

25 95 00 – Integrated Automation Control Sequences for HVAC

A. GENERAL

1. The HVAC operational sequences in this guideline are commonly used by Duke University. They are being provided as a preferred design base reference. They are not meant to be used as the only permitted sequences. Exceptions for HVAC systems other than those provided in this guideline may be allowed with Duke FMD approval.

B. INDEX

1. Economizer
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3. AHU Unoccupied Mode and Morning Warm-up/Cool-down
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C. OPERATIONAL SEQUENCES

1. **Economizer**

- a. Initiate economizer mode operation when outdoor air enthalpy reaches **28 Btu/lb.** (adjustable) and disable economizer mode when outdoor air enthalpy increases to **29 Btu/lb.** Enthalpy information shall be gathered via broadcast outdoor temperature, humidity and enthalpy calculation supplied by Duke FMD.

When the unit is in economizer mode the return and outside air damper shall modulate to maintain a mixed air setpoint equal to the supply air set point minus **5°F** (adjustable). Return, exhaust, and outside air dampers shall each have a separate signal from the BAS. The exhaust damper shall track to outdoor air damper and the return shall modulate opposite the outdoor air damper. If the outdoor air damper is fully open and supply air setpoint is not maintained, the chilled water valve shall modulate to maintain the supply temp setpoint.

Outdoor air damper shall maintain a minimum outside cfm air setpoint (adjustable) set by the air balance company. A drop in mixed air temp below the mixed air low limit setpoint of 45°F (adjustable) will override economizer, minimum outdoor air, and CO2 to maintain mixed air temp above low limit setpoint.

2. **Economizer with Demand CO2 Ventilation**

- a. Initiate economizer mode operation when outdoor air enthalpy reaches **28 Btu/lb** (adjustable) and disable economizer mode when outdoor air enthalpy increases to **29**

Btu/lb. Enthalpy information shall be gathered via broadcast outdoor temp, humidity and enthalpy calculation supplied by Duke FMD.

When the unit is in economizer mode the return and outside air damper shall modulate to maintain a mixed air setpoint equal to the supply air setpoint minus **5°F** (adjustable). Return, exhaust and outside air dampers shall each have a separate signal from the BAS. The exhaust damper shall track to outdoor air damper and the return shall modulate opposite the outdoor air damper. If the outdoor air damper is fully open and supply air setpoint is not maintained, the chilled water valve shall air setpoint is not maintained, the chilled water valve shall modulate to maintain the supply temp setpoint.

Outdoor air dampers shall maintain a minimum outside cfm air setpoint (adjustable) set by the air balance company. A drop in mixed air temp below the mixed air low limit setpoint of **45°F** (adjustable) will override economizer, minimum outdoor air, and CO2 to maintain mixed air temp above low limit setpoint.

- b. System will monitor CO2 via air handler return sensor and/or space CO2 sensor located in a high occupancy area. The system should sample the level every 10 min (adjustable) and trigger a "high CO2 mode" when the level reaches greater the **1100 ppm**. When in high CO2 mode the outside air damper shall modulate to maintain **1000 ppm**. When CO2 level drops to less than **950 ppm** the system will turn off the high CO2 mode. Outside air cfm should be limited to **40%** of the total supply unless there are special considerations. If any sensor reads greater than **1600 ppm**, that sensor should be ignored by the DCV sequence and an alarm should be set. The number of sensors used in the DCV sequence should be minimized to only what is necessary. At no time should be minimized to only what is necessary. At no time should the DCV sequence override the mixed air low temp limit.

c. Summary of OA Damper Control Modes

- 1) System not in Economizer or High CO2 Mode:

OA damper shall control to the minimum OA damper settings and the mixed air low limit loop output.

- 2) System in Economizer but not in High CO2 Mode:

Damper shall control to the minimum of the economizer mixed air loop output, minimum OA damper setting and the mixed air low limit loop output.

- 3) System in CO2 Mode but not Economizer Mode:

OA damper shall control to the maximum of the CO2 loop output and minimum and minimum OA damper setting, with mixed air low limit loop output overriding.

- 4) System in Economizer and High CO2 Mode:

OA damper shall control to the maximum of the economizer mixed air loop output, CO2 loop output, and minimum OA damper setting, with the mixed air low limit loop output overriding.

