

SECTION 25 90 00

INTEGRATED AUTO CONTROL SEQUENCES FOR FACILITY

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Sequence Of Operation:
 - a) Air Handling Units (VAV).
 - b) Makeup Air Unit (gas-fired).
 - c) CV AHU.
 - d) Chilled Water Cooling.
 - e) Air-cooler Chiller.
 - f) Chilled Water Pump.
 - g) Hot water heating.
 - h) Terminal Units.
 - i) Exhaust Fans.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 SEQUENCE OF OPERATION

A. VAV Air Handler:

1. The occupancy mode (occupied-unoccupied) shall be determined through a user-adjustable, graphical, seven-day schedule with an additional holiday schedule.
 - a) Occupied Mode:
 - i) All fans shall have a starter with 'hand-off-auto' switch or a Variable Frequency Drive (VFD).
 - When the starter switch is in the 'hand' position, the fan shall run. When the switch is in the 'off' position the fans shall stop. When the switch is in the 'auto' position, the fan shall be under the control of the DDC Controls System.
 - When the fan is controlled by the VFD, the DDC Control System shall interface with the VFD controller and make all monitoring and control points available to the DDC System. The VFD shall have a by-pass switch to allow for manual operation of the fan when the VFD is not operational.
 - The supply fan shall be energized. The supply fan speed shall modulate to maintain duct static pressure setpoint (adjustable). The final setpoint shall be determined in consultation with the balancing contractor. Initial duct static pressure setpoint shall be 1.0' w.g. (adjustable).
 - Provide a high static alarm when the duct static pressure rises above 3.0" w.g. (adjustable).
 - ii) Whenever the supply fan is energized, the return/exhaust fan shall be energized. The return fan speed shall modulate to maintain the return Building static pressure setpoint of 0.10" w.g. (adjustable).
 - iii) The exhaust air damper shall modulate to maintain the space static pressure setpoint of 0.05" w.g. (adjustable).

- Building static pressure sensors shall be located in a space where there will be small changes in the pressure between inside and outside pressure changes. Recommended places: Second floor corridors, common spaces, offices, or library. Do not locate sensor near elevators or exterior doors.
- iv) Discharge air temperature setpoint shall be reset based upon return air temperature according to the following reset schedule. All parameters shall be independently adjustable.
- The cooling coil control valve shall modulate to maintain the discharge air temperature setpoint, 55 degrees F (adjustable).
 - The heating coil control valve shall modulate to maintain the discharge air temperature as described below.
 - Discharge air temperature setpoint is 55 degrees F (adjustable) when outdoor temperature is greater than 70 degrees F.
 - Discharge air temperature setpoint is 65 degrees F (adjustable) when outdoor temperature is less than 30 degrees F.
- v) Economizer Control: Whenever the outside air temperature is above the space temperature (75 degrees F, cooling; 72 degrees F, heating) the outside air and return air dampers shall positioned for the minimum outside air scheduled. Or the CO2 sensor in the return air duct shall modulate the outside and return air dampers to maintain the minimum outside air required for the occupancy. When the outside air temperature is below 55 degrees F (adjustable), the outside and return air dampers shall be positioned to maintain the mixed air temperature.
- vi) Indirect tower cooling (where applicable for evaporative cooling)
- Fill the tower sump if the outside air temperature is above 55 degrees F (adjustable).
 - Maintain tower sump water temperature by cycling tower fan's 'off-low-high' using a local temperature controller mounted to the tower sump.
 - Provide hardwired time delay internal to the magnetic motor starter when going from fan high-speed to low-speed to allow for fan deceleration.
 - The tower sump shall drain to the interior sump whenever the outdoor air temperature is below 35 degrees F (adjustable) for 60 minutes (adjustable).
- vii) Filter Status: A differential pressure switch across the filter shall signal an alarm the DDC system when the pressure drop across the filter is above the allowed minimum (adjustable). In addition, provide a magnic-helic gauge to indicate dirty filters.
- b) Unoccupied Mode:
- i) The supply and return fans shall be de-energized. Both outdoor air dampers and exhaust dampers shall be closed. The return air damper shall be open.
 - ii) The heating coil valve and pump shall cycle to maintain mixed-air temperature of 45degrees F (adjustable).
 - iii) The supply fan shall cycle to maintain the unoccupied setpoint temperature (65°F, adjustable).
 - iv) If the unoccupied space temperature is not maintained the heating control valve shall modulate to maintain the space temperature. And the supply fan shall cycle on.
- c) Morning Warm-up:
- i) When the outside air temperature is below 55 degrees F, the DDC system shall perform a morning warm-up cycle prior to the occupied mode.
 - ii) The outside air damper shall be closed and the return air damper shall be open.
 - iii) The supply fan shall energize and the heating coil control valve shall open.

