Section 230993
SEQUENCE OF OPERATION – Table of Contents

SECTION 230993
SEQUENCE OF OPERATION

PART I. GENERAL

1.01 SECTION INCLUDES

A. Air Handling Units

B. Chilled Water System

C. Terminal Units

D. Exhaust Fans

1.02 RELATED DOCUMENTS:

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

B. Section ***{Insert Section Number}*** - Basic Mechanical Requirements

C. Section 230900 - Building Automation System (BAS) General

D. Section 230901 - BAS Basic Materials, Interface Devices, and Sensors

E. Section 230903 - BAS Field Panels

F. Section 230904 - BAS Communications Devices

G. Section 230905 - BAS Software and Programming

H. Section 230801 – BAS Commissioning

1.03 SYSTEM DESCRIPTION

A. The systems to be controlled under work of this section basically comprise ***{describe the scope of the project}***. The HVAC systems being control are ***{describe the configuration of and the type of systems included in the project.***

B. This Section defines the manner and method by which controls function.

1.04 SUBMITTALS

A. Refer to Section 230900 and Division 1 for requirements for control shop drawings, product data, Users Manual, etc.

B. Programming Manual: Provide DDC system programming manual as well as documentation of site-specific programming prior to the start of Acceptance Phase.

1.05 PROJECT RECORD DOCUMENTS

A. Within two weeks of the completion of commissioning, provide record documents to represent the final control configuration with actual setpoints and tuning parameters as existed at acceptance.

B. Record documents shall be modified control drawings with the actual installed information. Drawings shall be delivered in both reproducible hard copy and electronic

format in AutoCAD 2002 drawing files. Provide all supporting files, blocks, fonts, etc. required by the drawings.

C. Provide final points list as described above

D. Provide final detailed wiring diagrams with all wire numbers and termination points indicated

E. Accurately record final sequences and control logic made after submission of shop drawings.

PART II. PRODUCTS

Not Used

PART III. EXECUTION

3.01 GENERAL

A. Sequences specified herein indicate the functional intent of the systems operation and may not fully detail every aspect of the programming that may be required to obtain the indicated operation. Contractor shall provide all programming necessary to obtain the sequences/system operation indicated.

B. When an air handling unit is not in operation, control devices shall remain in their "off" positions. "Off" positions may differ from the "normal" (meaning failed) position. Except as specified otherwise, "off" and "normal" positions of control devices shall be as follows:

Device	"Off" Position	"Normal" Position
Heating coil valves	**closed**	**open**
Cooling coil valves	**closed**	**closed**
Steam coil valves	**closed**	**closed**
Outside air damper	**closed**	**closed**
Return air damper	**open**	**open**
Exhaust/relief air damper	**closed**	**closed**

Variable Frequency Drives: For a VFD dependent on an external input for its output setting (e.g. the VFD gets "Frequency" as an input), loss of that external input shall result in the VFD holding its last value. If the VFD is running its own PID loop and the external input to the VFD is a setpoint (e.g. duct static pressure setpoint), the VFD shall hold the last setpoint. If the VFD loses its process variable (e.g. duct static pressure), the VFD shall go to its minimum speed setting.

C. Except as specified otherwise, throttling ranges, proportional bands, and cycle differentials shall be centered on the associated setpoint. All modulating feedback control loops shall include the capability of having proportional, integral, and derivative action. Unless the loop is specified "proportional only" or "P+I", Contractor shall apply appropriate elements of integral and derivative gain to each control loop which shall result in stable operation, minimum settling time, and shall maintain the primary variable within the specified maximum allowable variance.

D. Provide a real time clock and schedule controller with sufficient scheduling capability to schedule all required controllers and sequences. Schedule functionality may reside in BPOC or a controller. If BPOC is used, document scheduling functionality on BPOC submittal, if a controller is used, document scheduling functionality including SNVT names and types on controller points list submittal. Set up initial schedules in coordination with UNC.

E. Scheduling Terminology: When air handlers are scheduled throughout the day, the following defines the terminology used:

1. ***Designer to verify with UNC*** **Occupied Period**: period of time when the building is in use and occupied. Unless indicated otherwise, this period is defined as X:00 AM – X:00 PM weekdays and X:00 AM to X:00 Saturdays. Exclude all national holidays. Generally systems will be fully operational throughout this period and ventilation air shall be continuously introduced.

Space temperature setpoints will generally be in the "normal" range of 69°-77°F.

2. **Unoccupied period**: period of time when the building or zone is not in use and unoccupied. Ventilation air shall not be introduced.
3. **Preoccupancy Period**: Time prior to the Occupied period when the systems are returning the space temperatures from setback to "normal" or occupied setpoints (warm-up and cool-down). Ventilation air shall not be introduced unless outside air conditions permit free-cooling. Time period shall be determined by an optimum start strategy unless otherwise specified.
4. **Setback Period**: Setback will typically start with the end of the occupied period and end with the start of the preoccupancy period, however it shall be provided with its own schedule. Generally systems will be off except to maintain a "setback" temperature, economization may be enabled to maintain "setback" cooling setpoint when applicable.

F. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the BAS start commands shall be staggered by 5 second (adj.) intervals to minimize inrush current.

G. Wherever a value is indicated as adjustable (adj.), it shall be modifiable, with the proper password level, from the LCS via an LNS plug-in or via a function block menu. For these points, it is unacceptable to have to modify programming statements to change the setpoint.

H. When a power failure is detected in any phase, the BAS start commands shall be retracted immediately from all electrically powered units served by the failed power source. If the associated controller is powered by normal or emergency power, it may monitor its own power source as an indication of power status. If the controller is powered by uninterruptible power supply (UPS), or if it is not capable of monitoring its own power for use in sequences, Contractor shall provide at least one voltage monitor (three phase when applicable) per building. When the BAS detects that normal or emergency power has been restored, all equipment for which the BAS start command had been retracted shall be automatically restarted in an orderly manner on staggered 5 second intervals to minimize inrush current.

I. Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, one of the following methods shall be employed:

1. Contractor shall determine a fixed reset schedule which shall result in stable operation and shall maintain the primary variable within the specified maximum allowable variance.
2. A floating reset algorithm shall be used which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance.
3. Primary variable shall control the devices directly using a PID feedback control loop without resetting the secondary variable. However, the control devices shall still modulate as necessary to maintain upper and lower limits on the secondary variable. Proportional band, integral gain, and derivative term shall be selected to maintain the primary variable within the specified

maximum allowable tolerance while minimizing overshoot and settling time. Contractor shall gain prior approval for implementing this method of reset.

J. Where a supply air temperature or duct pressure setpoint is specified to be reset by the space temperature of the zones calling for the most cooling/heating, the following method shall be employed:

1. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. space temperature) setpoint. The reset increment shall be determined by the quantity of "need heat" or "need cool" requests from individual SCU's. A SCU's "need heat" virtual point shall activate whenever the zone's space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint throttling range. A SCU's "need cool" virtual point shall activate whenever the zone's space temperature rises above the currently applicable (occupied, unoccupied, or economy) cooling setpoint throttling range. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. Reset range maximum and minimum values shall limit the setpoint range.

K. Where a supply air temperature, duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method shall be employed:

1. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature, pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. cooling valve, heating valve, damper position) setpoint of 85% open. The reset increment shall be calculated based on the average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. The BAS analog output value shall be acceptable as indicating the position of the control device.
2. Alternatively to continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the "need heat" or "need cool" virtual point shall increment by one unit each time a zone's valve/damper position rises to greater than 95%. The quantity of "need heat" or "need cool" points shall then be the basis for reset.

L. Where "prove operation" of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS shall, after an adjustable time delay after the device is commanded to operate (feedback delay) , confirm that the device is operational via the status input. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (debounce delay) while the device is commanded to run, an alarm shall be enunciated audibly. Upon failure, run command shall be removed and the device shall be locked out until the alarm is manually acknowledged unless specified otherwise.

M. BAS shall provide for adjustable maximum rates of change for increasing and decreasing output from the following analog output points:

1. Speed control of variable speed drives
2. Control Reset Loop
3. Valve Travel Limit

N. Wherever a value is indicated to be dependent on another value (i.e.: setpoint plus 5°F) BAS shall use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points shall be provided. One to store the parameter (5°F), one to store the setpoint, and one to store the value which is the result of the equation.

3.02 AIR HANDLING UNITS - GENERAL

A. **Logic Strategies**: The BAS shall fully control the air handlers. Generally the BAS shall energize the AH (start the fans and activate control loops) as dictated for each air handler. The following indicates when and how the BAS shall energize the AHs and control various common aspects of them. The following "logic strategies" shall be included by reference with each air handler with any specific clarifications required:

1. **Scheduled Occupancy:** BAS shall determine the occupancy periods (occupied, unoccupied, preoccupancy, and setback) as defined above. The following details the common control aspects related to the scheduled occupancy. ***Designer to consider extent of BAS controls, shut down ALL bathroom EF's, etc..***

   a) **Occupied Period**: BAS shall energize the AH during all occupied periods. Note that the beginning of the occupancy period shall be set sufficiently before the actual start of occupancy to obtain the required building component of ventilation per ASHREA 62. Specific times shall be as directed by the A/E. Minimum OA flow setpoint shall be as scheduled on the drawings. "Normal" setpoints shall apply.

   b) **Unoccupied Period**: Minimum OA flow shall be 0 CFM and the minimum OA damper position shall be 0%. If during the unoccupied period there is a request for occupancy override, the occupancy mode shall become active for an adjustable period. The unoccupied period and the preoccupancy period will typically overlap.

   c) **Setback Period**: the BAS shall deenergize the unit except as required to maintain a setback temperature as indicated in the individual sequences with a 5°F cycle differential. Generally, where setback

temperatures apply in multiple zones, the worst zone shall control the system. Setback setpoints generally apply except during preoccupancy. If during the unoccupied period there is a request for occupancy override, the occupancy mode shall become active for an adjustable period.

d) **Preoccupancy**: . BAS shall energize the AH continuously during the preoccupancy period. Minimum OA flow shall be 0 CFM or the minimum OA damper position shall be 0%. "Normal" setpoints shall apply. Preoccupancy duration shall be one of the following as specified by reference:

1) **Fixed**: The duration of the preoccupancy period shall be reset based on outside air temperature as follows:

