: indication.
16. Outdoor air temperature – indication.
17. Return air temperature: indication.
18. Smoke detector status - indication and alarm.
19. Filter differential pressure: indication and alarm.
20. Economizer status: indication.
21. Bipolar Ionization generator status: indication, and alarm.
22. Freezestat status: indication and alarm.

3.8 PACKAGED ENERGY RECOVERY UNITS: ERU-11 AND 12

A. The packaged energy recovery units are single zone units and contains compressors, DX cooling coil, hot-gas reheat coil, hydronic heating coil, energy recovery wheel, supply fan, exhaust fan, filters, and other components.

B. Control of the units will be through the BMS system with all controls furnished by the BMS supplier / Installer. The units shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start/stop programing.

C. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

D. Provide a modulating heating control valve that fails in the open position. Outdoor air dampers are to fail in the closed position with return dampers failing in the open position.

E. Provide an analog pressure transducer to monitor and record pressure drop across the final filters in the air-handling unit. An alarm will be activated at the BMS workstation if the actual filter pressure drop exceeds the dirty filter pressure drop established by the TABC.

F. Provide return air and room temperature and humidity sensors to control the unit. The minimum and maximum space set points shall be set at the operator work station.

G. Freeze Protection: Provide a freeze stat, with manual reset, serpentined across the leaving air side of the heating coil. Provide programming per the following sequence if the leaving air temperature falls below 35 deg. F (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers.
3. Fully open the heating coil control valve.
4. Stop the fans.

H. In unoccupied modes provide controls to monitor the temperature in the mixed air section of the air handling unit. When the outdoor air temperature is below 35 deg. F. (adjustable) and the temperature in the mixed air section falls below 35 deg. open the heating coil control valve to maintain a temperature of 40 Deg. F (adjustable) in the unit section.

I. Provide controls to detect and eliminate frost accumulation on the energy recovery wheel.

J. Unoccupied heating cycle:

1. The supply and exhaust fans will be off, the outdoor air damper closed and the return air damper open. The energy recovery wheel will be off.
2. When the space temperature falls below the fully adjustable unoccupied set point temperature of 60 deg. F. start the supply fan at full speed and open the heating coil control valve to provide a 95

deg. F. leaving air temperature. When the unoccupied set point temperature has been restored, reverse the above sequence.

3. The outside air damper will remain closed. The return air damper shall remain fully open. The energy recovery wheel and exhaust fan will remain off. The return air flow will bypass the energy recovery wheel. When setback temperature has been restored, reverse this sequence.

K. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off and the outside air damper closed. The second choice is for a higher space cooling set point, which is described as follows:

1. The supply fan and exhaust fans will be off, the outdoor air damper closed and the return air damper open. The energy recovery wheel will be off.
2. When the space temperature rises above the unoccupied set point of 80 deg. F. (adjustable) start the supply fan at low speed and energize the DX cooling to supply a 54 deg. F. leaving air temperature. If required to maintain space temperature, slowly increase the fan speed and increase the DX cooling to maintain a 54 deg. F. (adjustable) leaving air temperature.
3. The outside air damper will remain closed. The return air damper shall remain fully open. The energy recovery wheel and the exhaust fan will remain off. The return air flow will bypass the energy recovery wheel. When setback temperature has been restored, reverse this sequence.

L. Occupied heating cycle:

1. Warm-up: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the return air temperature reaches the occupied set point, the unit will operate in the occupied cycle.
2. During the occupied cycle the supply and exhaust fans shall run continuously.
3. Modulate the heating coil control valve to maintain return air temperature setpoint.
4. The outdoor air damper will be open to allow full ventilation air.

M. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status. At this time, the unit will operate in the same mode as the unoccupied cooling cycle. When the return air temperature reaches the occupied set point, the unit will operate in the occupied cooling cycle.
2. During the occupied cycle the supply and exhaust fans shall run continuously.
3. When the return air temperature is above setpoint, modulate the DX cooling to maintain a discharge air temperature of 54 deg. F. (adjustable).
4. The outdoor air damper will be open to allow full ventilation air.

N. Energy Recovery: during occupied cycles when ventilation air is required, energize the energy recovery wheel when the outdoor air temperature is below 50 deg. or above 60 deg. F. The temperature set points are to be fully adjustable. All outdoor air will flow through the energy recovery wheel. Position the bypass dampers in the energy recovery section as required.

O. Dehumidification: At any time the space humidity is above the set point, run the supply fan at full speed, energize the DX cooling to provide a 54 deg. F. (adjustable) leaving air temperature and energize the hot-gas reheat to maintain the space temperature set point. When the space humidity level falls below the space sensor set point reverse the sequence. Dehumidification shall be available during unoccupied cycles with the outdoor air damper closed.

P. The BMS monitor, record and display the following monitoring points on a custom graphic at the operator work station:

1. System status - indication and adjustment.

2. Supply fan status - indication and alarm.
3. Exhaust fan status – indication and alarm.
4. V.F.D. status (both fans): indication and alarm.
5. Cooling coil supply air temperature (d.b. and w.b.) - indication and adjustment.
6. Unit supply air temperature (d.b. and w.b.) - indication and adjustment.
7. DX cooling status - indication and alarm.
8. DX cooling modulation - indication and alarm.
9. Heating coil control valve position: indication and adjustment.
10. Hot-gas reheat status – indication.
11. Energy recovery wheel status – indication.
12. Energy recovery wheel mixed-air-temperature: indication.
13. Energy recovery wheel leaving air temperature: indication.
14. Outdoor air damper position: indication.
15. Energy recovery wheel bypass damper position: indication.
16. Outdoor air temperature – indication.
17. Return air temperature: indication.
18. Smoke detector status - indication and alarm.
19. Filter differential pressure: indication and alarm.
20. Economizer status: indication.
21. Bipolar Ionization generator status: indication, and alarm.
22. Freezestat status: indication and alarm.