- iv) The Air Handling Unit shall remain in the morning warm-up mode until the return air temperature is 70 degrees F. After the system has achieved 70 degrees F (adjustable) the system shall enter the Occupied Mode.
 - d) Safety Shutdowns:
 - i) Duct smoke detection, high-pressure safeties and low-temperature limit trips shall de-energize the air-handling unit supply and return fans and close the outdoor air and exhaust air dampers. Manual reset shall be required to allow the fans to operate.
 - e) Freeze Protection:
 - i) When the outdoor air temperature is below 40degrees F (adjustable), the HW and CHW pumps shall be energized continuously for freeze protection. The heating coil valve shall cycle as described elsewhere.
 - ii) If the unit has shutdown on the low temperature limit switch, energize the return fan until the condition has been resolved.
2. Economizer Fault Detection and Diagnostics (FDD)
- a) The following temperature sensors shall be permanently installed to monitor system operation:
 - i) Outside air.
 - ii) Supply air.
 - iii) Return air.
 - b) Temperature sensors shall have an accuracy of $\pm 2^{\circ}\text{F}$ over the range of 40°F to 80°F .
 - c) Refrigerant pressure sensors, where used, shall have an accuracy of ± 3 percent of full scale.
 - d) The unit controller shall be capable of providing system status by indicating the following:
 - i) Free cooling available.
 - ii) Economizer enabled.
 - iii) Compressor enabled.
 - iv) Heating enabled.
 - v) Mixed air low limit cycle active.
 - vi) The current value of each sensor.
 - e) The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.
 - f) The unit shall be capable of reporting faults to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats.
 - g) The FDD system shall be capable of detecting the following faults:
 - i) Air temperature sensor failure/fault.
 - ii) Not economizing when the unit should be economizing.
 - iii) Economizing when the unit should not be economizing.
 - iv) Damper not modulating.
 - v) Excess outdoor air.
- B. Make-Air Unit (Gas-fired):
- 1. The occupied-unoccupied shall be determined by the kitchen exhaust fan status through a user-adjustable, graphical, seven-day schedule with an additional holiday schedule with the DDC system.
 - a) Occupied Mode:
 - i) All fans shall have a starter with 'hand-off-auto' switch.

- When the starter switch is in the ‘hand’ position, the fan shall run. When the switch is in the ‘off’ position the fans shall stop. When the switch is in the ‘auto’ position, the fan shall be under the control of the DDC Controls System.
 - The fan shall energize and run with the kitchen exhaust fan. When the exhaust fan is on the Make-up Unit shall run.
- ii) Discharge air temperature setpoint shall be reset based upon outdoor air temperature according to the following reset schedule. All parameters shall be independently adjustable.
- The cooling coil (if provided) control valve shall modulate to maintain the discharge air temperature setpoint, 55degrees F (adjustable).
 - The gas-fired heat exchanger shall have a modulating gas valve that shall modulate to maintain the discharge air temperature as described below:
 - 01) Discharge air temperature setpoint is 55degrees F (adjustable) when outdoor temperature is greater than 70degreesF.
 - 02) Discharge air temperature setpoint is 65degrees F (adjustable) when outdoor temperature is less than 30degrees F.
- iii) Indirect tower cooling (where applicable for evaporative cooling)
- Fill the tower sump if the outside air temperature is above 55degrees F (adjustable).
 - Maintain tower sump water temperature by cycling tower fan’s ‘off-low-high’ using a local temperature controller mounted to the tower sump.
 - Provide hardwired time delay internal to the magnetic motor starter when going from fan high-speed to low-speed to allow for fan deceleration.
 - The tower sump shall drain to the interior sump whenever the outdoor air temperature is below 35 degrees F (adjustable) for 60 minutes (adjustable).
- iv) Filter Status: A differential pressure switch across the filter shall signal an alarm at the BAS when the pressure drop across the filter is above the allowed minimum (adjustable).
- b) Unoccupied Mode:
- i) The supply fan shall be de-energized. The outdoor air damper shall close.
 - ii) The fan coil units or radiant heating control valve shall modulate to maintain the space temperature of 55degrees F (adjustable).
- C. Constant Volume Air Handler :
1. The occupancy mode (occupied-unoccupied) shall be determined through a user-adjustable, graphical, seven-day schedule with an additional holiday schedule.
- a) Occupied Mode:
- i) All fans shall have a starter with ‘hand-off-auto’ switch.
 - When the starter switch is in the ‘hand’ position, the fan shall run. When the switch is in the ‘off’ position the fans shall stop. When the switch is in the ‘auto’ position, the fan shall be under the control of the DDC Controls System.
 - The supply fan shall be energized.
 - ii) Whenever the supply fan is energized, the return/exhaust fan shall be energized.
 - iii) Discharge air temperature setpoint shall be reset based upon outdoor air temperature according to the following reset schedule. All parameters shall be independently adjustable.
 - The cooling coil control valve shall modulate to maintain the discharge air temperature setpoint, 55 degrees F (adjustable).
 - The heating coil control valve shall modulate to maintain the discharge air temperature as described below.