3. AHU Unoccupied Mode with Morning Warm-up/Cool-down

a. General Guidelines

- 1) Typical applications serving (including but not limited to): Private offices, open office layouts, classrooms, auditorium, dining, support spaces. These sequences do not apply to Dormitories, Laboratories and critical systems/spaces.
- 2) AHU's are typically off in Unoccupied Mode unless specified by Duke FMD.
- 3) Minimum OA set point should be set to zero during unoccupied heating/cooling modes.
- 4) All general exhaust fans shall be turned on during associated air handler occupied heating/cooling mode and shall be turned off during air handler unoccupied heating/cooling modes.
- 5) Unoccupied zone heating/cooling set-points shall be 65°F (adj.) for heating mode, and 80°F (adj.) for cooling mode.
- 6) Unoccupied zone heating/cooling will be determined by monitoring specific zones as determined by Duke.
- 7) AHU supply air reset temperature shall follow Duke FMD guidelines for supply air reset programming temperatures.

b. Sequences with Terminal Units

- 1) Sequences will be initiated 30 minutes (adj.) prior to building occupancy schedule.
- 2) Mode of operation will be determined by evaluating AHU return air temperature.
- 3) The AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. Heating of the zones will be performed using the zone VAV reheat valve until AHU return air temperature reaches 68°F (adj.). AHU cooling coil control valve will operate to maintain occupied supply air temperature set-point until AHU return air temperature drops below 76°F (adj.).
- 4) Unoccupied Mode Low Temperature Limit: If low temperature limit is activated, the AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. The AHU will operate for a min of 30 minutes (adj.) and modulate appropriate terminal unit reheat control valves until applicable zone sensors are 2°F above Low Limit set-point.

- 5) Unoccupied Mode High Temperature Limit: If high temperature limit is activated, the AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. The AHU will operate for a min of 30 minutes (adj.) and modulate chilled water coil control valve until applicable zone sensors are 2°F below High Limit set-point.
- c. Sequences without Terminal Units
- 1) Sequences will be initiated 30 minutes (adj.) prior to building occupancy schedule.
 - 2) Mode of operation will be determined by evaluating AHU return air temperature.
 - 3) The AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. Heating of the zones will be performed by modulating the AHU preheat coil control valve to maintain normal reset supply air temperature set-point until AHU return air temperature reaches 68°F (adj.). During cool-down mode, AHU cooling coil control valve will modulate to maintain occupied supply air temperature set-point until AHU return air temperature drops below 76°F (adj.).
 - 4) Unoccupied Mode Low Temperature Limit: If low temperature limit is activated, the AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. The AHU will operate for a minimum of 30 minutes (adj.) and will modulate the AHU preheat control valve to maintain normal reset supply air temperature set-point until applicable zone sensor is 2°F above Low Limit set-point.
 - 5) Unoccupied Mode High Temperature Limit: If high temperature limit is activated, the AHU will operate with return air damper fully open, and min/max relief and min/max outside air dampers closed. The AHU will operate for a minimum of 30 minutes (adj.) and modulate chilled water coil until applicable zone sensor is 2°F below High Limit set-point.

4. AHU Supply Fan VFD Control

- a. On startup, the static pressure set point shall be ramped from 0 to the design set point over a period of 3 minutes to prevent high static trips.
- b. The supply fan(s) VFD shall modulate to maintain supply duct static pressure via sensor located approximately 2/3 downstream in ductwork at the static pressure set point determined during air balance.

5. AHU Supply Air Temperature Reset

- a. Air handler supply temperature set point should reset from 55°F-65°F (adj.) and should be based on a maximum of several VAV box cooling loopOut values.

- b. The VAV boxes sampled for the reset should be selected to best represent all areas of the building. High occupancy spaces such as classrooms, conference rooms, auditoriums, etc. should be factored into the reset to ensure they are cooled properly. The number of VAV boxes used for the maximum cooling loopOut calculation should be kept to the minimum needed to represent all areas of the building. Using too many VAVs in the calculations increases the chance that one VAV box problem will drive down supply temp on the air handler. Final selection of VAV boxes used for reset should be approved by Duke project team.
- c. The supply reset statement should be executed in the program every 5 minutes. If any VAV included in the reset calculation stays at 100% cooling loopOut for greater than 60 minutes (adj.) continuous a virtual alarm should be activated. This alarm point should be on the air handler graphic near the supply temp set point.