3.9 PACKAGED OUTDOOR DX AIR HANDLING UNITS: RTU-1

A. The system is a single zone variable air volume system. The packaged air handling unit contains a variable speed supply fan, DX cooling, gas furnace, duct-mounted hydronic reheat coil, filters, air flow monitoring, and bipolar ionization air purification, as well as other components.

B. The unit shall be controlled by the BMS and shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start/stop programming.

C. Provide a temperature/humidity sensor with adjustable set points. The minimum and maximum set points shall be set through the BMS.

D. Freeze Protection: Provide a freeze stat, with manual reset, serpentined across the leaving air side of the heating coil and provide programming per the following sequence if the leaving air temperature falls below 35 deg. F. (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers and open the return air damper.
3. Fully open the heating coil control valve.
4. Stop the fan.

E. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

F. Provide a 3-way. fully modulating, control valve that fails in the last position for the duct-mounted reheat coil. Outdoor air dampers are to fail in the closed position and return dampers shall fail in the open position.

G. Provide a transducer to monitor and record pressure drop across the MERV 13 filters in the air-handling unit. An alarm will be activated at the BMS workstation if the actual filter pressure drop exceeds the dirty filter pressure drop established by the TAB Contractor.

H. Provide CO2 Control. Use standard factory calibrated CO2 sensors in locations shown on the drawings or as indicated in sequence of operations.

I. Unoccupied heating cycle:

1. The air handling unit fans will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature falls below the unoccupied set point temperature, start the supply fan at full speed and open the reheat coil control valve to provide a 95 deg. F. leaving air temperature. If the reheat coil is unable to provide the desired leaving air temperature, modulate the gas furnace as well.
3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.

J. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off and the outside air damper closed. The second choice is for a higher space cooling set point, which is described as follows:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature rises above the unoccupied set point, start the supply fan at the minimum speed and modulate the DX cooling to supply a 54 deg. F. leaving air temperature. If required to maintain space temperature slowly increase the fan speed and simultaneously modulate the DX cooling to maintain a 54 deg. F. (adjustable) leaving air temperature.
3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.
4. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the exhaust fan to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). DX cooling shall not be available when the system is in an economizer mode.

K. Occupied heating cycle:

1. Warm-up: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain the space temperature. Modulate the reheat coil control valve in unison with the supply fan VFD, to maintain a leaving air temperature of 95 deg. F. (adjustable). If the hydronic reheat coil is unable to provide the desired leaving air temperature, modulate the gas furnace in addition to the reheat coil.
3. Provide ventilation control per the CO2 sequence.

L. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain space temperature. The DX cooling shall modulate in unison with the supply fan to maintain a 54 deg. F. (adjustable) leaving air temperature.

3. The exhaust fan shall remain off, except when required for economizer cooling.
4. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the exhaust fan to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). DX cooling shall not be available when the system is in an economizer mode.
5. Provide ventilation control per the CO2 sequence.

M. CO2 Ventilation Control: Provide ventilation control during the occupied cycles. When the space is indexed to the occupied cycle open the outdoor air damper to minimum outdoor airflow as indicated on the drawings. If the space CO2 controller senses an increased CO2 level above 800 p.p.m. slowly modulate open the outside air damper to maintain the space CO2 level below 1000 p.p.pm. At any time during the occupied cycle the outdoor air damper shall not open past the position to allow more than the scheduled amount of design outside air, as indicated on the drawing schedule, unless the unit is in an economizer cycle. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable).

N. Dehumidification: At any time the space humidity is above 60% RH, run the supply fan at cooling airflow, modulate the DX cooling to provide a 54 deg. F. (adjustable) leaving air temperature and modulate open the duct-mounted reheat coil control valve to maintain the space temperature set point. When the space humidity level falls below 55% RH, reverse the sequence. Dehumidification shall be available during unoccupied cycles with the outdoor air damper closed.

O. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator work station:

1. System status (Occupied / Unoccupied): indication and adjustment.
2. Supply fan status: indication, adjustment, and alarm.
3. V.F.D. status: indication and alarm.
4. DX cooling status: indication and adjustment.
5. Gas furnace status: indication and alarm.
6. Reheat coil control valve position: indication and adjustment.
7. Supply air temperature, leaving unit: indication and adjustment.
8. Supply air temperature, leaving reheat coil: indication and adjustment.
9. Return air temperature: indication.
10. Mixed air temperature: indication
11. Outdoor air c.f.m.: indication.
12. Smoke detector status: indication and alarm.
13. Freezestat status: indication and alarm.
14. Filter differential pressure: indication and alarm.
15. Building pressurization: indication and adjustment.
16. Space temperature set point: indication and adjustment.
17. Space temperature: indication and alarm.
18. Space humidity set point: indication, adjustment.
19. Space humidity level: indication and alarm.
20. Space CO2 set point: indication and adjustment.
21. Space CO2 level: indication and alarm.
22. Bipolar Ionization generator status: indication, and alarm.
23. Economizer: indication.

3.10 PACKAGED OUTDOOR DX AIR HANDLING UNITS: RTU-2 AND 3

A. The system is a single zone variable air volume system. The packaged air handling unit contains a variable speed supply fan, DX cooling, hydronic reheat coil, filters, air flow monitoring, and bipolar ionization air purification, as well as other components.

B. The unit shall be controlled by the BMS and shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start/stop programming.

C. Provide a temperature/humidity sensor with adjustable set points. The minimum and maximum set points shall be set through the BMS.

D. Freeze Protection: Provide a freeze stat, with manual reset, serpentined across the leaving air side of the heating coil and provide programming per the following sequence if the leaving air temperature falls below 35 deg. F. (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers and open the return air damper.
3. Fully open the heating coil control valve.
4. Stop the fan.

E. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

F. Provide fully modulating heating valves that are to fail in the open position. Outdoor air dampers and relief vent dampers are to fail in the closed position with return dampers failing in the open position.

G. Provide a transducer to monitor and record pressure drop across the MERV 13 filters in the air-handling unit. An alarm will be activated at the BMS workstation if the actual filter pressure drop exceeds the dirty filter pressure drop established by the TAB Contractor.