Outside Air Temperature	Preoccupancy Start Time
> 70˚F	1 hour early start
60˚F to 70˚F	On time start
50˚F to 60˚F	30 minutes early start
40˚F to 50˚F	1 hour early start
30˚F to 40˚F	1½ hour early start
< 30˚F	2 hour early start

2. **Minimum OA Control:** BAS shall maintain minimum ventilation during the occupied period. The following strategies may apply:

a) **Balanced Position**: During the occupied period, applicable mixing and OA dampers shall never be positioned less than the position set for the required minimum OA ventilation rate. If the air handler has a single OA damper that is capable of economizer, the minimum position output shall be determined by the balancer. If the AH has a two position minimum OA damper, that position shall be fully open to its balanced position. This logic strategy is only applicable to constant volume Ahs.

b) **Reset Balanced Position**: During the occupied period, applicable mixing and OA dampers shall never be positioned less than the minimum position. Minimum position shall be reset between limits of a position delivering system exhaust make-up air CFM and the design minimum position delivering design minimum CFM to maintain a CO_2 setpoint of 800 ppm (adj.). Loop shall be a "sample and bump" or dynamic proportional only loop tuned for the slow response. The balancer shall determine the minimum position outputs at both extreme points. This logic strategy is only applicable to constant volume AHs.

c) **Damper Controlled Fixed**: During the occupied period, applicable mixing dampers shall be modulated to maintain an OA flow rate of no less than the MVR as dictated in the design and required by ASHRAE 62. Setpoint flow rates shall be provided by the A/E. Flow rate shall be determined in any of the following ways as specified for the particular AH:

1) Measured directly by an OA flow station

2) As determined by CO_2 mixing equations using the SA, OA, and RA CO_2 sensors

d) **Damper Controlled Reset**: During the occupied period, applicable mixing dampers shall be modulated to maintain an OA flow rate setpoint. Setpoint shall be reset between limits of system exhaust make-up air CFM ("absolute minimum") and the design minimum CFM to maintain an RA CO_2 setpoint of 800 ppm (adj.). Loop shall be a "sample and bump" or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E. Flow rate shall be determined in any of the following ways as specified for the particular AH:

1) Measured directly by an OA flow station

2) As determined by CO_2 mixing equations using the SA, OA, and RA CO_2 sensors

3. **VAV Return Fan Capacity Control**: BAS shall control the output of the return fan as follows: ***(Designer shall coordinate setup requirements of this section with section 230801/III)***

a) **Flow Tracking**: The return air fan shall run to maintain a return flow setpoint of the supply flow minus an offset value. The offset value shall be determined as follows:

1) **Fixed Differential**: It shall be fixed at the design minimum OA value.

2) **Differential Reset From RA CO_2**:.:It shall be reset between limits of system exhaust make-up air CFM and the design minimum CFM to maintain an RA CO_2 setpoint of 800 ppm (adj.). Loop shall be a "sample and bump" or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E

3) **Differential Reset From Measured OA to Maintain Fixed OA**: It shall be reset to maintain the measured minimum OA flow at the design value any time the economizer mode is inactive. Whenever it is inactve, it shall be set to the value that existed when the unit became active.

4) **Differential Reset From Measured OA to Maintain Reset OA** When the economizer mode is inactive, it shall be reset to maintain the measured OA flow setpoint. The OA setpoint shall be reset between limits of system exhaust make-up air CFM and the design minimum CFM to maintain an RA CO_2 setpoint of 800 ppm (adj.). Loop shall be a "sample and bump" or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E. Whenever the economizer is active, it shall be set to the value that existed when the unit became active.

b) **Rescaled Output Capacity Control**: The output for the return fan capacity control shall be rescaled from the output of the to the supply device such that the design minimum OA flow is maintained at both maximum and 50% flow conditions. The balancing contractor shall determine the coordinated output.

4. **Airside Economizer:** BAS shall modulate the mixing dampers to provide "free cooling" when conditions merit. The free cooling shall generally be staged before any mechanical cooling. While conditions merit, dampers shall be modulated in a DA PID loop to maintain mixed air temperature at a setpoint as specified for the individual unit. Economizer logic shall remain enabled during setback cooling where applicable. One of the following strategies shall be used to enable the economizer mode:
   a) **Dry Bulb Comparison**: Economizer mode shall be active while the unit is energized AND when outside air temperature falls below return air temperature (with 2°F cycle differential). Economizer mode shall be inactive when outside air temperature rises above return air temperature (with 2°F cycle differential), dampers shall return to their scheduled minimum positions as specified above. Economizer shall remain enabled during setback cooling.
   b) **Dry Bulb Switch**: Economizer mode shall be active while the unit is energized AND when outside air temperature falls below the switching setpoint of 70°F (adj.) (with 5°F cycle differential). Economizer mode shall be inactive when outside air temperature rises above switching setpoint, dampers shall return to their scheduled minimum positions as specified above.
5. **Sequenced Heating and Cooling:** BAS shall control the heating and cooling coils and air side economizer as detailed for the particular AH. Program logic shall directly prohibit the heating and cooling valves as well as the heating valve and economizer damper to be open (or above minimum) simultaneously. This does not apply to cooling and reheat valves that are used simultaneously for dehumidification.
6. **Mixed Air Low Limit Override**: BAS shall override the signal to the OA damper via a proportional only loop to maintain a minimum mixed air temperature of 45°F (adj.) (loop shall output 0% at 45°F which shall be passed to the output via a low selector).
7. **Smoke Pressurization Cycle**: when pressurization is commanded by the interface to the fire alarm system, supply fan shall start and deliver 100% outside air to the space. Return fan shall remain off. Hardwired interlock from safeties may still interrupt fan operation. (See damper and heating valve sequences for additional sequences associated with pressurization.)
8. **Smoke Exhaust Cycle**: when exhaust is commanded by the interface to the fire alarm system, return fan shall start and shall exhaust 100% return air from the space. Supply fan shall remain off. (See damper and heating valve sequences for additional sequences associated with pressurization.)
9. **Freeze Safety**: Upon operation of a freezestat, unit shall be deenergized with the exception of the heating loops. Typically supply and return fans where applicable shall be deenergized via a hardwired interlock, , and an indication of the operation shall be sensed by the BAS. BAS shall enunciate appropriate alarm and remove and lock out the start command, which shall initiate "fan failure" alarms. OA dampers shall close, RA dampers shall open, all hydronic valves shall open and heating loops shall remain active.

10. **Smoke Safety (Non-Smoke Control AHs)**: Upon indication of smoke by a smoke detector, BAS shall deenergize the AH. Smoke detector shall notify the fire alarm system, shut down the fans, and close the smoke dampers via hard-wired interlock.
11. **Smoke Safety (Smoke Control AHs)**: Upon indication of smoke by a smoke detector, BAS shall override the AH control as needed for smoke control sequence of operation.
12. **High or Low Pressure Safety**: Upon activation of a high or low pressure safety switch, AH shall be deenergized, fans shall be deenergized via a hard wired interlock, and an indication of the operation shall be sensed by the BAS. BAS shall enunciate appropriate alarm and remove and lock out the start command, which shall initiate "fan failure" alarms.

B. The detailed “logic strategies” above shall be required by reference to them in each of the individual sequences specified below.

3.03 SINGLE DUCT VAV AH WITH PREHEAT & CHW COIL, NO RETURN FAN [DWG C-1.00]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. damper controlled reset
5. mixed air low limit
6. high & low pressure safety
7. freeze safety.
8. smoke/ fire safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is “energized” as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **Supply Duct Pressure Setpoint**: Setpoint shall be:

a) Reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at [4] with all values adjustable.

5. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date
   d) KWH previous week
   e) KWH year to date
   f) KWH previous year

C. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: BAS shall maintain the minimum OA using the damper controlled reset strategy. BAS shall modulate the OA damper to maintain the OA flow at setpoint. Setpoint shall be reset between an "absolute minimum" flow setpoint (lowest OA flow setting that will maintain proper positive pressurization of the building/ space) and a "design minimum" flow setpoint (OA flow settings based on ASHRAE guidelines). The setpoint will be reset based on a PID output that compares Space (or Return) air CO2 to an adjustable setpoint initially set at 800 ppm.
3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F. The OA damper shall be modulate open per the higher of the economizer PID loop output and the Minimum OA flow control output described above. The Economizer dampers (Return and Relief) shall modulate linearly based on the economizer signal only. On an economizer PID loop output of 20 to 100% the economizer dampers shall modulate 0 to 100%.

D. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes.

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

F. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F, and
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

G. **Cooling Section**:

1. **Cooling Coil Valve**: N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature setpoint.

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.04 SINGLE DUCT VAV AH WITH PREHEAT, CHW COIL & RETURN FAN, NO UNIT EXHAUST AT MINIMUM OA FLOW [DWG C-1.01]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. mixed air low limit
5. high & low pressure safety
6. freeze safety.
7. smoke/ fire safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is “energized” as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.

2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **Supply Duct Pressure Setpoint**: Setpoint shall be:
   a) Reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at [4] with all values adjustable.
5. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date
   d) KWH previous week
   e) KWH year to date
   f) KWH previous year

C. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows.

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **Capacity Control**: BAS shall control the output of the return fan to maintain the return air flow at setpoint. Setpoint shall be equal to the supply air flow minus a flow offset. The flow offset shall be equal to the desired OA flow rate. The desired OA flow rate shall be reset between an "absolute minimum" flow setpoint (lowest OA flow setting that will maintain proper positive pressurization of the building/ space) and a "design minimum" flow setpoint (OA flow settings based on ASHRAE guidelines). The setpoint will be reset based on a PID output that compares Space (or Return) air CO2 to an adjustable setpoint initially set at 800 ppm. The flow offset shall be set to 0cfm when the unit operates in the occupied mode. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan

motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:

a) KWH day to date (total for the day)

b) KWH previous day

c) KWH week to date

d) KWH previous week

e) KWH year to date

f) KWH previous year

D. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: BAS shall maintain the minimum OA using the based on Supply/ Return fan flow offset. During the occupied mode the BAS shall open the OA damper to no less than a preset minimum position (initially 50% open). The minimum position shall be set to 0% open during the unoccupied mode.
3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F. The OA damper shall be commanded open to the higher of the economizer PID loop output and the Minimum OA damper position described above. The Economizer dampers (Return and Relief) shall modulate linearly based on the economizer PID loop. On an economizer PID loop output of 0 to 100% the economizer dampers shall modulate 0 to 100%.

E. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes. The setback setpoint for cycling the unit shall be 65°F (adj.) for heating and 80°F (adj.) for cooling, where applicable. Ensure that these setpoints are outside the control range of all box control loops.

F. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)

   A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

G. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of

   a) a PID loop to maintain a leaving coil temperature at 52°F, and

   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.

2. **HW Circulating Pump**:
    a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\
    b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

H. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain discharge temperature at setpoint.

I. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.05 SINGLE DUCT VAV AH WITH PREHEAT, CHW COIL & RETURN FAN, w/UNIT EXHAUST AT MINIMUM OA FLOW [DWG C-1.01a]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. mixed air low limit
5. high & low pressure safety
6. freeze safety.
7. smoke/ fire safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **Supply Duct Pressure Setpoint**: Setpoint shall be:
    a) Reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at [4] with all values adjustable.

5. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date
   d) KWH previous week
   e) KWH year to date
   f) KWH previous year

C. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows.

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **Capacity Control**: BAS shall control the output of the return fan to maintain the return air flow at setpoint. Setpoint shall be equal to the supply air flow minus a fixed flow offset. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date
   d) KWH previous week
   e) KWH year to date
   f) KWH previous year

D. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: BAS shall modulate the Economizer dampers to maintain the OA flow at setpoint. Setpoint shall be reset between an "absolute minimum" flow setpoint (lowest OA flow setting that will maintain proper

positive pressurization of the building/ space) and a "design minimum" flow setpoint (OA flow settings based on ASHRAE guidelines). The setpoint will be reset based on a PID output that compares Space (or Return) air CO2 to an adjustable setpoint initially set at 800 ppm.

3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F. The Economizer dampers shall be commanded open to the higher of the economizer PID loop output and the Minimum OA damper position described above.

E. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes.

F. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)

   A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

G. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of

   a) a PID loop to maintain a leaving coil temperature at 52°F, and

   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.

2. **HW Circulating Pump**:

   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\

   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

H. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain discharge temperature at setpoint.

I. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.06 SINGLE DUCT VAV AH WITH PREHEAT & CHW COIL, MIN OA DAMPER, NO RETURN FAN [DWG C-1.02]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy with optimum preoccupancy
2. dry bulb comparison economizer control

3. sequenced heating and cooling coil valve control
4. minimum outside air damper control
5. mixed air low limit
6. high & low pressure safety
7. freeze Safety.
8. smoke Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **Supply Duct Pressure Setpoint**: Setpoint shall be:
   a) Reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at [4] with all values adjustable.
5. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date
   d) KWH previous week
   e) KWH year to date
   f) KWH previous year

C. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the minimum OA damper.
2. **Minimum OA Damper Control**: BAS shall modulate the minimum OA damper to maintain a fixed OA flow setpoint whenever the unit is occupied.

3. **Economizer**: BAS shall modulate the economizer dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F.

D. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes.

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

F. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F, and
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

G. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain discharge temperature at setpoint.

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.07 SINGLE DUCT CV AH WITH PREHEAT, CHW & REHEAT COIL, MIN OA DAMPER & RETURN FAN [DWG C-1.03]

A. **General**: The single zone air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. min outside air damper balanced position, minimum outside air control
5. mixed air low limit
6. freeze Safety.
7. smoke Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

C. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows.

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above..
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

D. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the minimum OA damper.
2. **Minimum OA Damper Control**: BAS shall modulate the minimum OA damper to maintain a fixed OA flow setpoint whenever the unit is occupied.
3. **Economizer**: BAS shall modulate the economizer dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F.

E. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

F. **Discharge Temperature Control**: The discharge temperature setpoint shall be reset from space temperature as follows:

1. During Heating mode, the DAT setpoint shall be reset from 70˚F to 105˚F (adj.) via a PID loop output set to maintain the space temperature at the active heating setpoint
2. During Cooling mode, the DAT setpoint shall be reset from 68˚F to 55˚F (adj.) via a PID loop output set to maintain the space temperature at the active cooling setpoint
3. Whenever the unit operates in the unoccupied mode, the discharge temperature cooling setpoint shall be increased by 5˚F (adj.) and heating setpoint shall be decreased by 5˚F (adj.) until the occupied mode is active again.

G. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at setpoint. The leaving coil setpoint shall normally be equal to the DAT setpoint (described above) -5°F, and shall be set to 52°F when the unit operates in the dehumidification mode.
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

H. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain the cooling coil discharge temperature at setpoint. The cooling coil discharge temperature setpoint shall be set to the lower of the following:

1. The discharge air temperature setpoint, and
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj) whenever the dehumidification mode is enabled. The dehumidification mode shall be enabled if the return air humidity is > 57% and disabled if the return air humidity is < 55%.

I. **Reheating Section**:

1. **HW Heating Valve**: Whenever the dehumidification mode is enabled, N.O. valve shall modulate per a PID loop output to maintain the discharge air temperature at the discharge air temperature setpoint.

J. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.08 SINGLE DUCT CV AH WITH PREHEAT, CHW & REHEAT COIL, MIN OA DAMPER, CO2 VENTILATION & RETURN FAN [DWG C-1.04]

A. **General**: The single zone air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. min outside air damper reset balanced position
5. mixed air low limit
6. freeze Safety.
7. smoke Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

C. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows.

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above..
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

D. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: During the occupied period when the AHU is proven ON, the BAS shall open the Economizer dampers to no less than the minimum damper position. The minimum position shall be reset between an

"absolute minimum" position (lowest setting that will maintain proper positive pressurization of the building/ space) and a "design minimum" position (settings based on ASHRAE guidelines). The minimum position will be reset based on a PID output that compares Space (or Return) air CO2 to an adjustable setpoint initially set at 800 ppm.

3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F. The Economizer dampers shall be commanded open to the higher of the economizer PID loop output and the Minimum OA damper position described above.

E. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

F. **Discharge Temperature Control**: The discharge temperature setpoint shall be reset from space temperature as follows:

1. During Heating mode, the DAT setpoint shall be reset from 70˚F to 105˚F (adj.) via a PID loop output set to maintain the space temperature at the active heating setpoint
2. During Cooling mode, the DAT setpoint shall be reset from 68˚F to 55˚F (adj.) via a PID loop output set to maintain the space temperature at the active cooling setpoint
3. Whenever the unit operates in the unoccupied mode, the discharge temperature cooling setpoint shall be increased by 5˚F (adj.) and heating setpoint shall be decreased by 5˚F (adj.) until the occupied mode is active again.

G. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at setpoint. The leaving coil setpoint shall normally be equal to the DAT setpoint (described above) -5°F, and shall be set to 52°F when the unit operates in the dehumidification mode.
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:

a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\

b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

H. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain the cooling coil discharge temperature at setpoint. The cooling coil discharge temperature setpoint shall be set to the lower of the following:

1. The discharge air temperature setpoint, and
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj) whenever the dehumidification mode is enabled. The dehumidification mode shall be enabled if the return air humidity is > 57% and disabled if the return air humidity is < 55%.

I. **Reheating Section**:

1. **HW Heating Valve**: Whenever the dehumidification mode is enabled, N.O. valve shall modulate per a PID loop output to maintain the discharge air temperature at the discharge air temperature setpoint.

J. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.09 100% OA CV AH WITH HEAT RECOVERY, PREHEAT & CHW COIL [DWG C-1.05]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. sequenced heating and cooling coil valve control
3. freeze Safety.
4. smoke/fire Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is “energized” as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the associated exhaust fan, BAS shall

deenergize the supply fan, lockout the run command, and enunciate an alarm as specified above.

C. **OA Dampers**: The dampers shall open whenever the Supply Fan is energized and close when it is deenergized. A damper position end switch shall prove the damper open before the fan is allowed to run. Upon failure of the OA damper, BAS shall deenergize the supply fan, lockout the run command, and enunciate an alarm.

D. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

E. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F, and
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enable the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

F. **Cooling Section**:

1. **Cooling Coil Valve**: N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.

G. **Energy Recovery Section**

1. **Energy Recovery Pump**:
   a) BAS shall enable the pump in the heating mode whenever the unit is enabled and the OA Temperature is less than 52°F. BAS shall disabled the pump whenever the OA Temperature is greater than 53°F.
   b) BAS shall enable the pump in the cooling mode whenever the unit is enabled and the OA Temperature is greater than 85°F. BAS shall disabled the pump whenever the OA Temperature is less than 83°F.
   c) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.
2. **VSD Control**:
   a) Whenever the pump is energized in the heating mode, the BAS shall control the speed of the VSD to maintain the energy recovery coil leaving temperature at setpoint. The energy recovery coil leaving

temperature setpoint shall be equal to the unit discharge temperature setpoint - 4°F. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

b) Whenever the pump is energized in the cooling mode, the BAS shall set the speed of the pump to 100%. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

3. **Energy Recovery Metering:** BAS shall also accumulate energy savings/recovery of the energy recovery system (BTU) utilizing the coil water temperatures and the coil flow meter on a daily, monthly & yearly basis. BAS shall display BTU values for the following:
   a) Instantaneous BTU/Hr
   b) BTU day to date (total for the day)
   c) BTU previous day
   d) BTU week to date
   e) BTU previous week
   f) BTU year to date
   g) BTU previous year

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.10 100% OA VAV AH WITH PREHEAT & CHW COIL [DWG C-1.06]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. sequenced heating and cooling coil valve control
3. high & low pressure safety
4. freeze Safety.
5. smoke/fire Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.

2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the associated exhaust fan, BAS shall deenergize the supply fan, lockout the run command, and enunciate an alarm as specified above.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **Supply Duct Pressure Setpoint**: Setpoint shall be:
   a) Reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at [4] with all values adjustable.
5. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date
   d) KWH previous week
   e) KWH year to date
   f) KWH previous year

C. **OA Dampers**: The dampers shall open whenever the Supply Fan is energized and close when it is deenergized. A damper position end switch shall prove the damper open before the fan is allowed to run. Upon failure of the OA damper, BAS shall deenergize the supply fan, lockout the run command, and enunciate an alarm.

D. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

E. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F, and
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:

a) BAS shall enable the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.

b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

F. **Cooling Section**:

1. **Cooling Coil Valve**: N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.

G. **Energy Recovery Section**

1. **Energy Recovery Pump**:

a) BAS shall enable the pump in the heating mode whenever the unit is enabled and the OA Temperature is less than 52°F. BAS shall disabled the pump whenever the OA Temperature is greater than 53°F.

b) BAS shall enable the pump in the cooling mode whenever the unit is enabled and the OA Temperature is greater than 85°F. BAS shall disabled the pump whenever the OA Temperature is less than 83°F.

c) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

2. **VSD Control**:

a) Whenever the pump is energized in the heating mode, the BAS shall control the speed of the VSD to maintain the energy recovery coil leaving temperature at setpoint. The energy recovery coil leaving temperature setpoint shall be equal to the unit discharge temperature setpoint - 4°F. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

b) Whenever the pump is energized in the cooling mode, the BAS shall set the speed of the pump to 100%. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

3. **Energy Recovery Metering:** BAS shall also accumulate energy savings/recovery of the energy recovery system (BTU) utilizing the coil water temperatures and the coil flow meter on a daily, monthly & yearly basis. BAS shall display BTU values for the following:

a) Instantaneous BTU/Hr

b) BTU day to date (total for the day)

c) BTU previous day

d) BTU week to date

e) BTU previous week

f) BTU year to date

g) BTU previous year

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.11 SINGLE DUCT CV AH WITH PREHEAT & CHW COIL, MIN OA DAMPER & RETURN FAN [DWG C-1.07]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy with optimum preoccupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. minimum outside air damper control
5. mixed air low limit
6. high & low pressure safety
7. freeze Safety.
8. smoke Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

C. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows.

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

D. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA damper shall remain closed.
2. **Minimum OA Damper Control**: BAS shall open the minimum OA damper whenever the unit is operating in the occupied mode.

3. **Economizer**: BAS shall modulate the economizer dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F.

E. **Space Temperature Control**: The space temperatures shall be controlled via individual terminal units.

F. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

G. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F, and
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

H. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain discharge temperature at setpoint.

I. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.12 SINGLE DUCT CV AH WITH PREHEAT & CHW COIL, MIN OA DAMPER, NO RETURN FAN [DWG C-1.08]

A. **General**: The single zone air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. min outside air damper control
5. mixed air low limit
6. freeze Safety.
7. smoke Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

C. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: During the occupied period when the AHU is proven ON, the BAS shall open the Minimum OA damper to no less than the minimum damper position. The minimum position shall be reset between an "absolute minimum" position (lowest setting that will maintain proper positive pressurization of the building/ space) and a "design minimum" position (based on ASHRAE guidelines). The minimum position will be reset based on a PID output that compares Space (or Return) air CO2 to an adjustable setpoint initially set at 800 ppm.
3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F. The OA damper shall be modulate open per the economizer PID loop output.

D. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be reset from space temperature as follows:

1. During Heating mode, the DAT setpoint shall be reset from 70˚F to 105˚F (adj.) via a PID loop output set to maintain the space temperature at the active heating setpoint
2. During Cooling mode, the DAT setpoint shall be reset from 68˚F to 55˚F (adj.) via a PID loop output set to maintain the space temperature at the active cooling setpoint
3. Whenever the unit operates in the unoccupied mode, the discharge temperature cooling setpoint shall be increased by 5˚F (adj.) and heating setpoint shall be decreased by 5˚F (adj.) until the occupied mode is active again.

F. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at setpoint. The leaving coil setpoint shall normally be equal to the DAT setpoint (described above) -5°F.
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

G. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain the cooling coil discharge temperature at setpoint. The cooling coil discharge temperature setpoint shall be set to the lower of the following:

1. The discharge air temperature setpoint, and
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj). Cooling shall be disabled for dehumidification purposes if the space temperature is below the space heating setpoint.

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.13 DUAL DUCT VAV AH CONTROL, NO EXHAUST AT MINIMUM FLOW [DWG C-1.09]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. mixed air low limit
5. high & low pressure safety
6. freeze safety.
7. smoke/ fire safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **Supply Duct Pressure Setpoint**: Setpoint shall be:
   a) Reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at [4] with all values adjustable.
5. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date

d) KWH previous week

e) KWH year to date

f) KWH previous year

C. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows.

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **Capacity Control**: BAS shall control the output of the return fan to maintain the return air flow at setpoint. Setpoint shall be equal to the supply air flow minus a flow offset. The flow offset shall be equal to the desired OA flow rate. The desired OA flow rate shall be reset between an "absolute minimum" flow setpoint (lowest OA flow setting that will maintain proper positive pressurization of the building/ space) and a "design minimum" flow setpoint (OA flow settings based on ASHRAE guidelines). The setpoint will be reset based on a PID output that compares Space (or Return) air CO2 to an adjustable setpoint initially set at 800 ppm. The flow offset shall be set to 0cfm when the unit operates in the occupied mode. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:

   a) KWH day to date (total for the day)

   b) KWH previous day

   c) KWH week to date

   d) KWH previous week

   e) KWH year to date

   f) KWH previous year

D. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: BAS shall maintain the minimum OA using the based on Supply/ Return fan flow offset. During the occupied mode the BAS shall open the OA damper to no less than a preset minimum position (initially

50% open). The minimum position shall be set to 0% open during the unoccupied mode.

3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F. The OA damper shall be commanded open to the higher of the economizer PID loop output and the Minimum OA damper position described above. The Economizer dampers (Return and Relief) shall modulate linearly based on the economizer PID loop. On an economizer PID loop output of 0 to 100% the economizer dampers shall modulate 0 to 100%.

E. **Space Temperature Control**: The space temperatures shall be controlled via individual Dual Duct VAV boxes.

F. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F, and
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

G. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain discharge temperature at setpoint.

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

I. **Hot Deck Discharge Temperature Setpoint Reset**: Whenever the AH is energized, the Hot Deck discharge temperature setpoint for shall be reset by a reverse acting PID algorithm outputting a temperature range as follows (PID output can be rescaled if necessary):.

1. Setpoint shall be reset from 75°F to 100°F (or the heating design temperature) both adjustable to maintain the heating requests at [4] (adj.)

J. **Cold Deck Discharge Temperature Setpoint Reset**: The cold deck discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

K. **Hot Deck**:

1. **Heating Coil Valve**: Whenever AH is energized, N.O. heating coil valve shall modulate via a PID loop to maintain the Hot Deck discharge air temperature at setpoint.

L. **Cooling Section**:

1. **Cold Deck Coil Valve**: N.C. cooling coil valve shall modulate via a DA PID loop to maintain the Cold Deck discharge temperature at setpoint.

M. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.14 DUAL DUCT VAV AH CONTROL, W/ UNIT EXHAUST AT MINIMUM FLOW [DWG C-1.09A]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. mixed air low limit
5. high & low pressure safety
6. freeze safety.
7. smoke/ fire safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **Supply Duct Pressure Setpoint**: Setpoint shall be:
   a) Reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at [4] with all values adjustable.

5. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date
   d) KWH previous week
   e) KWH year to date
   f) KWH previous year

C. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows.

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **Capacity Control**: BAS shall control the output of the return fan to maintain the return air flow at setpoint. Setpoint shall be equal to the supply air flow minus a fixed flow offset. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
   a) KWH day to date (total for the day)
   b) KWH previous day
   c) KWH week to date
   d) KWH previous week
   e) KWH year to date
   f) KWH previous year

D. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: BAS shall modulate the Economizer dampers to maintain the OA flow at setpoint. Setpoint shall be reset between an "absolute minimum" flow setpoint (lowest OA flow setting that will maintain proper

positive pressurization of the building/ space) and a "design minimum" flow setpoint (OA flow settings based on ASHRAE guidelines). The setpoint will be reset based on a PID output that compares Space (or Return) air CO2 to an adjustable setpoint initially set at 800 ppm.

3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air setpoint shall be equal to the discharge air setpoint specified herein minus 3°F. The Economizer dampers shall be commanded open to the higher of the economizer PID loop output and the Minimum OA damper position described above.

E. **Space Temperature Control**: The space temperatures shall be controlled via individual Dual Duct VAV boxes.

F. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F, and
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

G. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain discharge temperature at setpoint.

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

I. **Hot Deck Discharge Temperature Setpoint Reset**: Whenever the AH is energized, the Hot Deck discharge temperature setpoint for shall be reset by a reverse acting PID algorithm outputting a temperature range as follows (PID output can be rescaled if necessary):.

1. Setpoint shall be reset from 75°F to 100°F (or the heating design temperature) both adjustable to maintain the heating requests at [4] (adj.)

J. **Cold Deck Discharge Temperature Setpoint Reset**: The cold deck discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

K. **Hot Deck**:

1. **Heating Coil Valve**: Whenever AH is energized, N.O. heating coil valve shall modulate via a PID loop to maintain the Hot Deck discharge air temperature at setpoint.

L. **Cooling Section**:

1. **Cold Deck Coil Valve**: N.C. cooling coil valve shall modulate via a DA PID loop to maintain the Cold Deck discharge temperature at setpoint.

M. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.15 SINGLE DUCT CV AH WITH PREHEAT & CHW COIL [DWG C-1.10]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy with optimum preoccupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. balanced position, minimum outside air control
5. mixed air low limit
6. freeze Safety.
7. smoke Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime

C. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the OA damper will close unless economizer is available.
2. **Minimum OA Control**: BAS shall maintain the minimum OA using balanced position outside control.
3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air temperature setpoint shall be 3°F below the design discharge air temperature setpoint.

D. **Space Temperature Control**: The space temperatures shall be controlled via individual reheat coils as specified below. The setback setpoint for cycling the unit shall be 65°F (adj.) for heating and 80°F (adj.) for cooling both based on the

worst zone. Ensure that these setpoints are outside the control range of all box control loops.

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be controlled as follows

1. Setpoint shall be reset from 55°F to 65°F both adjustable to maintain the cooling requests at [4] (adj.)
2. When the unit is energized for setback heating during the unoccupied period, the discharge temperature setpoint shall be 75°F (adj.)
3. When the unit is energized for morning cool-down or setback cooling, the discharge setpoint shall be the warmest zone temperature, minus 15°F.

F. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of 1) a PID loop to maintain a leaving temperature of the discharge air temperature setpoint minus 5°F and 2) a proportional only loop maintaining a low limit of 40°F preheat discharge air temperature.

G. **Cooling Section**:

1. **Cooling Coil Valve**: N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature setpoint. During unoccupied period, if AH is energized for heating, or warm-up, the cooling coil valve shall remain closed.

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.16 100% OA CV AH WITH HEAT RECOVERY, FACE & BYPASS STEAM, CHW COIL [DWG C-1.11]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. sequenced heating and cooling coil valve control
3. freeze Safety.
4. smoke/fire Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.

2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the associated exhaust fan, BAS shall deenergize the supply fan, lockout the run command, and enunciate an alarm as specified above.

C. **OA Dampers**: The dampers shall open whenever the Supply Fan is energized and close when it is deenergized. A damper position end switch shall prove the damper open before the fan is allowed to run. Upon failure of the OA damper, BAS shall deenergize the supply fan, lockout the run command, and enunciate an alarm.

D. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. A PID loop output (or Sample and Bump output) reset from 58°F to 65°F (both adjustable) to maintain the cooling requests at [4] (adj.)
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj.).

E. **Preheating Section**:

1. **Integrated Face & Bypass Steam Coil**: Whenever AH is energized, integrated unit shall modulate as follows:
   a) While OA temperature is at or below 38˚F (adj.) steam valve shall open fully and dampers shall modulate to maintain 52°F (adj.) preheat discharge air temperature via a PID loop.
   b) While OA temperature is above 38˚F (adj.) dampers shall open fully to face and steam valve shall modulate to maintain 52°F (adj.) preheat discharge air temperature via a PID loop.

F. **Cooling Section**:

1. **Cooling Coil Valve**: N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.

G. **Energy Recovery Section**

1. **Energy Recovery Pump**:
   a) BAS shall enable the pump in the heating mode whenever the unit is enabled and the OA Temperature is less than 52°F. BAS shall disabled the pump whenever the OA Temperature is greater than 53°F.
   b) BAS shall enable the pump in the cooling mode whenever the unit is enabled and the OA Temperature is greater than 85°F. BAS shall disabled the pump whenever the OA Temperature is less than 83°F.
   c) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.
2. **VSD Control**:
   a) Whenever the pump is energized in the heating mode, the BAS shall control the speed of the VSD to maintain the energy recovery coil leaving temperature at setpoint. The energy recovery coil leaving temperature setpoint shall be equal to the unit discharge temperature

setpoint - 4°F. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

b) Whenever the pump is energized in the cooling mode, the BAS shall set the speed of the pump to 100%. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

3. **Energy Recovery Metering:** BAS shall also accumulate energy savings/recovery of the energy recovery system (BTU) utilizing the coil water temperatures and the coil flow meter on a daily, monthly & yearly basis. BAS shall display BTU values for the following:

a) Instantaneous BTU/Hr

b) BTU day to date (total for the day)

c) BTU previous day

d) BTU week to date

e) BTU previous week

f) BTU year to date

g) BTU previous year

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

I. **Humidifier-Steam**: When the AH is energized during occupied periods and the outside air temperature is below 55°F (with 3°F cycle differential), N.C. steam humidifier valve shall modulate via a PID loop to maintain space relative humidity setpoint of 40%, or to limit the maximum discharge humidity to 75% (adj.). Steam valve shall close if the supply duct RH exceeds 90% continuously for 5 minutes.

3.17 SINGLE DUCT CV-VSD AH WITH PREHEAT & CHW [DWG C-1.12]

A. **General**: The single zone air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item 3.02 Air Handling Units General on page 230993 - 7. Air handler control logic strategies shall include

1. scheduled occupancy
2. dry bulb comparison economizer control
3. sequenced heating and cooling coil valve control
4. min outside air damper reset balanced position
5. mixed air low limit
6. freeze Safety.
7. smoke Safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item Air Handlers General on page 230993 - 7 above. Typically, the unit will run continuously in both the occupied and unoccupied modes. Provide a software switch that will allow the user to choose between running the unit continuously in the unoccupied mode and cycling on only when needed to maintain minimum space temperatures.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply air flow setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
    a) Supply Air Flow Setpoint: Supply air flow setpoint shall be reset between minimum and maximum values as the cooling and heating PID loop outputs rise from 80% (adj.) to 100% (adj.) demand. The heating PID output shall take precedence over the cooling PID output.
4. **VSD LON Interface:** BAS shall monitor the VSD via a LON interface. All available information shall be accessible via the interface for display on the VFD graphic. BAS shall also accumulate energy consumption of the fan motor (KWH) on a daily, monthly & yearly basis. BAS shall display KWH values for the following:
    a) KWH day to date (total for the day)
    b) KWH previous day
    c) KWH week to date
    d) KWH previous week
    e) KWH year to date
    f) KWH previous year

C. **Return/Exhaust/OA Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions.
2. **Minimum OA Control**: BAS shall maintain the minimum OA using balanced position outside control. Optionally minimum OA may be controlled through demand ventilation to maintain a maximum return air CO2 setpoint.
3. **Economizer**: BAS shall modulate dampers per the dry bulb comparison economizer detailed in 'Air Handlers General' on page 230993 - 7 above. Mixed air temperature setpoint shall be 3°F below the design discharge air temperature setpoint.

D. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values

shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be reset from space temperature as follows:

1. During Heating mode, the DAT setpoint shall be reset from 70˚F to 105˚F (adj.) via a PID loop output set to maintain the space temperature at the active heating setpoint
2. During Cooling mode, the DAT setpoint shall be reset from 68˚F to 55˚F (adj.) via a PID loop output set to maintain the space temperature at the active cooling setpoint
3. Whenever the unit operates in the unoccupied mode, the discharge temperature cooling setpoint shall be increased by 5˚F (adj.) and heating setpoint shall be decreased by 5˚F (adj.) until the occupied mode is active again.

F. **Preheating Section**:

1. **HW Heating Valve**: Whenever AH is energized, N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at setpoint. The leaving coil setpoint shall normally be equal to the DAT setpoint (described above) -5°F.
   b) a proportional only loop maintaining a low limit of 40°F pre-heat air temperature.
2. **HW Circulating Pump**:
   a) BAS shall enabled the pump whenever the OA Temperature is less than 45°F. BAS shall disabled the pump whenever the OA Temperature is greater than 50°F.\
   b) **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. BAS shall enunciate an alarm upon pump failure.

G. **Cooling Section**: Whenever AH is energized, N.C. cooling coil valve shall modulate per a DA PID loop to maintain the cooling coil discharge temperature at setpoint. The cooling coil discharge temperature setpoint shall be set to the lower of the following:

1. The discharge air temperature setpoint, and
2. A PID loop output reset from 55°F to 65°F (both adjustable) to maintain the return air humidity at 55% (adj). Cooling shall be disabled for

dehumidification purposes if the space temperature is below the space heating setpoint.

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.18 SINGLE DUCT VAV BOX (COOLING ONLY) [DWG C-2.00]

A. **General**: Control shall be pressure independent with minimum and maximum flow setpoints, scheduled occupancy with optimum preoccupancy and occupancy override. VAV box shall be assigned to one of a minimum of 5 scheduling groups per air handler.

B. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

C. **Zone Damper**: Zone damper shall modulate to maintain zone volume setpoint. Zone volume setpoint shall be reset between maximum and minimum volume settings to maintain space temperature cooling setpoint with a 2°F (adj.) reset range.

1. **Cooling Minimum Volume setpoint** shall be as scheduled on the drawings during the occupied period and shall be set to zero otherwise.

D. **Cooling Request**: This terminal shall issue a "cooling request" as follows"

1. Whenever the zone damper output is at 100% (full cooling), or
2. Whenever the space temperature rises above the throttling range of the cooling loop

E. **Reports**:

1. Configure a tabular report using real-time data with the following column headings: VAV TERMINAL DESCRIPTION, ZONE TEMPERATURE, DAMPER POSITION (0 to 100% cooling. At the top of the table, list building number, floor or area description if applicable, air handling unit designation, air handling unit volume (% of full volume) and air handler discharge air temperature.

3.19 SINGLE DUCT VAV BOX (WITH HW REHEAT CONTROL) [DWG C-2.01]

A. **General**: Control shall be pressure independent with minimum and maximum flow setpoints, scheduled occupancy with optimum preoccupancy and occupancy

override. VAV box shall be assigned to one of a minimum of 5 scheduling groups per air handler.

B. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

C. **Zone Damper**: Zone damper shall modulate to maintain zone volume setpoint. Zone volume setpoint shall be reset between maximum and minimum volume settings to maintain space temperature cooling setpoint with a 2°F (adj.) reset range.

1. **Cooling Minimum Volume setpoint** shall be as scheduled on the drawings during the occupied period and shall be set to the unoccupied flow setpoint during the unoccupied period.
2. **Cooling Maximum Volume setpoint** shall be as scheduled on the drawings during all modes.

D. **Hydronic Reheat**: N.O. Zone reheat coil valve shall modulate in a PI loop to maintain space temperature at heating setpoint as defined above with a 2°F throttling range. Valve shall be closed whenever the parent AH is off.

E. Heating Request: This terminal shall issue a "heating request" as follows"

1. Whenever the reheat output is at 100%, or
2. Whenever the space temperature falls below the throttling range of the heating loop (i.e. setpoint - 2°F (adj.)).

F. Cooling Request: This terminal shall issue a "cooling request" as follows:

1. Whenever the cooling loop output is at 100% (i.e. flow setpoint is at maximum), or
2. Whenever the space temperature rises above the throttling range of the cooling loop (i.e. setpoint + 2°F (adj.)).

G. Pressure Request: This terminal shall issue a "pressure request" whenever the zone damper output is greater than 95% open, with a 5% hyst.

H. Reports:

1. Configure a tabular report using real-time data with the following column headings: VAV TERMINAL DESCRIPTION, ZONE TEMPERATURE, EFFECTIVE Htg & Clg ZONE SETPOINTS, PRIMARY AIR FLOW SETPOINT, PRIMARY AIR FLOW, DAMPER POSITION (0 to 100%), REHEAT OUTPUT (0 to 100% heating), DISCHARGE AIR TEMPERATURE. At the top of the table list floor or area description,

parent air handling unit designation, air handling unit static pressure and setpoint and air handler discharge air temperature and setpoint.