- 01) Discharge air temperature setpoint is 55 degrees F (adjustable) when outdoor temperature is greater than 70 degrees F.
- 02) Discharge air temperature setpoint is 65 degrees F (adjustable) when outdoor temperature is less than 30 degrees F.
- The local DDC Controller shall modulate the Re-heat coils control valve in the zone duct to maintain the space setpoint, 72 degrees F.
- iv) Economizer Control: Whenever the outside air temperature is above the space temperature (75 degrees F, cooling; 72 degrees F, heating) the outside air and return air dampers shall be positioned for the minimum outside air scheduled. Or the CO2 sensor in the return air duct shall modulate the outside and return air dampers to maintain the minimum outside air required for the occupancy. When the outside air temperature is below 55 degrees F (adjustable), the outside and return air dampers shall be positioned to maintain the mixed air temperature.
- v) Filter Status: A differential pressure switch across the filter shall signal an alarm at the BAS when the pressure drop across the filter is above the allowed minimum (adjustable).
- b) Unoccupied Mode:
 - i) The supply and return fans shall be de-energized. Both outdoor air dampers and exhaust dampers shall be closed. The return air damper shall be open.
 - ii) The heating coil valve and pump shall cycle to maintain mixed-air temperature of 45 degrees F (adjustable).
 - iii) The supply fan shall cycle to maintain the unoccupied setpoint temperature (65 degrees F, adjustable).
 - iv) If the unoccupied space temperature is not maintained the heating control valve shall modulate to maintain the space temperature. And the supply fan shall cycle on.
- c) Morning Warm-up:
 - i) When the outside air temperature is below 55 degrees F, the DDC system shall perform a morning warm-up cycle prior to the occupied mode.
 - ii) The outside air damper shall be closed and the return air damper shall be open.
 - iii) The supply fan shall energize and the heating coil control valve shall open.
 - iv) The Air Handling Unit shall remain in the morning warm-up mode until the return air temperature is 70 degrees F. After the system has achieved 70 degrees F (adjustable) the system shall enter the Occupied Mode.
- d) Safety Shutdowns:
 - i) Duct smoke detection, high-pressure safeties and low-temperature limit trips shall de-energize the air-handling unit supply and return fans and close the outdoor air and exhaust air dampers. Manual reset shall be required to allow the fans to operate.
- e) Freeze Protection:
 - i) When the outdoor air temperature is below 40degrees F (adjustable), the HW and CHW pumps shall be energized continuously for freeze protection. The heating coil valve shall cycle as described elsewhere.
 - ii) If the unit has shutdown on the low temperature limit switch, energize the return fan until the condition has been resolved.
- 2. Economizer Fault Detection and Diagnostics (FDD)
 - a) The following temperature sensors shall be permanently installed to monitor system operation:
 - i) Outside air.
 - ii) Supply air.
 - iii) Return air.

- b) Temperature sensors shall have an accuracy of $\pm 2^{\circ}\text{F}$ over the range of 40°F to 80°F .
- c) Refrigerant pressure sensors, where used, shall have an accuracy of ± 3 percent of full scale.
- d) The unit controller shall be capable of providing system status by indicating the following:
 - i) Free cooling available.
 - ii) Economizer enabled.
 - iii) Compressor enabled.
 - iv) Heating enabled.
 - v) Mixed air low limit cycle active.
 - vi) The current value of each sensor.
- e) The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.
- f) The unit shall be capable of reporting faults to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats.
- g) The FDD system shall be capable of detecting the following faults:
 - i) Air temperature sensor failure/fault.
 - ii) Not economizing when the unit should be economizing.
 - iii) Economizing when the unit should not be economizing.
 - iv) Damper not modulating.
 - v) Excess outdoor air.