H. Provide CO2 Control. Use standard factory calibrated CO2 sensors in locations shown on the drawings or as indicated in sequence of operations.

I. Unoccupied heating cycle:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature falls below the unoccupied set point temperature of 60 deg. F. (adjustable) start the supply fan at full speed and open the reheat coil control valve to provide a 95 deg. F. leaving air temperature.
3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.

J. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off and the outside air damper closed. The second choice is for a higher space cooling set point, which is described as follows:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature rises above the unoccupied set point of 80 deg. F. (adjustable) start the supply fan at the minimum speed and modulate the DX cooling to supply a 54 deg. F. leaving air temperature. If required to maintain space temperature slowly increase the fan speed and simultaneously modulate the DX cooling to maintain a 54 deg. F. (adjustable) leaving air temperature.

3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.
4. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). DX cooling shall not be available when the system is in an economizer mode.

K. Occupied heating cycle:

1. Warm-up: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain the space temperature. Modulate the reheat coil control valve in unison with the supply fan VFD, to maintain a leaving air temperature of 95 deg. F. (adjustable).
3. Provide ventilation control per the CO2 sequence.

L. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain space temperature. The DX cooling shall modulate in unison with the supply fan to maintain a 54 deg. F. (adjustable) leaving air temperature.
3. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). DX cooling shall not be available when the system is in an economizer mode.
4. Provide ventilation control per the CO2 sequence.

M. CO2 Ventilation Control: Provide ventilation control during the occupied cycles. When the space is indexed to the occupied cycle open the outdoor air damper to minimum outdoor airflow as indicated on the drawings. If the space CO2 controller senses an increased CO2 level above 800 p.p.m. slowly modulate open the outside air damper to maintain the space CO2 level below 1000 p.p.pm. At any time during the occupied cycle the outdoor air damper shall not open past the position to allow more than the scheduled amount of design outside air, as indicated on the drawing schedule, unless the unit is in an economizer cycle. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable).

N. Dehumidification: At any time the space humidity is above 60% RH, run the supply fan at cooling airflow, modulate the DX cooling to provide a 54 deg. F. (adjustable) leaving air temperature and modulate open the duct-mounted reheat coil control valve to maintain the space temperature set point. When the space humidity level falls below 55% RH, reverse the sequence. Dehumidification shall be available during unoccupied cycles with the outdoor air damper closed.

O. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator work station:

1. System status (Occupied / Unoccupied): indication and adjustment.
2. Supply fan status: indication, adjustment, and alarm.
3. V.F.D. status: indication and alarm.
4. DX cooling status: indication and adjustment.
5. Reheat coil control valve position: indication and adjustment.
6. Supply air temperature: indication and adjustment.
7. Return air temperature: indication.
8. Mixed air temperature: indication
9. Outdoor air c.f.m.: indication.
10. Smoke detector status: indication and alarm.
11. Freezestat status: indication and alarm.
12. Filter differential pressure: indication and alarm.
13. Building pressurization: indication and adjustment.
14. Space temperature set point: indication and adjustment.
15. Space temperature: indication and alarm.
16. Space humidity set point: indication, adjustment.
17. Space humidity level: indication and alarm.
18. Space CO2 set point: indication and adjustment.
19. Space CO2 level: indication and alarm.
20. Bipolar Ionization generator status: indication, and alarm.
21. Economizer: indication.

3.11 PACKAGED OUTDOOR CHILLED WATER AIR HANDLING UNITS: RTU-4

A. The packaged air handling units and systems serve areas conditioned with shutoff type variable air volume units. The units contain a variable speed supply fan, variable speed exhaust fan, hydronic pre-heat coil, hydronic cooling coil, filters, air flow monitoring, and bipolar ionization air purification, as well as other components.

B. The unit shall be controlled by the BMS and shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start/stop programming.

C. Refer to variable air volume sequences for requirements on room sensors such as thermostats, and humidistats.

D. Freeze Protection: Provide a freeze stat, with manual reset, serpentined across the leaving air side of the heating coil. Provide programming per the following sequence if the leaving air temperature falls below 35 deg. F (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers.
3. Fully open the heating coil control valve.
4. Stop the fans.

E. In unoccupied modes provide controls to monitor the temperature in the mixed air section of the air handling unit. When the outdoor air temperature is below 35 deg. F. (adjustable) and the temperature in the mixed air section falls below 35 deg. open the heating coil control valve to maintain a temperature of 40 Deg. F (adjustable) in the unit section.

F. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

G. Provide fully modulating control valves that fails in the open position for the preheat coil and the last position for the cooling coil. Outdoor air dampers are to fail in the closed position and return dampers shall fail in the open position.

H. Provide an analog transducer to monitor and record pressure drop across the MERV 13 filters in the air-handling unit. An alarm will be activated at the BMS workstation if the actual filter pressure drop exceeds the dirty filter pressure drop established by the TAB Contractor.

I. Fan Pressure Optimization Control: At a frequency of once every 2 minutes, the BMS shall monitor the damper position of all VAV terminal units. The BMS shall calculate a new supply fan duct static pressure set point based on the position of the furthest open VAV damper, and send this newly-calculated set point to the AHU controller. When any VAV damper is more than 75% (adjustable) open, the supply fan duct static pressure set point shall be reset upward by 5% until no damper is more than 75% (adjustable) open or the static pressure set point has reset to the maximum setting. When all VAV dampers are less than 65% (adjustable) open, the supply fan duct static pressure set point shall be reset downward by 5% until at least one damper is more than 65% (adjustable) open or the static pressure set point has reset to the minimum setting.

J. Duct System Static Pressure Safety: Provide supply duct high static pressure sensors to stop the unit fan(s) and alarm the system if the supply duct static pressure is above the high limit set point. The sensor shall be hard wired and have manual reset. The TABC will determine the location of the sensors. The initial duct static pressure set point shall be +1.25" w.c. The TABC will determine the final static pressure set point.

K. Provide a high static pressure sensor, located at the supply fan discharge. The sensor is to be hard wired with manual reset. The initial set point for this sensor is to be +3.0" w.c. with final adjustment by the TABC Contractor.