3.20 SINGLE DUCT VAV BOX (WITH HW REHEAT CONTROL) [DWG C-2.01a]

A. **General**: Control shall be pressure independent with minimum and maximum flow setpoints, scheduled occupancy with optimum preoccupancy and occupancy override. VAV box shall be assigned to one of a minimum of 5 scheduling groups per air handler.

B. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

C. **Zone Damper**: Zone damper shall modulate in a PI loop to maintain zone volume setpoint. Zone volume setpoint shall be reset as follows:

1. **Cooling**: The zone volume setpoint shall be reset between the minimum and the cooling maximum volume settings to maintain the space temperature at the cooling space temperature setpoint via a PID loop output. The zone volume setpoint shall be reset linearly between the minimum and cooling maximum volume setpoints on a loop output of 0 to 100%.
2. **Heating**: The zone volume setpoint shall be reset between the minimum and the heating maximum volume settings to maintain the space temperature at the heat space temperature setpoint via a PID loop output. Note that a common space heating PID loop output will be used to reset the zone volume setpoint (in the heating mode) and the HW reheat valve (see below). The zone volume setpoint shall be reset linearly between the minimum and heating maximum volume setpoints on a loop output of 25 to 100% (adj.).
3. **Dead band**: When the space temperature is between the effective space temperature heating and cooling setpoints (heating and cooling PID outputs are both at 0%), the zone volume setpoint shall remain at the minimum flow setpoint.
4. Zone Volume setpoints shall be as scheduled on the drawings.

D. **Hydronic Reheat**: N.O. Zone reheat coil valve shall modulate in a PID loop output (same loop output that resets the volume setpoint in the heating mode) to maintain the space temperature at the heating setpoint as defined above. The valve shall modulate from 0 to 100% on a PID loop output of 0-75% (adj.). The valve shall be closed whenever the parent air system is off.

E. Heating Request: This terminal shall issue a "heating request" as follows"

1. Whenever the reheat output is at 100%, or
2. Whenever the space temperature falls below the throttling range of the heating loop (i.e. setpoint - 2°F (adj.)).

F. Cooling Request: This terminal shall issue a "cooling request" as follows:

1. Whenever the cooling loop output is at 100% (i.e. flow setpoint is at maximum), or
2. Whenever the space temperature rises above the throttling range of the cooling loop (i.e. setpoint + 2°F (adj.)).

G. Pressure Request: This terminal shall issue a "pressure request" whenever the zone damper output is greater than 95% open, with a 5% hyst.

H. Reports:

1. Configure a tabular report using real-time data with the following column headings: VAV TERMINAL DESCRIPTION, ZONE TEMPERATURE, EFFECTIVE Htg & Clg ZONE SETPOINTS, PRIMARY AIR FLOW SETPOINT, PRIMARY AIR FLOW, DAMPER POSITION (0 to 100%), REHEAT OUTPUT (0 to 100% heating), DISCHARGE AIR TEMPERATURE. At the top of the table list floor or area description, parent air handling unit designation, air handling unit static pressure and setpoint and air handler discharge air temperature and setpoint.

3.21 DUCT MOUNTED HW REHEAT COIL AND HUMIDIFIER [DWG C-2.02]

A. **General**: Control shall be for reheat space temperature, space humidification, scheduled occupancy with optimum preoccupancy and occupancy override.

B. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

C. **Hydronic Reheat**: N.O. Zone reheat coil valve shall modulate in a PI loop to maintain space temperature heating setpoint as defined above with a 2°F throttling range. Valve shall be closed whenever the parent AH is off.

D. **Heating Request**: This terminal shall issue a "heating request" as follows"

1. Whenever the reheat output is at 100%, or
2. Whenever the space temperature falls below the throttling range of the heating loop

E. **Cooling Request**: This terminal shall issue a "cooling request" as follows"

1. Whenever the calculated cooling PID output is at 100%, or
2. Whenever the space temperature rises above the throttling range of the cooling loop

F. **Humidifier-Self Contained Steam Generator**: BAS shall control the output of the humidifier via 0-10v and an enable signal. A single output with a switching relay is acceptable if no DOs are available on the controller for the enable. During periods when normal temperatures are in effect and the outside air temperature is below 55°F (with 3°F cycle differential) humidifier shall be enabled. BAS shall use a RA PID loop to maintain space relative humidity setpoint of 40%, or to limit the maximum discharge humidity to 75% (adj.). Humidifier shall be disabled if the supply duct RH exceeds 90% continuously for 5 minutes

G. **Reports**:

1. Configure a tabular report using real-time data with the following column headings: TERMINAL DESCRIPTION, ZONE TEMPERATURE, HUMIDIFIER OUTPUT (0 to 100% cooling), REHEAT OUTPUT (0 to 100% heating). At the top of the table, list building number, floor or area description if applicable, air handling unit designation and air handler discharge air temperature.
2. BAS shall record the following on an hourly basis: the descriptors of any terminals that have terminal dampers at full cooling position. The information shall be accumulated in a report format for periodic printing upon operator command.

3.22 DUAL DUCT VAV BOX CONTROL [DWG C-2.03]

A. **General**: Control shall be pressure independent with minimum and maximum flow setpoints, scheduled occupancy with optimum preoccupancy and occupancy override. VAV box shall be assigned to one of a minimum of 5 scheduling groups per air handler.

B. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 4°F (adj.)

C. **Cooling Zone Damper**: Zone damper shall modulate to maintain the cooling zone volume setpoint. Cooling zone volume setpoint shall be reset between the minimum scheduled volume and the maximum scheduled volume settings to maintain space temperature cooling setpoint with a 2°F (adj.) reset range, and 2) the box total minimum volume setpoint.

1. **Minimum Volume setpoint** for the box shall be as scheduled on the drawings during the normal period and shall be set to zero otherwise.

D. **Heating Zone Damper**: Zone damper shall modulate to maintain the total Zone volume setpoint. Zone volume setpoint shall be the higher of 1) the minimum total cfm setpoint and 2) the calculated total cfm setpoint. The calculated total cfm setpoint shall be the cooling zone volume setpoint + the heating zone volume setpoint. Heating volume setpoint shall reset between the minimum scheduled volume and the maximum scheduled volume settings to maintain space temperature heating setpoint with a 2°F (adj.) reset range.

E. [**Occupancy Sensing**: When occupancy sensor senses that space has been unoccupied for more than 15 minutes, minimum volume setpoint shall be set to zero.]

F. **Heating Request**: This terminal shall issue a "heating request" as follows"

1. Whenever the heating PID output is at 100%, or
2. Whenever the space temperature falls below the throttling range of the heating loop

G. **Cooling Request**: This terminal shall issue a "cooling request" as follows"

1. Whenever the cooling PID output is at 100%, or
2. Whenever the space temperature rises above the throttling range of the cooling loop

H. **Reports**:

1. Configure a tabular report using real-time data with the following column headings: VAV TERMINAL DESCRIPTION, ZONE TEMPERATURE, DAMPER POSITION (0 to 100% cooling), REHEAT OUTPUT (0 to 100% heating). At the top of the table, list building number, floor or area description if applicable, air handling unit designation, air handling unit volume (% of full volume) and air handler discharge air temperature.
2. [BAS shall record the following on an hourly basis: the descriptors of any terminals that have terminal dampers at full cooling position. The information shall be accumulated in a report format for periodic printing upon operator command.]

3.23 LAB MONITORING & REHEAT CONTROL [DWG C-2.04]

A. **General**: Control shall be reheat control as specified below with scheduled occupancy, with optimum preoccupancy, occupancy override.

B. **Space Temperature Control:** Normal setpoint shall be72°F (adj.) and setback shall be (65°F).

C. **Hydronic Reheat**: N.O. Zone reheat coil valve shall modulate in a PI loop to maintain space temperature heating setpoint as defined above with a 2°F throttling range. Valve shall be closed whenever the parent AH is off.

D. **Hood Alarms**: BAS shall monitor Hood alarms as indicated. When alarm condition is detected, the BAS shall enunciate an alarm.

E. **Reports**: Configure a tabular report using real-time data with the following column headings: TERMINAL DESCRIPTION, ZONE TEMPERATURE, , REHEAT OUTPUT (0 to 100% heating). At the top of the table, list building number, floor or area description if applicable, air handling unit designation, and air handler discharge air temperature.

3.24 LAB FLOW TRACKING ZONE WITH VAV HOOD [DWG C-2.05]

A. Space Temperature Control: Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. Normal space cooling setpoint: shall be the normal space temperature plus 2°F (adj.)
2. Normal space heating setpoint: shall be the normal space temperature minus 2°F (adj.)

B. The fume hood exhaust valves (FEV) shall be controlled by packaged lab controllers. The BAS shall monitor the fume hood exhaust flow via a 0-10v (or similar) signal directly from the Fume hood controller. The BAS shall also

monitor each fume hood controller via a direct LAN interface. Provide all points available via the interface for display on the BAS graphic.

C. Response Time: The FEV packaged lab controllers shall respond quickly to ensure that FEV has completed adjustment no more than 3 seconds after the hood sash height is changed. BAS controllers shall respond quickly to ensure that all SAV and GEV adjustments are complete no more than 7 seconds after FEV adjustment is complete (a total for 10 seconds to respond reach setpoint for each zone).

D. Snorkel Exhaust Terminal Unit (SETU) Control: The BAS shall control the damper via a PID loop to maintain the SETU constant volume setpoint.

E. General Exhaust Terminal Unit (GETU) Control: The BAS shall control the damper via a PID loop to maintain the GETU volume at setpoint.

1. BAS shall continuously calculate a total zone exhaust flow setpoint based on the temperature in the zone. This setpoint shall be reset between maximum and minimum volume settings to maintain space temperature cooling setpoint with a 2°F (adj.) reset range. Zone exhaust volume setpoint shall remain at the minimum volume setting whenever space temperature is below the cooling throttling range.
2. The GETU flow setpoint shall be equal to the Zone total exhaust flow setpoint minus the Fume Hood exhaust and Snorkel Exhaust flows.

F. Supply Air Terminal Unit (SATU) Control: The BAS shall control the damper via a PID loop to maintain the SATU volume at setpoint.

