

SECTION 230950 – SEQUENCE OF OPERATIONS

1.1 VARIABLE VOLUME AIR HANDLER SEQUENCE OF OPERATIONS

A. UNIT REQUEST

Unit shall be requested to run upon a call for occupied or unoccupied heating or cooling from any zone served by its supply ductwork. See floor plans for associated zones. See VAV Box sequence of operations in this section.

B. SUPPLY FAN CONTROL

Supply fan shall be commanded to run when unit is requested. Variable frequency drive shall modulate to maintain an end-of-line static pressure of 1.5" W.C. (adjustable) as sensed by a differential pressure sensor located two-thirds down the longest duct run. Fan shall run continuously while unit is requested. When VAV1-01 is achieving target airflow and control damper is still being requested to close, S.P. set point shall be adjusted down. Conversely when VAV1-01 is not achieving airflow set point and the damper has been commanded fully open, SP set point shall be adjusted up, but to exceed setpoint set by T&B contractor.

C. RETURN FAN CONTROL

Return fan shall be commanded to run when unit is requested. Variable frequency drive shall modulate 20% (adjustable) behind the Supply fan VFD signal. Fan shall run continuously while unit is requested.

D. CHILLED WATER COIL CONTROL

When unit is requested to run, chilled water valve shall modulate to maintain a supply air temperature of 55° F (adjustable). Supply air temperature shall reset linearly based upon outside air conditions where: When outside air is 50° F or below supply air shall be set at 65° F. When outside air is 70° F or above supply air shall be set at 55° F. The limits on this scale shall be fully adjustable.

E. PRE-HEAT COIL CONTROL

When unit is requested to run, preheat coil valve shall modulate to maintain a preheat air temperature 2° F below unit supply air temperature setpoint as described above. Upon a fall in mixed air temperature below 40° F, preheat coil valve shall be forced fully open until pre-heat air temperature setpoint has been reached, where upon valve shall resume normal control.

F. OUTSIDE AIR DAMPER CONTROL

BAS Shall monitor outside airflow provided to unit.

1. Unit not Requested, Unoccupied Operation, And morning warm-up,
 - a. OA Damper shall be fully shut.
2. Occupied Start-Up:
 - a. OA Damper shall modulate to maintain Minimum Outside Air setpoint as scheduled. This airflow shall be monitored by an OA airflow monitoring station and shall be reported to the BAS
3. Occupied Demand Control:

- a. Outside airflow setpoint may be reduced to save energy and to maintain acceptable CO2 levels in all spaces. CO2 levels shall be determined to be the Maximum of all reporting thermostats. Demand Control setpoint shall be 600ppm (adjustable)
- b. Upon a fall in max CO2 levels below setpoint, OA damper shall shut in increments of 10% (adjustable). Adjustments shall not be further lowered unless conditions exist for reducing airflow again for 30 min (adjustable)
- c. Upon a rise in max CO2 levels above setpoint, OA damper shall immediately open to maintain scheduled minimum airflow setpoint.
- d. Upon a rise in maximum CO2 levels above 1000ppm from any space, outside air damper shall be forced fully open and an alarm shall be generated in the BAS.

G. HUMIDITY CONTROL

A humidity sensor located in the return air duct shall monitor space return humidity. When this sensor reports a humidity level above 65%R.H. (adjustable) chilled water valve supply air temperature setpoint shall be command to dehumidification control setpoint of 50°F (adjustable) Unit shall remain in dehumidification mode until return air humidity falls below 60%R.H. (adjustable)

H. SAFETIES

1. A high static pressure switch shall be located in the supply duct and shall disable unit supply fan upon sensing a discharge air static pressure above 4" w.c. This hi-static condition shall generate an alarm in the BAS. Unit shall not be commanded to run until alarm has been manually reset in the BAS.
2. A freeze stat located in after the pre-heat coil shall be hard wired to the fan starter. Supply fan shall be disabled at any time the freeze stat senses air below 34° F and shall be manually reset at the unit.
3. A smoke detector located in the return air duct shall be connected to the building fire alarm system.
4. Unit controller shall monitor the fire alarm system and supply fan shall be shut off on any building smoke alarm.

I. TRENDING

BAS shall monitor and trend the following points at 15 min intervals and shall store the data for a minimum of 30 days.