D. Chilled Water System

1. The chiller shall be enabled whenever the outside air temperature is above 55°F for 30 minutes (both adjustable). The chiller shall be disabled when the outside air temperature drops below 54°F for 30 minutes (both adjustable).
2. Water-Cooled Chiller Control:
 - a) The chiller shall not be enabled unless the cooling tower sump is filled.
 - b) The chiller shall start and stop the chilled water and condenser water pumps through its internal controls.
 - c) The cooling tower fan shall sequence 'off-low-high' to maintain condenser water supply temperature setpoint of 74°F (adjustable). The fan shall be locked out whenever the chiller is de-energized.
 - d) The cooling tower sump drain and fill lines shall drain whenever the outdoor air temperature is less than 35°F for 30 minutes (both adjustable). The tower sump shall be filled whenever the outside air temperature is greater than 54°F for 30 minutes (both adjustable).
3. The chilled water supply temperature shall be reset from 45°F to 52°F .
 - a) The chilled water supply temperature setpoint shall be 52°F when the outdoor air temperature is less than or equal to 55°F .
 - b) The chilled water supply temperature setpoint shall be 45°F when the outdoor air temperature is greater than or equal to 80°F .
4. Activation of any emergency-stop switches or refrigerant-detection alarms shall de-energize all central plant equipment except makeup-air units and exhaust fans.

E. Air-Cooled Chiller Control:

1. The chiller shall operate with its associated pump in a lead/lag configuration.
2. The chiller controls shall alternate the lead chiller every 336 hours, minimum.

3. The chilled water system shall be enabled by the DDC System when ever the outside air temperature is above the setpoint listed above.
 4. The chiller shall operate by the micro-processor based control system provided by the manufacturer. The chiller controls shall stage the chiller to maintain the discharge water temperatures listed above.
 5. Each chiller shall have a flow switch directly connected to the control chiller panel. The chiller shall not operate unless water flow is proven.
 6. All points shall be available to the DDC System.
- F. Chilled Water Pump Control:
1. The pumps shall be designed for 100% and stand-by operation. The pumps shall be started simultaneously.
 2. Each pump shall be provide with a 'hand-off-auto' switch. When the switch is in the 'hand' position the pump shall run. When the switch is in the 'off' position the pump shall be stopped. When the switch is in the 'auto' position, the pump shall be under control of the DDC System.
 3. The distribution pumps shall be started and run when the outside air temperature rises 55°F (adjustable).
 4. Each Pump status shall be reported through a current sensing relay
- G. Cabinet Unit Heater
1. A conventional electric space thermostat shall open/close the control valve and cycle the unit fan to maintain space temperature at setpoint of 68degrees F(adjustable). For hot water heating, when heating water is not available as sensed by the aquastat, the fan shall be de-energized.
- H. Unit Heater
1. A conventional electric thermostat shall cycle the unit fan to maintain space temperature at setpoint of 68 degrees F. For hot water heating, when heating water is not available as sensed by the aquastat the fan shall be de-energized.
- I. Baseboard Heating
1. Fintube radiation shall be modulated in sequence with the associated VAV box. Heating with Fintube and cooling with the VAV box shall not occur simultaneously. Use non-overlapping spring ranges or sequencing relays on the Fintube control valve and VAV damper actuator.
- J. Vav Boxes
1. DDC Control varies the airflow from maximum to minimum and modulates the heating valve in sequence to maintain the space temperature setpoint. The heating valve shall not begin to open until the airflow has reached its minimum setting Set minimum and maximum CFM as shown on the drawings.
- K. Face And Bypass Preheat Coil (Make-Up Air Units Only)
- A. Two-position preheat coil valve shall open full when outside air temperature is below 35°F. Face and bypass dampers shall modulate to maintain 50°F (adjustable) preheat coil discharge air temperature.
- L. Hot Water Heating
1. Heating Water Supply (Steam Heat Exchanger):
 - a) Hot water supply temperature shall be reset inversely with changes in outside temperature locate OA sensor on north exposure). ~~its setting~~ by modulating in sequence, two normally-closed control valves in parallel in the steam supply to the hot water heat exchanger. Fail-safe operation of steam valve shall be to fail closed.
 2. Zone Control:
 - a) Building to be zoned as required by floors, orientation and function as determined for specific project.
 - b) Provide for each zone a night, weekend and holiday setback.
 - c) Provide each zone with an adjustable morning warm-up time period.
 3. Temperature reset of a controlled variable is encouraged where overall system energy use will be minimized while still maintaining building temperature control requirements.