1. BAS shall continuously calculate a zone total supply flow setpoint The supply flow setpoint shall equal the sum of all respective exhausts in the zone served, minus a Zone Flow Offset value which shall be as shown on the drawings.
2. Note that if the Zone Total Exhaust flow is greater than or less than the scheduled minimum and maximum Total Exhaust Flow values, then the Total supply flow setpoint may be less than or greater than the supply scheduled minimum and maximum values.

G. Purge Button: Upon indication of emergency purge mode, which shall be started when the panic button is depressed, the total Zone Exhaust Flow setpoint shall be overridden to its maximum setpoint (regardless of the cooling loop output).

H. Hydronic Reheat: N.O. Zone reheat coil valve shall modulate in a PI loop to maintain space temperature heating setpoint as defined above with a 2°F throttling range. Valve shall be closed whenever the parent AHU is off.

I. Occupancy Override Button: Occupancy override buttons shall be placed as shown on the drawings. When these are depressed, the associated systems and zones shall go into the occupied period for 1 hr. (adj.)

3.25 LAB FLOW TRACKING ZONE WITH MULTIPLE VAV HOODS [DWG C-2.05A]

A. Tracking Zones: In all lab spaces with combinations of supply air terminal units (SATU), general exhaust terminal units (GETU), snorkel exhaust terminal units

(SETU),and fume hood exhaust valves (FEV), the Zones shall controll as follows:

B. Space Temperature Control: Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. Normal space cooling setpoint: shall be the normal space temperature plus 2°F (adj.)
2. Normal space heating setpoint: shall be the normal space temperature minus 2°F (adj.)

C. The fume hood exhaust valves (FEV) shall be controlled by packaged lab controllers. The BAS shall monitor the fume hood exhaust flow via a 0-10v (or similar) signal directly from the Fume hood controller. The BAS shall also monitor each fume hood controller via a direct LAN interface. Provide all points available via the interface for display on the BAS graphic.

D. Response Time: The FEV packaged lab controllers shall respond quickly to ensure that FEV has completed adjustment no more than 3 seconds after the hood sash height is changed. BAS controllers shall respond quickly to ensure that all SAV and GEV adjustments are complete no more than 7 seconds after FEV adjustment is complete (a total for 10 seconds to respond reach setpoint for each zone).

E. Snorkel Exhaust Terminal Unit (SETU) Control: The BAS shall control the damper via a PID loop to maintain the SETU constant volume setpoint (typical for each Snorkel Exhaust Terminal Unit in the zone).

F. General Exhaust Terminal Unit (GETU) Control: The BAS shall control the damper via a PID loop to maintain the GETU volume at setpoint for each GEV in the Zone.

1. BAS shall continuously calculate a zone total exhaust flow setpoint based on the temperature in the zone. This setpoint shall be reset between maximum and minimum volume settings to maintain space temperature cooling setpoint with a 2°F (adj.) reset range. Zone exhaust volume setpoint shall remain at the minimum volume setting whenever space temperature is below the cooling throttling range.
2. The total General Exhaust flow setpoint shall be equal to the total exhaust flow setpoint minus any Fume Hood exhaust flows and Snorkel Exhaust flows.
3. The BAS shall reset the flow setpoint of all GETUs in a zone proportionally between their minimum and maximum flow values to maintain the total General Exhaust flow at setpoint (and thus, the total Zone Exhaust flow).
4. The BAS shall modulate the damper of each GETU in a zone to maintain each individual exhaust flow setpoint.

G. Supply Air Terminal Unit (SATU) Control: The BAS shall control the damper via a PID loop to maintain the SATU volume setpoint for each SATU in the Zone.

1. BAS shall continuously calculate a zone total supply flow setpoint The supply flow setpoint shall equal the sum of all respective exhausts in the zone served, minus a Zone Flow Offset value which shall be as shown on the drawings.
2. The BAS shall reset the flow setpoint of all SATUs in a zone proportionally (based on their scheduled minimum an maximum flow setpoints) to maintain the Zone Flow Offset at setpoint. Note that if the Zone Total Exhaust flow is greater than or less than the scheduled minimum and maximum Total Exhaust Flow values, then the Total supply flow setpoint (and thus the individual SATU flow setpoints) may be less than or greater than the supply scheduled minimum and maximum values.
3. The BAS shall modulate the damper of each SATU in a zone to maintain each individual supply flow setpoint.

H. Purge Button: Upon indication of emergency purge mode, which shall be started when the panic button is depressed, the total Zone Exhaust Flow setpoint shall be overridden to its maximum setpoint (regardless of the cooling loop output).

I. Hydronic Reheat: N.O. Zone reheat coil valve shall modulate in a PI loop to maintain space temperature heating setpoint as defined above with a 2°F throttling range. Valve shall be closed whenever the parent AHU is off.

J. Occupancy Override Button: Occupancy override buttons shall be placed as shown on the drawings. When these are depressed, the associated systems and zones shall go into the occupied period for 1 hr. (adj.)

K. Tracking Zone Combinations: The control of each tracking zone shall be as stated above. There are multiple combinations of different quantities of supply, general exhaust, snorkel exhaust and fume hood exhaust valves. The control shall be similar in that the total supply shall track the total exhaust flow to maintain the zone flow offset at setpoint. The general exhaust shall be modulated to maintain the total exhaust at setpoint that is reset based on the space temperature.

3.26 LAB FLOW TRACKING ZONE WITH VARIABLE VOLUME HOOD [DWG C-2.06]

A. **General**: BAS shall control the supply air systems in the zone including the supply air reheat box (SA). Generally, the BAS will receive exhaust flow data from the factory exhaust controllers and adjust supply air to maintain the specified offset. The system shall be controlled to maintain a negative pressure in the room by maintaining the supply flow less than the exhaust.

B. **Hood Monitoring Interface**: BAS shall continuously monitor the face velocity, on the hood and provide a local indication of the status of the hood. Safe conditions shall be set up for ± 30% of the active face velocity setpoint. Local visual and audible indication of unsafe conditions shall be enunciated. Include a silence button, and emergency purge button.

C. **Supply Box Control**: BAS shall modulate the damper on the supply box to maintain the supply flow setpoint. The supply flow setpoint shall equal the sum of all respective exhausts in the zone served, minus an offset value which shall be determined as follows:

1. It shall be fixed at the differential scheduled on the drawings and/or as refined by the balancing contractor
2. It shall be reset between adjustable limits based on sensed room differential pressure. This loop shall be a slow “check and bump” or dynamic proportional loop both with a no adjustment dead band.

D. **Emergency Purge Button**: Panic buttons shall be located adjacent to all exits which, when depressed will start emergency purge mode for the zone. Mode shall remain active until manually reset by the operator via the graphic interface.

3.27 LAB FLOW TRACKING ZONE WITH VARIABLE VOLUME HOOD (COMMON EXHAUST AFMS) [DWG C-2.07]

A. **General**: BAS shall control the supply air systems in the zone including the supply air reheat box (SA). Generally, the BAS will monitor total exhaust flow from a single total exhaust air flow monitoring and adjust supply air to maintain the specified offset. Factory controllers shall control the lab exhaust and general exhaust systems providing data to the BAS for monitoring and alarming purposes. The system shall be controlled to maintain a negative pressure in the room by maintaining the supply flow less than the exhaust.

B. **Hood Monitoring Interface**: BAS shall continuously monitor the face velocity, on the hood and provide a local indication of the status of the hood. Safe conditions shall be set up for ± 30% of the active face velocity setpoint. Local visual and audible indication of unsafe conditions shall be enunciated. Include a silence button, and emergency purge button.

C. **Supply Box Control**: BAS shall modulate the damper on the supply box to maintain the supply flow setpoint. The supply flow setpoint shall equal the sum of all respective exhausts in the zone served, minus an offset value which shall be determined as follows:

1. It shall be fixed at the differential scheduled on the drawings and/or as refined by the balancing contractor
2. It shall be reset between adjustable limits based on sensed room differential pressure. This loop shall be a slow "check and bump" or dynamic proportional loop both with a no adjustment dead band.

D. **Emergency Purge Button**: Panic buttons shall be located adjacent to all exits which, when depressed will start emergency purge mode for the zone. Mode shall remain active until manually reset by the operator via the graphic interface.

3.28 STEAM TO HW CONVERTER WITH CV PUMPS [DWG C-3.00]

A. **General**: BAS shall control the hot water systems and equipment and provide monitoring and diagnostic information for management purposes.

B. **Heating Enable**: Heating shall be enabled when:

1. Any hot water valve opens to more than 50% continuously for 10 min. (adj.).
2. OR, the Outside Air temperature is below 55°F
3. OR, whenever manually enabled by the operator at the operator interface. Once enabled, the Heating Water System shall run for a minimum of 1 hour.
4. AND, the system is not manually disabled by the operator at the operator interface.

C. **HW Pump Control:**

1. One HW pump shall run continuously whenever heating system is enabled.

2. BAS shall prove operation of the pump. Upon failure of the lead pump, and alarm shall be enunciated and the standby pump shall be started.
3. BAS shall monitor pump status and accumulate runtime of the pumps. The lead pump shall be rotated to equalize runtime between the pumps.

D. **Heating Water Temperature Control**: BAS shall reset the hot water supply temperature setpoint via a sliding 20˚F temperature band from 180°F (adj.) to 100°F (adj.) based on heat requests as the OA temperature rises from 20°F (adj.) to 60°F (adj.)

1. The BAS shall modulate the 1/3 [and 2/3 steam] valves to the Heat Exchanger in sequence via a PID loop to maintain the HW supply temperature setpoint.
2. The valves shall remain closed until pump status is proven.
3. Steam supply pressure to the Heat Exchanger shall be monitored by the BAS and enunciate an alarm if it falls below 5 psi (adj.)

3.29 STEAM TO HW CONVERTER WITH VV PUMPS [DWG C-3.01]

A. **General**: BAS shall control the hot water systems and equipment and provide monitoring and diagnostic information for management purposes.

B. **Heating Enable**: Heating shall be enabled when:

1. Any hot water valve opens to more than 50% continuously for 10 min. (adj.).
2. OR, the Outside Air temperature is below 55°F
3. OR, whenever manually enabled by the operator at the operator interface. Once enabled, the Heating Water System shall run for a minimum of 1 hour.
4. AND, the system is not manually disabled by the operator at the operator interface.