1. Return Air Temperature
2. Return Air Humidity
3. Mixed Air Temperature
4. Preheat Air Temperature
5. Supply Air Temperature
6. Supply Air Temperature setpoint
7. Fan speed
8. Maximum CO2 Level of connected zones (and reporting zone)
9. End-of-line static pressure

J. ALARMS

Unit shall generate alarms in the BAS upon the following conditions: Additional alarm points may be requested by owner.

1. Return Air Temperature above 90 ° F or below 50 ° F
2. Return Air Humidity above 65% R.H.
3. Mixed Air Temperature below 40° F
4. Preheat Air Temperature below 40° F
5. Fan failure to run (as sensed by a current switch) after 20 seconds of request signal.
6. Supply Static Pressure above 4" w.c.
7. End-of-line static pressure 0.5" w.c. below setpoint or lower for more than 5 minutes and unit is requested to run.
8. High Zone CO2 levels.
9. Filter Dirty
10. Building fire alarm activated.

1.2 ENERGY RECOVERY VENTILATOR SEQUENCE OF OPERATIONS

A. UNIT REQUEST

Unit shall be requested to run upon during all occupied times.

B. FAN CONTROL

Supply and exhaust fans shall be commanded to run when unit is requested.

1. Variable frequency drive shall modulate to maintain supply airflow setpoint as follows:
 - a. ERV controller shall monitor the OA flow setpoints calculated by summing the Outside Airflow setpoints of AHU-1 and also future setpoints for AHU-2 (future) and AHU-3 (future)
 - b. Setpoints for future AHU-2 and AHU-3 shall be zero and shall be displayed on the ERV front end graphics.
 - c. Fan shall modulate supply airflow to maintain this setpoint.
2. Exhaust fan VFD signal shall modulate to maintain relief airflow setpoint.
 - a. In order to maintain building pressurization, Exhaust fan shall modulate to maintain an exhaust/relief airflow 200 CFM below the supply airflow setpoint determined above.

C. DAMPER CONTROL

Outside air and exhaust air dampers shall remain shut when unit is not requested. Dampers shall be commanded 100% open upon request for ERV to run.

D. SAFETIES

1. Unit controller shall monitor the fire alarm system and supply fan shall be shut off on any building smoke alarm.
2. A smoke detector located in the supply air duct shall be connected to the building fire alarm system.
3. A smoke detector located in the relief air duct shall be connected to the building fire alarm system.
4. Filter status shall be monitored on both the outside air and relief airstreams.

E. TRENDING

BAS shall monitor and trend the following points at 15 min intervals and shall store the data for a minimum of 30 days.

1. Supply Air Temperature
2. Supply Air Humidity
3. Supply Fan Speed
4. Supply Airflow
5. Relief Airflow
6. Exhaust Fan Speed
7. End-of-line static pressure

F. ALARMS

Unit shall generate alarms in the BAS upon the following conditions: Additional alarm points may be requested by owner.

1. Supply Fan failure to run (as sensed by a current switch) after 20 seconds of request signal.
2. Exhaust Fan failure to run (as sensed by a current switch) after 20 seconds of request signal
3. Supply Static Pressure above 4" w.c.
4. Outside Air Filter Dirty
5. Relief Air Filter Dirty
6. Building fire alarm activated.

1.3 VAV BOX SEQUENCE OF OPERATION

Typical of all new and existing VAV Boxes.

- A. UNIT REQUEST - VAV Boxes shall operate on a user defined 365-day occupancy schedule. Occupied and unoccupied space temperature setpoints shall be set up as a global value.
- B. The VAV Box shall run under the following conditions:
1. OCCUPANCY - Unit shall be requested at all occupied times.
 2. SETUP-UP & SET-BACK - Unit shall be requested to run during unoccupied times if its space temperature sensor reports a temperature below 55° F (adjustable) or above 85° F (adjustable) Unit shall remain requested until space is brought to set back temperature.
 3. MORNING WARM-UP/COOLDOWN – Unit shall be requested to run in unoccupied mode at a calculated time interval prior to occupancy such that space setpoint has been achieved at the time of building occupancy. This time interval shall be calculated using a self-learning algorithm based upon space temperature and outside air temperature.
 4. OVERRIDE REQUEST - Upon a request from the zone thermostat over-ride request – VAV shall enter “occupied mode” for a period of 2 hours.
- C. DAMPER CONTROL - Supply air damper shall modulate to maintain space temperature set point of 72° F (adjustable). Air valve shall not be shut below 20% real air flow during occupied times. Damper position shall be reported to the BAS.