L. Ventilation Optimization Control: The actual outdoor air flow shall be sensed at the outdoor air intake of the air handling unit and controlled to an air flow set point determined according to ASHRAE Standard 62.1. When the BMS indicates the air handling unit is occupied, the required outdoor airflow for that system shall equal the design outdoor airflow. The required outdoor-air fraction (current required outdoor airflow divided by the current primary airflow) shall be continuously calculated for each VAV terminal unit. At a frequency of once every 2 minutes, the BMS shall gather this data from all VAV terminal units, calculate the minimum required outdoor airflow for the system according to ASHRAE 62.1, and send this newly-calculated outdoor airflow set point to the AHU controller. Monitor ventilation air flow c.f.m.

M. Unoccupied heating cycle:

1. The supply and exhaust unit fans will be off. The outdoor air damper shall be closed and the return air damper shall be open.
2. When the space temperature in a pre-determined, fully adjustable, number of areas, is below the unoccupied set point, start the unit's supply fan and modulate the fan speed to maintain the duct static pressure setting. Open and modulate the heating coil control valve to maintain a 95 deg. F. leaving air temperature. The outside air damper will remain closed. The return air damper shall remain full open. When setback temperature has been restored, reverse this sequence.

N. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans and the energy recovery wheel off and all dampers closed. The second choice is for an adjustable higher space cooling set point, which is described as follows:

1. The supply and exhaust unit fans will be off. The outdoor air damper closed and the return air damper open.
2. When the space temperature in any area is above the unoccupied set point, start the air handling unit supply fan and modulate the fan speed to maintain the duct static pressure setting. Modulate

the cooling control valve to maintain a leaving air temperature of 54 degrees F (adjustable). The outside air damper will remain closed. The return air damper shall remain full open. When setback temperature has been restored, reverse this sequence.

3. The VAV terminal units will function per the unoccupied cooling sequence.
4. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor spaces, allow the unit to operate in an economizer mode. Modulate the unit's supply fan to maintain duct static pressure. The exhaust fan shall modulate to maintain a building differential pressure with relationship to the atmosphere of +0.02" w.c. (adjustable). Modulate the outdoor air damper(s) to maintain a fully adjustable leaving air temperature with the initial set point of 55 degrees F.

O. Occupied Heating Cycle:

1. Warm-up: provide optimal start through the BMS to index the respective zone to the occupied status. At this time, the unit will operate in the same mode as the unoccupied heating cycle. When the space temperatures reach the occupied set point the unit will operate in the occupied heating cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating as required to maintain the duct static pressure setting. Modulate the heating coil control valve to maintain a fully adjustable leaving air temperature with an initial set point of 58 degrees F. (adjustable).
3. Modulate the outdoor air damper to provide Ventilation Optimization Control. The exhaust fan shall remain off.

P. Occupied Cooling Cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status. At this time, the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cooling cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating as required to maintain the duct static pressure setting.
3. Modulate the outdoor air damper to provide Ventilation Optimization Control. The exhaust fan shall remain off, unless in economizer.
4. Provide programming to reset the supply air temperature based on the outdoor air temperature by modulating the cooling control valve. The set points shall be fully adjustable. Provide the following initial set points:

    a. Outdoor air temperature above 85 deg. F. – 54 deg. l.a.t.
    b. Outdoor air temperature 72 to 84 deg. F. – 56 deg. l.a.t.
    c. Outdoor air temperature 57 to 71 deg. F – 58 deg. l.a.t.

5. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor spaces, allow the unit to operate in an economizer mode. Modulate the unit's supply fan to maintain duct static pressure. The exhaust fan shall modulate to maintain a building differential pressure with relationship to the atmosphere of +0.02" w.c. (adjustable). Modulate the outdoor air damper(s) to maintain a fully adjustable leaving air temperature with the initial set point of 55 degrees F.

Q. Dehumidification Mode: The air handling unit will operate in both the occupied and unoccupied modes to provide dehumidification. During occupied mode, the unit shall operate in dehumidification mode when the return air is above 60% RH and shall terminate when below 55%. Provide a minimum of two space temperature humidity sensors located in representative spaces within area served to enable and disable dehumidification mode when unit is unoccupied.

1. Modulate the cooling coil control valve to maintain 54 deg. discharge air temperature.
2. All associated VAV terminal units shall index to cooling airflow.

3. Modulate VAV terminal unit reheat coils to maintain space temperature setpoints.
4. Dehumidification mode shall only be enabled when boilers are operating.
5. Also refer to VAV sequences for additional requirements.

R. The BMS shall display the following monitoring points on a custom graphic at the operator work station:

1. System status (occupied/unoccupied): indication and adjustment.
2. Supply fan status: indication, adjustment, and alarm.
3. Exhaust fan status: indication, adjustment, and alarm.
4. V.F.D. status, both fans: indication and alarm.
5. Smoke detector status: indication and alarm.
6. Freezestat status: indication and alarm.
7. MERV 13 filter differential pressure: indication and alarm.
8. Supply duct static pressure setting: indication and alarm.
9. Heating coil control valve position: indication and adjustment.
10. Cooling coil control valve position: indication and adjustment.
11. Unit supply air temperature: indication and adjustment.
12. Unit return air temperature: indication.
13. Outdoor air c.f.m.: indication.
14. Building pressurization: indication and adjustment.
15. Bipolar Ionization generator status: indication, and alarm.
16. Economizer: indication.

3.12 PACKAGED OUTDOOR CHILLED WATER AIR HANDLING UNITS: RTU-5

A. The system is a single zone variable air volume system. The packaged air handling unit contains a variable speed supply fan, chilled-water cooling coil, hydronic pre-heat coil, duct-mounted hydronic reheat coil, filters, air flow monitoring, and bipolar ionization air purification, as well as other components.

B. The unit shall be controlled by the BMS and shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start/stop programming.

C. Provide a temperature/humidity sensor with adjustable set points. The minimum and maximum set points shall be set through the BMS.

