

## 230923S09- SEQUENCE OF OPERATION

### 1. VARIABLE AIR VOLUME (VAV) SYSTEM WITH TRACKING RETURN FAN

#### 1. Variable Air Volume Control

1. On start up the inlet vanes shall be in the minimum position.
2. A static pressure controller shall, through the DDC panel, modulate the variable volume vanes as required to maintain the desired end of line duct static and space static where applicable. End of line duct static shall be sensed approximately 2/3 the distance from the supply fan to the end of the duct. Actual end of line duct static sensor location shall be determined by system design and shall be the responsibility of the DDC installer to insure correctness of operation.

#### 2. Occupied cycle

1. The unit fan shall be started and stopped from the central monitoring and control FMS system. Return fan s/s shall be interlocked with supply fan.
2. When the unit supply fan is started, the outdoor air dampers shall assume their minimum design position (approx. 10%). The mixed air and exhaust air dampers shall assume their corresponding design positions. Provide a morning warm-up cycle, which shall maintain the outdoor air dampers in a closed position until return air temperature is 70 degree F (adjustable).
3. A mixed air sensor, averaging type, shall (through its DDC panel) override the control of the outdoor air, mixed air, return air and exhaust air dampers as required to prevent the mixed air temperature from falling below 55 degree F.
4. Summer/Winter Switch-over - Switch system to summer operation when the following conditions have been met:
  1. Space temperature indicates cooling is required.
  2. Outside air temperature indicates cooling is required.
  3. Cooling is available. e.g. Chilled water is available from central chilled water system or local package unit.
  4. CWS temperature sensor indicates that cooling is available if needed.

Note: The exact numbers specifying the variables in the conditions above shall be initially installed with the building function in mind and shall be modifiable from the Central FMS system by UK personnel as required.

When conditions are met for summer operation, the outdoor air damper shall be returned to their minimum design position with the return and exhaust dampers going to their corresponding design position.

#### 3. Unoccupied cycle

1. The unit fan shall be de-energized and outdoor air dampers shall go to the closed position.
2. Night Cycle - An RTD space sensor shall (through the DDC panel) cycle the unit fan as required to maintain the design unoccupied temperature in summer approx. (78 degree F) and the design unoccupied temperature in winter approx. (65 degree F). The outdoor air dampers shall remain closed when chilled water is available in summer and heating is needed in winter. Outdoor air shall be utilized for cooling in summer when no chilled water is available and cooling is required.

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### 4. Temperature Control

1. An RTD temperature sensor in the duct, shall (through the DDC panel) modulate the two-way valve on the cooling coils, return air dampers, mixed air dampers and the heating coil three-way valve as required to maintain the desired space temperature, approximately (78 degree F).
2. Unit discharge temperature shall be capable of being set from the Central System. The absolute setpoint shall be reset and by space temperature load reset schedule. An increment/decrement setpoint reset algorithm is not acceptable.

### 5. Fire Alarm Interlock

1. Supply and return fan shall be hard wire electrically interlocked to stop upon actuation of the building Fire Alarm System.
2. Install smoke detectors in the supply and return air plenums in accordance with UK standard 16720S01.

### 6. Freeze Stat

A low limit thermostat on the inlet to the chilled water coil shall be hard wire electrically interlocked to stop the supply fan and close all unit dampers below 40 degree F.

## 2. FAN POWERED VAV TERMINAL UNITS

1. For each fan terminal unit, provide a heating coil control valve. Provide pneumatic thermostats to control individual units or multiple units in parallel as indicated on the drawings. UK's preference is to have a dedicated thermostat for each room.

### 2. Occupied cycle

During the "day" (occupied) cycle, the fan terminal unit shall be energized and run continuously through the PE switch and the day/night zone signal line. Day night cycles for each individual zone shall be indexed from the Delta 5600 system through the 540 DDC panel. Each air handling system shall have separate day/night zones and each floor served shall be a separate day/night zone also.

During the "day" (occupied) cycle, the room thermostat shall maintain space temperature by modulating the unit primary air damper and the heating coil valve. Upon demand for cooling, heating coil shall be off, and the box damper shall modulate flow of primary air through the box to control space temperature to setting of cfm limiter. When room temperature begins to fall below the setting of the room thermostat, the primary air damper shall modulate to its closed or minimum position. If the space temperature continues to fall below room thermostat setting, the thermostat shall modulate the heating coil valve to maintain room temperature.