M. Boiler Control:

1. The boilers shall be enabled or disabled by the DDC System. Packaged boiler controllers shall modulate the boilers to maintain the heating water supply temperature scheduled (140°F, adjustable).
2. The following points shall be available to the DDC System:
 - a) Enable/Disable the boilers.
 - b) High Temperature Limit
 - c) Low Water Cut-off
 - d) No flow detected
 - e) Manual Shut Down
3. Combustion Air Control: Combustion air dampers shall open when the boiler is enabled. The damper end switch shall prove that the damper is open prior to enabling the boiler. If the damper is not proven open, the DDC System shall sense and alarm and the boilers shall be shut down.

N. Heating Water Pumps:

1. Each boiler production (primary) pump shall be provided with a 'hand-off-auto' switch. When the switch is in the 'hand' position the pump shall run. When the switch is in the 'off' position the pump shall be stopped. When the switch is in the 'auto' position, the pump shall be under control of the DDC System.
2. Each production pump shall be started whenever its associated boiler is enabled.
3. Heating water distribution (secondary) pumps shall be provided with a 'hand-off-auto' switch. When the switch is in the 'hand' position the pump shall run. When the switch is in the 'off' position the pump shall be stopped. When the switch is in the 'auto' position, the pump shall be under control of the DDC System.
4. The distribution pumps shall be started and run when the outside air temperature falls below 65°F (adjustable).
5. Each Pump status shall be reported through a current sensing relay.

O. Elevator Shaft Venting:

1. Meet with the Denver Fire Department and Denver Building Department staffs to discuss what they require for control of the elevator hoistway vent.

P. Exhaust Fans:

1. Toilet/Locker Rooms: Toilet room exhaust fans shall be controlled by a time of day clock. During the occupied mode, the fan shall run continuously. During the unoccupied mode the fans shall be off. The DDC system shall associate the exhaust fan with the Air Handling Unit in the vicinity of the exhaust fan. Also allow for manual override of the fan with a 'hand-off-auto' switch.
2. Kitchen Exhaust: Kitchen Hood exhaust fan controls shall be locally controlled by the kitchen staff. The make-up air unit shall be interlocked with the kitchen hood exhaust. The make-up air unit and the hood exhaust shall be monitored by the DDC Control System. The DDC system shall report the following points, minimum.
 - a) Exhaust fan status.
 - b) Make-up Air Unit fan status.
 - c) Make-up Air Unit discharge air temperature.

Q. Laboratory Exhaust/Dust Collection: Lab Exhaust and Dust Collection systems shall be locally controlled. Refer to Special Exhaust Systems Specification Section for additional requirements. The following points shall be reported to the DDC Systems:

1. Fume Hood fan status.
2. Dust Collection fans status.

R. Kiln Hood Exhaust: Kiln exhaust fans shall be locally controlled by a wall mounted switch. The fan status shall be reported through the DDC Control System.

3.11 COLD WEATHER SEQUENCE

- A. A cold weather emergency sequence shall be built in to the BAS that enables DPS to manually control:
 - 1. Mixed Air temperature of RTU and AHU to 45 F.
 - 2. Set OA damper position to minimum or zero.
 - 3. Set the global building night set back temperature to the occupied temperature.
- B. The cold weather sequence shall automatically provide the following when outside air temperature is below 10 F (adj):
 - 1. Set the unoccupied temperature equal to the occupied temperature.
 - 2. close Outside air dampers when the average building temperature is more than 5 deg F below setpoint.
- C. Controls contractor shall coordinate with DPS Controls Engineer on implementation of this sequence.

3.12 DOMESTIC HW

- A. Domestic HW Circ Pump:
 - 1. HWC pump shall operate to maintain the HWC temperature sensor at a point prior to connection to the water heater/CW pipe at a maximum of 104 F. The pump shall shut off when 104 F is reached. The HWC pump shall operate based on a schedule at the BAS and shall be off whenever the school is unoccupied.
 - 2. A flow switch shall detect flow at the CW supply going into the HW system. Whenever flow is present, the HWC pump shall run.