D. Freeze Protection: Provide a freeze stat, with manual reset, serpentined across the leaving air side of the heating coil and provide programming per the following sequence if the leaving air temperature falls below 35 deg. F. (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers and open the return air damper.
3. Fully open the heating coil control valve.
4. Stop the fan.

E. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

F. Provide fully modulating heating valves that are to fail in the open position. Control valves on the duct mounted reheat coils shall fail in the last position. Provide fully modulating cooling valves that are to fail in the last position. Outdoor air dampers and relief vent dampers are to fail in the closed position with return dampers failing in the open position.

G. Provide a transducer to monitor and record pressure drop across the MERV 13 filters in the air-handling unit. An alarm will be activated at the BMS workstation if the actual filter pressure drop exceeds the dirty filter pressure drop established by the TAB Contractor.

H. Provide CO2 Control. Use standard factory calibrated CO2 sensors in locations shown on the drawings or as indicated in sequence of operations.

I. Unoccupied heating cycle:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature falls below the unoccupied set point temperature of 60 deg. F. (adjustable) start the supply fan at full speed and open the preheat coil control valve to provide a 95 deg. F. leaving air temperature.
3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.

J. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off and the outside air damper closed. The second choice is for a higher space cooling set point, which is described as follows:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature rises above the unoccupied set point of 80 deg. F. (adjustable) start the supply fan at the minimum speed and open the cooling coil control valve to supply a 54 deg. F. leaving air temperature. If required to maintain space temperature slowly increase the fan speed and simultaneously modulate open the cooling coil control valve to maintain a 54 deg. F. (adjustable) leaving air temperature.
3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.
4. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). Close the chilled water coil control valve when the system is in an economizer mode.

K. Occupied heating cycle:

1. Warm-up: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain the space temperature. Modulate the preheat coil control valve in unison with the supply fan VFD, to maintain a leaving air temperature of 95 deg. F. (adjustable).
3. Provide ventilation control per the CO2 sequence.

L. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.

2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain space temperature. The cooling coil control valve shall modulate in unison with the supply fan to maintain a 54 deg. F. (adjustable) leaving air temperature.
3. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). Close the chilled water coil control valve when the system is in an economizer mode.
4. Provide ventilation control per the CO2 sequence.

M. CO2 Ventilation Control: Provide ventilation control during the occupied cycles. When the space is indexed to the occupied cycle open the outdoor air damper to minimum outdoor airflow as indicated on the drawings. If the space CO2 controller senses an increased CO2 level above 800 p.p.m. slowly modulate open the outside air damper to maintain the space CO2 level below 1000 p.p.pm. At any time during the occupied cycle the outdoor air damper shall not open past the position to allow more than the scheduled amount of design outside air, as indicated on the drawing schedule, unless the unit is in an economizer cycle. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable).

N. Dehumidification: At any time the space humidity is above 60% RH, run the supply fan at cooling airflow, open the cooling coil control valve to provide a 54 deg. F. (adjustable) leaving air temperature and modulate open the duct-mounted reheat coil control valve to maintain the space temperature set point. When the space humidity level falls below 55% RH, reverse the sequence. Dehumidification shall be available during unoccupied cycles with the outdoor air damper closed.

O. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator work station:

1. System status (Occupied / Unoccupied): indication and adjustment.
2. Supply fan status: indication, adjustment, and alarm.
3. V.F.D. status: indication and alarm.
4. Preheat coil control valve position: indication and adjustment.
5. Cooling coil control valve position: indication and adjustment.
6. Reheat coil control valve position: indication and adjustment.
7. Supply air temperature: indication and adjustment.
8. Return air temperature: indication.
9. Mixed air temperature: indication
10. Outdoor air c.f.m.: indication.
11. Smoke detector status: indication and alarm.
12. Freezestat status: indication and alarm.
13. Filter differential pressure: indication and alarm.
14. Building pressurization: indication and adjustment.
15. Space temperature set point: indication and adjustment.
16. Space temperature: indication and alarm.
17. Space humidity set point: indication, adjustment.
18. Space humidity level: indication and alarm.
19. Space CO2 set point: indication and adjustment.
20. Space CO2 level: indication and alarm.
21. Bipolar Ionization generator status: indication, and alarm.
22. Economizer: indication.

3.13 PACKAGED AIR HANDLING UNITS – WITH OUTDOOR AIR (PAH-9, 10, and 14)

A. The units are single zone units with a variable speed supply air fan, hydronic pre-heat coil, chilled water cooling, duct-mounted hydronic reheat coils, filters, and dampers, as well as other components.

B. The unit(s) shall be controlled by the BMS and shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start / stop programming.

C. Provide a space thermostat/sensor and humidistat with adjustable temperature and humidity set points. The minimum and maximum space set points shall be set through the BMS.

D. Freeze Protection: Provide a freeze stat, with manual reset, serpentined across the leaving air side of the heating coil and provide programming per the following sequence if the leaving air temperature falls below 35 Degrees F (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers and open the return air damper.
3. Fully open the heating coil control valve.
4. Stop the fan.

E. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates.

F. Provide fully modulating heating control valves that are to fail in the open position. Control valves on the duct mounted reheat coils shall fail in the last position. Provide fully modulating cooling control valves that are to fail in the last position. Outdoor air dampers and relief vent dampers are to fail in the closed position and return dampers shall fail in the open position.

G. Unoccupied heating cycle:

1. The outside air damper and any relief dampers will be closed and the return air damper fully open. The supply air fan will be off.
2. When the space temperature falls below the fully adjustable unoccupied set point temperature of 60 degrees F. start the supply fan at full speed and open the heating coil control valve to provide a 95-degree F. (adjustable) leaving air temperature. When the unoccupied set point temperature has been restored, reverse the above sequence.

H. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off and the outside air damper closed. The second choice is for a higher space cooling set point, which is described as follows:

1. The outside air damper and any relief dampers will be closed and the return air damper fully open. The supply air fan will be off.
2. When the space temperature rises above the fully adjustable unoccupied set point temperature of 80 degrees F. (adjustable) start the supply fan at low speed and open the chilled water valve to supply a 54-degree F. (adjustable) leaving air temperature. If required to maintain the space temperature, increase the fan speed and simultaneously modulate open the cooling coil control valve to maintain a 54-degree F. leaving air temperature. When the unoccupied space temperature has been restored, reverse the above sequence.
3. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the global indoor space sensor located in Classroom 142, PAH-1, 2, 3, 4, 5 & 6 shall all operate in the economizer mode. PAH-8 shall use the enthalpy of its respective indoor space. Start the supply fan at low speed and open the outdoor air damper to provide a 54-degree F (adjustable) leaving air temperature. If required to maintain the space temperature increase the supply fan speed and simultaneously modulate open the outdoor air damper to maintain a 54-degree F. leaving

air temperature. Fully open the relief vent. A combination of chilled water cooling and economizer cooling may be used when applicable to minimize energy consumption.

I. Occupied heating cycle:

1. Warm-up: provide optimal start/stop programing through the BMS to index the respective zone to the occupied status and initiate morning warm-up. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the space temperature reaches the fully adjustable occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain the space temperature. Modulate the heating coil control valve in unison with the supply fan to maintain a leaving air temperature of 95 degrees F. (adjustable) and maintain the space temperature set point. Open the outside air and relief air dampers as required to relieve the minimum scheduled outside air quantity.

J. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status and initiate morning cool-down. At this time, the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the fully adjustable occupied set point the unit will operate in the occupied heating cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain space temperature. The cooling coil control valve will modulate in unison with the supply fan, to maintain a 54-degree F. (adjustable) leaving air temperature. Open the outside air and relief air dampers as required to relieve the minimum scheduled outside air quantity.

K. Dehumidification: At any time the space humidity is above 60% RH, run the supply fan at cooling airflow, open the cooling coil control valve to provide a 54 deg. F. (adjustable) leaving air temperature and modulate open the duct-mounted reheat coil control valve to maintain the space temperature set point. When the space humidity level falls below 55% RH, reverse the sequence. Dehumidification shall be available during unoccupied cycles with the outdoor air damper closed.

L. The BMS shall monitor, record, and display the following points on a custom graphic at the operator workstation:

1. System status: indication and adjustment
2. Fan status: indication, adjustment, and alarm.
3. Fan speed: indication and adjustment.
4. Smoke detector status: indication and alarm.
5. Freezestat status: indication and alarm.
6. Preheat coil control valve position: indication and adjustment.
7. Cooling coil control valve position: indication and adjustment.
8. Reheat coil control valve position: indication and adjustment.
9. Supply air temperature: indication and adjustment.
10. Return air temperature: indication.
11. Space temperature set point: indication and adjustment.
12. Space temperature: indication.
13. Space humidity set point - indication and adjustment.
14. Space humidity: indication and alarm.
15. Bipolar Ionization generator status: indication, and alarm.
16. Economizer: indication.

3.14 PACKAGED AIR HANDLING UNITS – NO OUTDOOR AIR (PAH)

A. The units are single zone units with a variable speed supply air fan, hydronic pre-heat coil, chilled water cooling, and filters, as well as other components.

B. The unit(s) shall be controlled by the BMS and shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start / stop programming.

C. Provide a space thermostat/sensor and humidistat with adjustable temperature and humidity set points. The minimum and maximum space set points shall be set through the BMS.

D. Provide fully modulating heating and cooling control valves that fail in the last position. Refer to drawings for units that require 3-way control valves.

E. Unoccupied heating cycle:

1. The supply air fan will be off.
2. When the space temperature falls below the fully adjustable unoccupied set point temperature of 60 degrees F, start the supply fan at full speed and open the heating coil control valve to provide a 95-degree F (adjustable) leaving air temperature. When the unoccupied set point temperature has been restored, reverse the above sequence.

F. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off. The second choice is for a higher space cooling set point, which is described as follows:

1. The supply air fan will be off.
2. When the space temperature rises above the fully adjustable unoccupied set point temperature of 80 degrees F. (adjustable) start the supply fan at low speed and open the chilled water valve to supply a 54-degree F. (adjustable) leaving air temperature. If required to maintain the space temperature, increase the fan speed and simultaneously modulate open the cooling coil control valve to maintain a 54-degree F. leaving air temperature. When the unoccupied space temperature has been restored, reverse the above sequence.

G. Occupied heating cycle:

1. Warm-up: provide optimal start/stop programing through the BMS to index the respective zone to the occupied status and initiate morning warm-up. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the space temperature reaches the fully adjustable occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain the space temperature. Modulate the heating coil control valve in unison with the supply fan to maintain a leaving air temperature of 95 degrees F. (adjustable) and maintain the space temperature set point.

H. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status and initiate morning cool-down. At this time, the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the fully adjustable occupied set point the unit will operate in the occupied heating cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain space temperature. The cooling coil control valve will modulate in unison with the supply fan, to maintain a 54-degree F. (adjustable) leaving air temperature.

I. Dehumidification: At any time the space humidity is above 60% RH, run the supply fan at cooling airflow, open the cooling coil control valve to provide a 54 deg. F. (adjustable) leaving air temperature and modulate open the reheat coil control valve to maintain the space temperature set point. When the space humidity level falls below 55% RH, reverse the sequence. Dehumidification shall be available during occupied and unoccupied cycles.

J. The BMS shall monitor, record, and display the following points on a custom graphic at the operator workstation:

1. System status: indication and adjustment
2. Fan status: indication, adjustment, and alarm.
3. Fan speed: indication and adjustment.
4. Cooling coil control valve position: indication and adjustment.
5. Reheat coil control valve position: indication and adjustment.
6. Supply air temperature: indication and adjustment.
7. Return air temperature: indication.
8. Space temperature set point: indication and adjustment.
9. Space temperature: indication.
10. Space humidity set point - indication and adjustment.
11. Space humidity: indication and alarm.
12. Bipolar Ionization generator status: indication, and alarm.