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### 3. Unoccupied cycle

During the "night" (unoccupied) cycle when floor zone is indexed to night by the Delta 5600 system, the heating coil valve shall be full open, the primary air damper shall be closed and the unit fan shut down by the zone day/night PE switch. The zone night cycle sensor, shall through the 540 DDC panel cycle a separate PE switch for each zone which shall index all units to "day" to maintain reduced night thermostat setting. After night thermostat setting is satisfied, pneumatic switch shall open, shutting down all fan terminal units.

4. On lab VAV Terminal Units, see exact Sequence of Operation for the Unit in question, reference to fume hood interlocks must be addressed.

### 3. VARIABLE AIR VOLUME TERMINAL UNITS

1. A pneumatic space thermostat shall modulate the VAV unit actuator from full open to minimum position to maintain the design space temperature (adjustable). UK's preference is to have a dedicated thermostat for each room.
2. On lab VAV Terminal Units, see exact Sequence of Operation for the Unit in question, reference to fume hood interlocks must be addressed.

### 4. CHILLER(S)

1. Operation of the chiller shall be enabled and disabled from the 5600 FMS.
2. When evaporator flow is proven the chiller shall start and operate under the control of the manufacturer unit mounted control panel to maintain 55 degree F (adjustable) return water temperature. The evaporative condenser control damper shall modulate to maintain the head pressure via a modulating proportional controller furnished by the unit manufacturer.
3. Provide individual start/stop of chilled water pumps.
4. When the chiller is energized the closed circuit evaporative condenser spray pump and fan(s) shall be energized.
5. Chiller shall be factory equipped with safeties and these shall not be defeated by the FMS system in any way.

### 5. GAS-FIRED HOT WATER BOILER

1. The boilers shall be enabled and disabled from the 5600 FMS. When heating water flow is proven, the lead boiler shall be able to fire in response to the load under the control of the unit mounted control panel to maintain the discharge water temperature. Then the lead boiler is unable to maintain the load the second boiler shall fire under the control of the unit mounted control panel to maintain the discharge water setpoint.
2. The heating hot water supply temperature to the building loop shall be maintained by a modulating three-way mixing valve. The valve shall act in response to a panel mounted, adjustable ratio controller that receives the outdoor air and hot water supply temperature signals. The controller shall have a remote setpoint input port for future connection to a remote setpoint adjustment signal from the FMS. The controller shall modulate the control valve to reset the hot water supply temperature in an inverse ratio to outdoor air temperature variations according to the following reset schedule:

Outdoor Air Temp	Hot Water Temp
0 degree F	180 degree F
70 degree F	90 degree F

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3. Provide a high limit in the hot water supply header, which shall override the reset controls to prevent the hot water supply temperature from exceeding 200 degree F.
4. Boiler shall be factory equipped with safeties and these shall not be defeated by the FMS system in any way.
5. Provide start/stop control of hot water pumps.

### 6. HOT WATER CONVERTOR

#### 1. Temperature Control

1. An RTD temperature sensor in the outdoor air and in the space being served shall (through the DDC panel) modulate steam valves to maintain the design water temperature in accordance with the following be reset algorithm.

2. Given the design reset schedule for the building:

For Example:

OAT	HWT	OAT	HWT
OAT <sub>1</sub>	HWT <sub>1</sub>	0°F	200°F
OAT <sub>2</sub>	HWT <sub>2</sub>	65°F	120°F

HWT = hot water temperature

HWT<sub>1</sub>= design low hot water temperature

HWT<sub>2</sub>= design high hot water temperature

OAT = outside air temperature

OAT<sub>1</sub>= design low outdoor air temperature

OAT<sub>2</sub>= design high outdoor air temperature

HWSP = converter temperature setpoint entered at 5600 terminal

ST = space temperature

STSP = space temperature setpoint entered a 5600 terminal

m<sub>1</sub> = multiplier entered at 5600 terminal = (HWT<sub>1</sub>-HWT<sub>2</sub>/OAT<sub>1</sub>-OAT<sub>2</sub>)

m<sub>2</sub> = space temperature ratio multiplier entered at 5600 terminal

If space temperature is above or equal to the space temperature setpoint

$$HWT = HWSP + m_1 \times OAT$$

If space temperature is below the space temperature setpoint

$$HWT = HWSP + m_1 \times OAT + m_2 \times (STSP - ST)$$

3. Unit HWT discharge temperature shall be capable of being set from the Central System. The absolute setpoint shall be varied by space temperature load reset schedule. An additional incremental reset of the absolute setpoint shall be reset by the space temperature when the space temperature is below the space temperature setpoint.
4. The temperature load reset/reset control shall be enabled/disabled and operate when the HW circulating pumps are on or off

Note: All algorithm values shall be modifiable by the owner to fine tune the control sequence under actual operating conditions.