PART 4 POINT/DATA LIST

- A. General information:
 - 1. These lists include the point/data that should be available for viewing/modification at the IBAS. Other points/data needed by the DDC or other systems to provide their specified functionality are not necessarily listed here. It is the A/E's responsibility to ensure that all points/data required for the DDC of other systems be specified.
 - 2. Under the "Point/Data" column "Occupied Until..." is a time clock value indicating the end of the occupied mode.
 - 3. Under the "Type" column: AO = Analog Output Point, AI = Analog Input Point, BO = Binary Output Point, BI = Binary Input Point, AD = Analog Data, and BD = Binary Data.
 - 4. Under the "R/W" column: R = Read (or monitor) and W = Write (or control)
 - 5. Under the "Notes" column "Emergency" means that an off-normal condition shall generate an emergency-level alarm sent to security or the HVAC Shop (contractor is to consult with owner about where, in each case, the alarm shall be sent and what the alarm message shall state).
 - 6. There may be more than one instance of each point listed. Provide all instances included in the DDC or other system design.
 - 7. Not all points listed are applicable (or applicable as described) for the specific HVAC or other system design. Further some HVAC or other system designs may involve points that could not have been predicted by or included in the below list. The design engineer shall edit the list accordingly.

B. Point/Data Lists (by HVAC or other system type)

1. Constant Volume AHU, RTU or H&V Unit

Point/Data	Type	R/W	Notes
Mixed Air Dampers Actuator(s)	AO	R/W	Provide additional points if the DDC system controls these dampers with multiple points (e.g., a separate AO for the relief or exhaust air damper or a separate BO for a minimum outside air damper).
Mixed Air Temperature	AI	R	
Return Air Temperature	AI	R	
Heating Coil Valve	AO	R/W	Or stages of elec/gas heat controlled by multiple BO's. Provide BI status for gas furnace.
Cooling Coil Valve	AO	R/W	Or stages of DX cooling controlled by multiple BO's
Heating Coil Circulation Pump	BO	R/W	
Cooling Coil Circulation Pump	BO	R/W	
Heating Coil Circ. Pump Status	BI	R	
Cooling Coil Circ. Pump Status	BI	R	
Preheat Coil Valve Open/Close	BO	R/W	
Preheat Coil Face and Bypass Dampers	AO	R/W	
Preheat Discharge Air Temperature	AI	R	
Preheat Discharge Air Temperature Setpoint	AD	R/W	
Supply Fan Start/Stop	BO	R/W	
Supply Fan Status	BI	R	
Freezestat	BI	R	
Supply Air Temperature(s)	AI	R	
Supply Air Temperature Setpoint	AD	R/W	If reset off of space temperature.
Space Temperature	AI	R	Emergency
Space Temperature Set Points	AD's	R/W	Four AD's – Heating Occupied/Unoccupied and Cooling Occupied/Unoccupied
Space Temperature Set Point Adjustment(s)	AI or AD	R	At space temperature sensor
Zone Reheat Coil Modulation	AO	R/W	For reheat systems
Filter Status	BI	R	
Smoke Detector	BI	R	
Return Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Return Fan Status	BI	R/W	
Exhaust Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Exhaust Fan Status	BI	R/W	
CO ₂ Sensor	AI	R	
CO ₂ Set Point	AD	R/W	
Face & Bypass Dampers Actuator	AD	R/W	Emergency
Mixed Air Temperature Low Limit Set Point	AD	R/W	
Occupied Until....	AO	R	
Warm-up Mode	MD	R	
Economizer Mode	BD	R	
Minimum Outside Air Position or Air Flow Set Point	AD	R/W	
Outside Air Flow	AI	R	