3.15 UNIT VENTILATORS (UV) AND FAN COIL UNITS (FCU)

A. The units are single zone units with a supply air fan, hydronic pre-heat coil, chilled water cooling, and filters, as well as other components.

B. The unit(s) shall be controlled by the BMS and shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start / stop programming.

C. Provide a space thermostat/sensor and humidistat with adjustable temperature and humidity set points. The minimum and maximum space set points shall be set through the BMS.

D. Provide fully modulating heating and cooling control valves that fail in the last position.

E. Unoccupied heating cycle:

1. The supply air fan will be off.
2. When the space temperature falls below the fully adjustable unoccupied set point temperature of 60 degrees F, start the supply fan and open the heating coil control valve to provide a 95-degree F (adjustable) leaving air temperature. When the unoccupied set point temperature has been restored, reverse the above sequence.

F. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off. The second choice is for a higher space cooling set point, which is described as follows:

1. The supply air fan will be off.
2. When the space temperature rises above the fully adjustable unoccupied set point temperature of 80 degrees F. (adjustable) start the supply fan and modulate the chilled water valve to supply a 54-degree F. (adjustable) leaving air temperature. When the unoccupied space temperature has been restored, reverse the above sequence.

G. Occupied heating cycle:

1. Warm-up: provide optimal start/stop programing through the BMS to index the respective zone to the occupied status and initiate morning warm-up. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the space temperature reaches the fully adjustable occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously. Modulate the heating coil control valve to maintain a leaving air temperature of 95 degrees F. (adjustable) and maintain the space temperature set point.

H. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status and initiate morning cool-down. At this time, the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the fully adjustable occupied set point the unit will operate in the occupied heating cycle.
2. During the occupied cycle the supply fan shall run continuously. The cooling coil control valve shall modulate to maintain a 54-degree F. (adjustable) leaving air temperature.

I. Dehumidification: At any time the space humidity is above 60% RH, run the supply fan, open the cooling coil control valve to provide a 54 deg. F. (adjustable) leaving air temperature and modulate open the reheat coil control valve to maintain the space temperature set point. When the space humidity level falls below 55% RH, reverse the sequence. Dehumidification shall be available during occupied and unoccupied cycles.

J. The BMS shall monitor, record, and display the following points on a custom graphic at the operator workstation:

1. System status: indication and adjustment
2. Fan status: indication, adjustment, and alarm.
3. Cooling coil control valve position: indication and adjustment.
4. Reheat coil control valve position: indication and adjustment.
5. Supply air temperature: indication and adjustment.
6. Space temperature set point: indication and adjustment.
7. Space temperature: indication.
8. Space humidity set point - indication and adjustment.
9. Space humidity: indication and alarm.
10. Bipolar Ionization generator status: indication, and alarm.

3.16 SHUT-OFF AIR TERMINAL UNITS (SOV)

A. The units shall be controlled by the BMS. The respective unit(s) shall be indexed to occupied and unoccupied settings at the programmed times.

B. Provide a thermostat with adjustable set points for all fan powered variable air volume units. Refer to individual air handling unit sequence to determine which units require humidity sensors. The minimum and maximum space set points shall be set through the BMS.

C. Provide a modulating control valve for the hydronic heating coil that is provided with the variable air volume unit. Refer to the drawings for the required valve configurations. Valves are to fail in the last position.

D. Unoccupied heating: the primary air valve is closed. When the associated air handling unit energizes and the space temperature is below the unoccupied set point, open the primary air damper to the minimum

position and open the heating coil control valve to maintain the unoccupied space temperature. Reverse the sequence when the space temperature is above the unoccupied set point.

E. Unoccupied cooling: When the associated air handling unit energizes and the space temperature is above the unoccupied set point, open the primary air damper to the minimum c.f.m. position. If necessary, gradually open the primary air damper to maintain the unoccupied space temperature. Reverse the sequence when the space temperature is above the unoccupied set point.

F. Occupied: When the space temperature is above the room thermostat/sensor set point modulate open the primary air damper to allow the full cooling c.f.m. As the space temperature is satisfied gradually close the primary air damper to the minimum c.f.m. position. When the space temperature is below the thermostat/sensor setting, the primary air damper is to be in the heating c.f.m. position. Modulate the heating coil control valve to control the space temperature.

G. Dehumidification: When the associated air handling unit is in dehumidification mode, provide the following sequence:

1. Open the primary air damper to allow the full cooling c.f.m.
2. Modulate the heating coil control valve to maintain the space temperature.
3. Reverse the sequence when the humidity level falls below the set point.

H. Occupancy Control: Provide wiring and all required controls to allow all vav boxes to enter a stand-by mode when indicated to do so by the room occupancy sensor. The occupancy sensor will be provided by others. When in the stand-by mode the fan will be off and the air inlet valve will be closed. If the room temperature falls more than 4 deg. F. (adjustable) below the normal room occupied heating temperature start the supply fan, and open the heating coil control valve to heat the space. If the room temperature rises more than 4 deg. F. (adjustable) above the normal room occupied cooling temperature start the supply fan an open the vav box inlet valve to cool the space.

I. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator workstation:

1. Room set point: indication and adjustment.
2. Room temperature: indication.
3. Room humidity level (where required): indication.
4. Primary air c.f.m.: indication.
5. Leaving air temperature: indication.

3.17 KITCHEN VENTILATION SYSTEMS (KVS-1 and KEF-1)

A. Provide control wiring between the unit starter and a relay furnished by this contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

B. The unit shall have the following safety controls: duct smoke detector located in the supply mains shall signal an alarm, interrupt power to the supply fan only, and close outside air dampers when products of combustion are sensed.

C. The ventilation equipment will be provided with controls to energize the system when the associated process equipment is energized and shall run continuously until the process equipment is de-energized. When the outside air temperature is 65 deg. F. (adjustable) or lower, a supply duct temperature sensor shall modulate the gas valve to the heating section to maintain a constant discharge temperature of 65 deg. F. (adjustable).

D. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator work station:

1. System status (on/off): indication.
2. Gas furnace status: indication.
3. Gas furnace leaving air temperature: indication.
4. Exhaust fan status: indication.