- D. HEATING COIL CONTROL - hot water valve shall modulate to maintain the space temperature at 70° F (adjustable).. Valve position shall be reported to the BAS.
 - E. TEMPERATURE SENSORS – Zone thermostats shall have set point adjustments to individually control the spaces +/- 5° F (remotely adjustable) from global set points. Heating and cooling set points must never be less than 2° F apart.
 - F. SAFETIES: VAV Box shall monitor the building fire alarm signal. Upon activation of the fire alarm, the air valve shall shut fully until alarm status has been cleared...
 - G. TRENDING
BAS shall monitor and trend the following points at 15 min intervals and shall store the data for a minimum of 30 days.
 - 1. Space Temperature
 - 2. Space Temperature Setpoint
 - 3. Discharge Air Temperature
 - 4. Hot water valve position
 - 5. Damper Position
 - 6. Override Requested
 - H. ALARMS
Unit shall generate alarms in the BAS upon the following conditions: Additional alarm points may be requested by owner.
 - 1. Space Temperature more than 4° F above or below setpoint
 - 2. Discharge air above 100° F.
 - 3. Override requested more than 4 times in 24 hours.
- 1.4 HOT WATER SYSTEM CONTROL
- A. SYSTEM REQUEST
Hot water system shall be requested to run at upon a call for heating from any hot water coil in the building.
 - B. HEAT EXCHANGER CONTROL
Heat exchanger steam control valves shall modulate to maintain supply water temperature of 180 ° F as dictated by BAS. Boiler supply water temperature shall reset linearly based upon outside air conditions where: When outside air is 50° F or below hot water supply shall be set at 180° F. When outside air is 80° F or above hot water supply shall be set at 120° F. The limits on this scale shall be fully adjustable. As the hot water system optimizes to meet hot water supply set point, the following staging means shall be implemented.
 - 1. STAGE 0: (Not requested)
 - a. Steam isolation Valve: Closed
 - b. 1/3 Steam Control Valve: Closed
 - c. 2/3 Steam Control Valve: Closed

- d. Hot Water Isolation Valve: Closed
- 2. STAGE 1:
 - a. Steam isolation Valve: Open
 - b. 1/3 Steam Control Valve: Modulating
 - c. 2/3 Steam Control Valve: Closed
 - d. Hot Water Isolation Valve: Open
- 3. STAGE 2:
 - a. Steam isolation Valve: Open
 - b. 1/3 Steam Control Valve: Closed
 - c. 2/3 Steam Control Valve: Modulating
 - d. Hot Water Isolation Valve: Open
- 4. STAGE 3:
 - a. Steam isolation Valve: Open
 - b. 1/3 Steam Control Valve: Modulating
 - c. 2/3 Steam Control Valve: 100% Open
 - d. Hot Water Isolation Valve: Open
- 5. Stage limiters
Conditions shall exist for staging up consistently for 10 min (adjustable) before activating the next stage. Conditions shall exist for staging up consistently for 20 min (adjustable) before activating the next stage down.

C. HOT WATER PUMP CONTROL

HWP-1 and HWP-2 shall operate on a 100% Stand-By Lead-Lag relationship. Upon request lead hot water pump shall start and shall modulate to maintain building hot water pressure setpoint as sensed by differential pressure setpoint located before the coil on RTU-1 see plans. Upon failure of the lead pump, Lag pump shall be promoted to lead and shall generate an alarm in the BAS. Lead-Lag roles shall automatically switch roles on a weekly basis with a time of week to be directed by owner and shall be user adjustable. Differential pressure setpoint shall be set by the balancing contractor.

D. TRENDING

BAS shall monitor and trend the following points at 15 min intervals and shall store the data for a minimum of 30 days.

- 1. Hot water system differential pressure.
- 2. Hot water pump, HWP-1 speed.
- 3. Hot water pump, HWP-2 speed.
- 4. Building hot water supply temperature.
- 5. Building hot water return temperature.

E. ALARMS

Unit shall generate alarms in the BAS upon the following conditions: Additional alarm points may be requested by owner.

1. Pump failure to run (as sensed by a current switch) after 20 seconds of request signal
2. Hot water system differential pressure more than 10ft above or below setpoint.
3. Building hot water supply temperature more than 10 ° F above or below setpoint
4. Building hot water return temperature less than 10 ° F below hot water supply temperature. (system coils are designed on a 40° dT)

END OF SECTION 230950

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