2. VAV (Variable Air Volume) AHU or RTU

Points	Type	R/W	Notes
Outside and Return Air Dampers Actuator(s)	AO	R/W	Provide additional points if the DDC system controls these dampers with multiple points (e.g., a separate BO for a minimum outside air damper).
Exhaust/relief Air Damper	AO	R/W	
Mixed Air Temperature	AI	R	
Return Air Temperature	AI	R	
Heating Coil Valve	AO	R/W	Or stages of elec/gas heat controlled by multiple BO's. Provide BI status for gas furnace.
Cooling Coil Valve	AO	R/W	Or stages of DX cooling controlled by multiple BO's
Heating Circulation Pump	BO	R/W	
Cooling Circulation Pump	BO	R/W	
Heating Circ. Pump Status	BI	R	
Cooling Circ. Pump Status	BI	R	
Supply Fan Start/Stop	BO	R/W	
Preheat Coil Valve Open/Close	BO	R/W	
Preheat Coil Face and Bypass Dampers	AO	R/W	
Preheat Discharge Air Temperature	AI	R	
Preheat Discharge Air Temperature Setpoint	AD	R/W	
Supply Fan Status	BI	R	
Freezestat	BI	R	
Supply Air Temperature	AI	R	
Filter Status	BI	R	
Smoke Detector	BI	R	
Return Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Return Fan Status	BI	R/W	
Exhaust Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Exhaust Fan Status	BI	R/W	
CO ₂ Sensor	AI	R	
CO ₂ Set Point	AD	R/W	
Face & Bypass Dampers Actuator	AD	R/W	
Mixed Air Temperature Low Limit Set Point	AD	R/W	
Occupied Until....	AO	R	
Warm-Up Mode	MD	R	
Economizer Mode	BD	R	
Minimum Outside Air Position or Air Flow Set Point	AD	R/W	
Outside Air Flow	AI	R	
Supply Volume Control	AO	R/W	
Supply Air Duct Static Pressure	AI	R	
Return Volume Control	AO	R/W	
Building Static Pressure	AI	R	
Supply Air High Static Alarm	BI	R	
Return Air Low Static Alarm	BI	R	
Supply Air Temperature Set Point	AD	R/W	
Supply Air Duct Static Pressure Set point	AD	R/W	
Building Static Pressure Set point	AD	R/W	
Average or Warmest Space Temperature	AD	R	If used for supply air temperature reset

Evaporative Cooling Sump Fill/Drain	BO	R/W	
Evaporative Cooling Drain/Fill Outside Air Set Point	AD	R/W	
Evaporative Cooling pump start/stop	BO	R/W	
Evaporative Cooling fan status	BI	R	Indirect systems only

3. VAV & Fan Powered VAV Box

Points	Type	R/W	Notes
Heating Coil Valve	AO	R/W	
Damper Actuator	AO or 2 BO's	R/W	
Damper Position Setpoint	AD	R/W	If BO's are used for the damper actuator.
Fan Start/Stop	BO	R/W	
Space Temperature	AI	R	
CFM	AI	R	
CFM Set Point	AD	R	
Maximum CFM Set Point	AD	R/W	
Minimum CFM Set Point	AD	R/W	
Minimum CFM Set Point for Heating	AD	R/W	For VAV box with reheat coil.
Space Temperature Set Points	AD's		Four AD's – Heating Occupied/Unoccupied and Cooling Occupied/Unoccupied.
Space Temperature Set Point Adjustment	AI or AD		At space temperature sensor
Set Point Adjustment	AD	R	At sensor
Occupied/Unoccupied Mode	BD	R/W	
Occupied Until...	AD	R	
Discharge air temperature	AI	R	Not necessary if box is being used for ventilation only
CO ₂ Sensor	AI	R	If box is being used for ventilation control
CO ₂ Set Point	AD	R/W	If box is being used for ventilation control
Baseboard Heating Valve(s)	AO	R/W	

4. AHU or RTU

Points	Type	R/W	Notes
Mixed Air Dampers Actuator(s)	AO	R/W	Provide additional points if the DDC system controls these dampers with multiple points (e.g., a separate AO for the relief or exhaust air damper or a separate BO for a minimum outside air damper).
Mixed Air Temperature	AI	R	
Return Air Temperature	AI	R	
Heating Coil Valve	AO	R/W	Or stages of elec/gas heat controlled by multiple BO's. Provide BI status for gas furnace.
Cooling Coil Valve	AO	R/W	Or stages of DX cooling controlled by multiple BO's
Heating Circulation Pump	BO	R/Q	
Cooling Circulation Pump	BO	R/W	
Heating Circ. Pump Status	BI	R	
Cooling Circ. Pump Status	BI	R	
Preheat Coil Valve Open/Close	BO	R/W	
Preheat Coil Face and Bypass Dampers	AO	R/W	
Preheat Discharge Air Temperature	AI	R	
Preheat Discharge Air Temperature Setpoint	AD	R/W	
Supply Fan Start/Stop	BO	R/W	
Supply Fan Status	BI	R	
Freezestat	BI	R	
Filter Status	BI	R	
Smoke Detector	BI	R	
Return Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Return Fan Status	BI	R/W	
Exhaust Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Exhaust Fan Status	BI	R/W	
CO ₂ Sensor	AI	R	
CO ₂ Set Point	AD	R/W	
Face & Bypass Dampers Actuator	AD	R/W	
Mixed Air Temperature Low Limit Set Point	AD	R/W	
Occupied Until....	AO	R	
Warm-up Mode	MD	R	
Economizer Mode	BD	R	
Minimum Outside Air Position or Air Flow Set Point	AD	R/W	
Outside Air Flow	AI	R	
Cold Deck Temperature	AI	R	
Cold Deck Temperature Set Point	AD	R/W	
Warmest Space Temperature	AD	R	If used for reset of Cold Deck Temperature
Hot Deck Temperature	AI	R	
Hot Deck Temperature Set Point	AD	R/W	
Coldest Space Temperature	AD	R	If used for reset of Hot Deck Temperature
Zone Damper Actuators	AO's	R/W	One for each zone
Space Temperatures	AI	R	Emergency. One for each zone.
Space Temperature Set Points	AD's		Four AD's per zone – Heating Occupied/Unoccupied and Cooling