3.18 DUCTLESS SPLIT SYSTEMS

A. The units shall be controlled by the BMS.

B. Provide a space thermostat with adjustable set points. The minimum and maximum heating / cooling and humidity set points shall be set at the operator work station.

C. Cooling Cycles: When the space temperature in a room is above or below the unoccupied fully adjustable set point, energize the respective unit to satisfy the unoccupied temperature. When the unoccupied space temperature has been restored, reverse the sequence.

D. The BMS shall monitor, record, and display the following points on a custom graphic at the operator workstation:

1. System status (Off/On): indication and adjustment.
2. System trouble alarm: indication and alarm.
3. Compressor status: indication and alarm.
4. Space temperatures, set point: indication and adjustment.
5. Space temperatures: indication.

3.19 HOT WATER TERMINAL HEATING UNITS

A. All new terminal units and terminal units that are to remain shall be controlled by the BMS. Refer to the contract drawings for locations of existing terminal units. The respective unit(s) shall be indexed to occupied and unoccupied settings at the programmed times.

B. Provide a space thermostat/sensor with adjustable set points. The minimum and maximum heating and cooling set points shall be set at the operator work station.

C. Provide a two-position control valve for all terminal units. Refer to the drawings for the required valve configurations. Valves are to fail in the last position unless the unit has a connection to an outside air duct in which case the valve is to fail open.

D. Hydronic Baseboard / Finned Tube Control: Provide a thermostat/sensor to maintain occupied and unoccupied space temperature by opening the two-position heating control valve.

E. Hydronic Convector Control: Provide a thermostat/sensor to maintain occupied and unoccupied space temperature by opening the two-position heating control valve.

F. Hydronic Unit Heater Control: Provide thermostat/sensor to maintain the occupied and unoccupied space temperature by opening the two-position control valve and cycling the fan motor.

G. Cabinet Heater Control: Provide thermostat/sensor to maintain the occupied and unoccupied space temperature by opening the two-position control valve and cycling the fan motor.

H. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator workstation:

1. Status: indication and adjustment.
2. Room temperature set point: indication.
3. Room temperature: indication.

3.20 EXHAUST FANS

A. Refer to the drawings for notes to indicate fans that are to be controlled by the BMS.

B. Provide controls for exhaust fans noted as "Time of Day Schedule" to allow the fan(s) to operate during the occupied cycle of the respective area. De-energize the fan(s) during the unoccupied cycle.

C. Where fans are noted to have a manual switch, provide an interlock to allow the fan(s) to operate during the occupied cycle of the respective area. De-energize the fan(s) during the unoccupied cycle.

D. Refer to the contract drawings for exhaust fans that are to be operated with an interlock to other equipment. Where so indicated, provide the required interlock and controls. Provide programming to prevent fan operation when the area is in an unoccupied mode.

E. Where noted as "Reverse Acting T'stat", provide a reverse acting thermostat in the space to energize the fan when the space temperature is above the set point. De-energize the fan when the space temperature is below set point. If required, provide motorized dampers as well as the required interlock with the fan and damper(s).

F. Where the drawings indicate a motor operated damper (MOD) is required, provide the damper, and control the damper to open when the fan is on and closed when the fan is off.

G. The BMS shall monitor, record, and display the following points on a custom graphic at the operator workstation:

1. Status for all fans: indication and adjustment.
2. Occupied and unoccupied scheduling: indication and adjustment.

3.21 RELIEF VENTS

A. Where indicated on the drawings, relief vents are to be provided with motor operated dampers that are to fail closed.

B. Roof vents used for reducing building pressure are to modulate open based on an increase in building pressure during an occupied cycle of the respective system and are to be closed when the system is in an unoccupied mode unless the system is in an economizer cycle.

C. Relief vents that are connected to the discharge of an exhaust or relief fan are to be open when the respective fan is in an occupied mode and closed when the system is in an unoccupied mode.

3.22 DOMESTIC WATER SYSTEM PUMPS

A. Provide controls to start and stop all domestic hot water system re-circulating pumps based on a fully adjustable schedule that is to be determined by the owner.

B. Provide a alarm to indicate pump(s) failure.

C. The BMS shall display the following monitoring points on a custom graphic at the operator work station:

1. Status of all pumps: indication, adjustment, and alarm.

3.23 LIGHTING CONTROL INTERFACE

A. The management system shall be required to interface with the lighting control system and present the following sequence of operations. Each individual relay shall be designated as a control point at the exterior of the building. No interior lighting shall be controlled or monitored. The Owner reserves the right to request two (2) adjustments to this sequence within one (1) year after substantial completion at no additional cost:

1. Exterior Lighting:

a. Exterior lighting shall be controlled as follows:
Photocell on / off at 11:00pm (time to be verified with owner)
On at 5:00am – Photocell off (time to be verified with owner)
b. Exterior building mounted lighting, 1/3 of the area lighting and flag lights shall operate from dusk to dawn.
c. Coordinate exact lighting zones and lighting schedules with the owner.

B. Provide an outdoor photo sensor as an input to the BMS to trigger on the exterior light fixtures controlled by the network lighting control system. BMS timeclock or the photo sensor, depending on the owner's schedule will turn off exterior light fixtures by lighting zone.

C. Provide a digital interconnection with the BMS utilizing BACnet over IP.

1. Provide wiring, gateways and other equipment as required to communicate with system.
2. Refer to electrical drawings and specifications for coordination.

3.24 CONTROL SEQUENCES: MISCELLANEOUS POINTS

A. The BMS shall monitor, record, and display the following points on a custom graphic at the operator work station:

1. Outdoor air temperature: indication.
2. Outdoor air humidity: indication.
3. Temperature monitoring of three (5) data rooms. Provide independent room sensor to monitor and display room temperatures. Provide a high temperature alarm in all rooms with the temperature set point as directed by the owner.
4. Monitor temperature in the walk-in refrigerator and freezer. Provide alarms when temperatures are above the adjustable set point.

END OF SECTION 23 09 05