C. **HW Pump Control:**

1. Whenever the system is enabled, a minimum of one heating water pump shall run continuously.
2. BAS shall use a PID loop to maintain the differential pressure setpoint across the remote differential pressure sensor. The differential pressure setpoint shall initially be set at 15 psi (adj. as determined by the balance contractor).
3. The output of this loop shall control the starting, stopping, and speed of the pumps as follows:
   a) On a PID output of greater than 95% for 5 min (adj.), the BAS shall start an additional pump. The new pump shall ramp to speed per adjustable acceleration rates.
   b) If more that one pump is running, on a PID output of less than 40% for 5 min (adj.), the BAS shall stop a pump.
4. The output of the PID loop shall control the VSD's of .all operating pumps at the same speed.

5. BAS shall prove operation of each pump individually. Upon failure of a pump, the standby shall be started (if not already running) and an alarm shall be enunciated.
6. BAS shall monitor pump status and accumulate runtime of the pumps. The BAS shall rotate the lead and lag pumps as follows:
    a) Whenever a pump is started, the BAS shall start the pump with the least runtime.
7. Whenever a pump is stopped, the BAS shall stop the pump with the highest runtime.

D. **HW Bypass Valve:** BAS shall modulate the position of the valve as required to maintain HW RDP at least 2 psid above the HW RDP setpoint.

E. **Heating Water Temperature Control**: BAS shall reset the hot water supply temperature setpoint via a sliding 20˚F temperature band from 180°F (adj.) to 100°F (adj.) based on heat requests as the OA temperature rises from 20°F (adj.) to 60°F (adj.)

1. The BAS shall modulate the 1/3 [and 2/3 steam] valves to the Heat Exchanger in sequence via a PID loop to maintain the HW supply temperature setpoint.
2. The valves shall remain closed until pump status is proven.
3. Steam supply pressure to the Heat Exchanger shall be monitored by the BAS and enunciate an alarm if it falls below 5 psi (adj.)

3.30 PROCESS CHILLED WATER LOOP [DWG C-3.02]

A. **General**: BAS shall control the process chilled water system and equipment and provide monitoring and diagnostic information for management purposes.

a) **System Enable**: System shall be enabled whenever manually enabled by the operator at the operator interface. Once enabled, the Chilled Water System shall run continuously.

b) **System Disable**: System shall be disabled whenever manually disabled by the operator at the operator interface.

B. **Chilled Water Pump Control**

1. Whenever the system is enabled, a minimum of one chilled water pump shall run continuously.
2. BAS shall prove operation of each pump individually. Upon failure of a pump, the standby shall be started (if not already running) and an alarm shall be enunciated.
3. BAS shall monitor pump status and accumulate runtime of the pumps. The BAS shall rotate the lead and lag pumps as follows:
    a) Whenever a pump is started, the BAS shall start the pump with the least runtime.
    b) Whenever a pump is stopped, the BAS shall stop the pump with the highest runtime.

C. **Heat Exchanger Control**

1. Whenever the system is enabled, the building side and process side isolation valves shall open. BAS shall monitor valve operation and enunciate an alarm if limit switch does not prove open.

D. **Emergency Domestic Water Control**

1. Whenever the system is enabled, and the building chilled water system or HEX has failed or the process chilled water supply temperature rises above the alarm setpoint (setpoint+5˚F, adj.) for 10 minutes the Emergency Domestic Water system will start as follows:
   a) Pressure Regulated Domestic Water supply isolation and Domestic Water Drain isolation valves shall open. BAS shall monitor valve operation and enunciate and alarm if limit switch does not prove them open.

3.31 GLYCOL HEAT RECOVERY RUN AROUND LOOP [DWG C-3.03]

A. **General**: BAS shall control the glycol heat recovery system and equipment and provide monitoring and diagnostic information for management purposes.

a) **System Enable**: System shall be enabled whenever the following criteria are met:

1) System manually enabled by the operator at the operator interface, AND

2) Air systems served be recovery system are operational, AND

3) The criteria for efficient operation of the system as written below are met.

b) **System Disable**: System shall be disabled whenever any of the following occurs:

1) System manually disabled by the operator at the operator interface, OR

2) Air systems served by the recovery system are off, OR

3) The criteria for efficient operation of the system as written below is not met.

B. **Enable Criteria:**

1. Outside air temperature must be lower than the exhaust air temperature entering the heat recovery coil.
2. Outside air temperature must be higher than the lower limit temperature of the glycol system.
3. If there is no bypass valve, outside air temperature must be above 28˚F (adj.).

C. **Optional Bypass Valve Control**

1. Whenever the system is enabled, BAS shall modulate the valve to bypass the outside air recovery coil via a proportional only loop as outside air temperature falls from 30˚F to 28˚F (all adjustable).

D. **Circulating Pump Control**

1. Whenever the system is enabled, circulating pump shall run continuously.
2. BAS shall prove operation of the pump. Upon failure of a pump, an alarm shall be enunciated.
3. BAS shall monitor pump status and accumulate runtime of the pump.

3.32 BRIDGE CHWS & CHWR MONITORING [DWG C-3.04]

A. **General**: BAS shall monitor the building chilled water temperatures for diagnostic and management purposes.

B. **CHWS Temperature Alarm**: BAS shall enunciate an alarm if the CHWS temperature rises above adjustable limits for 10 minutes (adj.) when the system is enabled.

3.33 REDUNDANT CV EXHAUST FAN CONTROL FOR MANIFOLD EXHAUST LAB SYSTEMS [DWG C-4.00]

A. **General**: BAS shall control the exhaust system and equipment and provide monitoring and diagnostic information for management purposes.

B. **Fan Control**: BAS shall control the starting and stopping of the exhaust fans as follows:

1. **Start/Stop**: BAS shall command the operation of the exhaust fan and it shall run continuously.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of an exhaust fan, the BAS shall enunciate an alarm as specified above and start a lag fan.

C. **Isolation Damper**: Whenever the fan is energized, BAS shall open the associated isolation damper after a 5 second delay. Whenever the fan stops, the damper shall close.

D. **Outside Air Damper:** BAS shall modulate the position of the damper as required to maintain exhaust pressure at setpoint.

3.34 REDUNDANT VAV EXHAUST FAN CONTROL FOR MANIFOLD EXHAUST LAB SYSTEMS [DWG C-4.01]

A. **General**: BAS shall control the exhaust system and equipment and provide monitoring and diagnostic information for management purposes.

B. **Exhaust Fan**: BAS shall control the starting and stopping of the exhaust fan as follows:

1. **Start/Stop**: BAS shall command the operation of the exhaust fan and it shall run continuously.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime.

3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the minimum exhaust air flow setpoint. On start the fan will ramp to 40% (adj.) speed until the isolation damper is >80% open. Once the damper is proven, the VSD shall ramp to speed within adjustable acceleration limits. When commanded to stop the VSD shall ramp down within adjustable deceleration limits. BAS shall monitor a common alarm output from the drive and enunciate a level 2 alarm when an alarm is indicated.

C. **Isolation Damper**: Whenever the fan is energized, BAS shall open the associated isolation dampers. Whenever the fan stops, the damper shall close.

D. **Outside Air Damper:** BAS shall modulate the position of the damper as required to maintain exhaust pressure at setpoint.

3.35 FAN COIL UNITS [DWG C-4.02]

A. **General**: Control shall include scheduled occupancy with optimimum preoccupancy, occupancy override, and reheat control as specified below. Schedule shall be the same as the parent AH.

B. **Space Temperature Control:** Three setpoints shall apply. Normal (72°F adj.)), setback heating (65°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperatures. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input). During the normal periods, separate heating and cooling setpoints shall be calculated.

1. **Normal space cooling setpoint**: shall be the normal space temperature plus 2°F (adj.)
2. **Normal space heating setpoint**: shall be the normal space temperature minus 2°F (adj.)

C. **Fan:** Fan shall be enabled and run continuously during occupied mode. During unoccupied mode, fan shall be deenergized except as required to maintain setback temperature setpoints for both heating and cooling with a cycle differential of 3°f (adj.). Bas shall prove fan operation and use the status indication to accumulate runtime.

D. **Valves:** Heating and cooling control valves shall cycle as required to maintain space temperature setpoint for the associated mode (heating or cooling). Programming shall be implemented to prevent overlap of the heating and cooling valves.

E. **Heating Request:** This unit shall issue a "heating request" to the HW system as follows:

1. Whenever the heating output is at 100%, or
2. Whenever the space temperature falls below the throttling range of the heating loop.

F. **Cooling Request:** This unit shall issue a "cooling request" to the CHW system as follows:

1. Whenever the cooling output is at 100% (full cooling), or
2. Whenever the space temperature rises above the throttling range of the cooling loop.

3.36 ELECTRIC UNIT HEATER [DWG C-4.03]

A. **General**: BAS shall enable the unit heater and provide monitoring and diagnostic information for management purposes.

B. **Fan Control**: BAS shall control the starting and stopping of the unit heater as follows:

1. **Start/Stop**: BAS shall command the operation of the unit heater and it shall run continuously when enabled per occupancy schedule.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of an exhaust fan, the BAS shall enunciate an alarm.

C. **Enable Heater**: Unit heater shall be energized whenever space temperature falls below the active heating setpoint.

D. **Disable Heater**: Unit heater shall be deenergized whenever space temperature rises below the active heating setpoint deadband.

3.37 GENERATOR EXHAUST CONTROL [DWG C-4.04]

A. **General**: BAS shall enable the generator room exhaust fan and provide monitoring and diagnostic information for management purposes.

B. **Fan Control**: BAS shall control the starting and stopping of the exhaust fan as follows:

1. **Start/Stop**: BAS shall command the operation of the exhaust fan and it shall run continuously whenever enabled at the operator interface or receives a start signal from the generator control panel.
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of an exhaust fan, the BAS shall enunciate an alarm.

C. **Damper Control**: Pneumatically actuated dampers shall be controlled directly from the generator control panel as follows:

1. **Open/Close**: Generator control panel shall energize the EP’s to fully open the normally open intake and exhaust dampers within 10 seconds. Whenever the generator signal is removed the dampers will be closed.
2. **Proof**: BAS shall monitor status of the exhaust damper and enunciate an alarm if the limit switch does not prove.

END OF SECTION 230993