			Occupied/Unoccupied.
Space Temperature Set Point Adjustment	AI or AD		At each space temperature sensor

5. Kitchen Makeup Air Unit and Exhaust

Points	Type	R/W	Notes
Kitchen Hood on/off switch	BI	R	
Outside and Exhaust Air Dampers Open/Close	BO	R/W	
Supply Fan Start/Stop	BO	R/W	
Supply Fan Status	BI	R	
Exhaust Fan Status	BI	R	Also provide a BO, R/W if the start/stop of this fan is not interlocked to the supply fan.
Evaporator Cooling Drain/Fill Valves	BO	R/W	
Evaporator Cooling Drain/Fill Outside Air Set Point	AD	R/W	
Evaporator Cooling pump start/stop	BO	R/W	
Evaporative Cooling fan status	BI	R	Indirect systems only
Furnace On/Off	BI	R	
Furnace Modulation	AO	R/W	
Supply Air Temperature	AI	R	
Supply Air Temperature Set Point	AD	R/W	If reset off of space temperature.
Space Temperature	AI	R	
Space Temperature Set Points	AD's		Four AD's – Heating Occupied/Unoccupied and Cooling Occupied/Unoccupied
Space Temperature Set Point Adjustment	AI or AD		At space temperature sensor
Occupied Until...	AD	R	
Occupied/Unoccupied mode	BD	R/W	
Filter Status	BD	R	
Duct Smoke Detector	BD	R	

6. Unit Ventilator, Fan Coil Unit or Water Source Heat Pump

Points	Type	R/W	Notes
Mixed Air Dampers Actuator(s)	AO	R/W	
Heating Coil Valve	AO	R/W	
Cooling Coil Valve	AO	R/W	Or DX cooling BO's.
Fan Start/Stop	BO	R/W	
Fan Status	BI	R	
Freezestat	BI	R	
Reversing Valve	BO	R/W	Heat pump only.
Supply Air Temperature	AI	R	
Supply Air Temperature Low Limit	AD	R/W	
Space Temperature	AI	R	Emergency
Space Temperature Set Points	AD's		Four AD's – Heating Occupied/Unoccupied and Cooling Occupied/Unoccupied
Space Temperature Set Point Adjustment	AI or AD		At space temperature sensor
Occupied/Unoccupied Mode	BD	R/W	
Occupied Until...	AD	R	
Minimum Outside Air set point	AD	R/W	

7. Heating Plant

Points	Type	R/W	Notes
Boiler Start/Stop or Boiler System Enable/Disable	BO	R/W	The latter if there is a boiler management system
Boiler Status	BI	R	
Boiler Alarm – High Temperature	BI	R	
Boiler Hot Water Supply Temperature	AI	R	From boiler(s)
Boiler Alarm – Low Water	BI	R	
Boiler Alarm – No Water Flow	BI	R	
Manual Boiler Shutdown	BI	R	
Combustion Air Damper Position	BI	R	
Building Hot Water Supply Temperature	AI	R	If system is primary/secondary
Boiler Hot Water Return Temperature	AI	R	To boiler(s)
Building Hot Water Return Temperature	AI	R	If system is primary/secondary
Boiler System Hot Water Supply Set Point	AD	R/W	
Building Hot Water Supply or Return Temperature Set Point	AD	R/W	If system is primary/secondary
Steam Pressure	AD	R	Steam boiler(s) only
Steam Converter Valves	1 or 2 AO's	R/W	1/3-2/3 valves
Pump Start/Stop**	BO	R/W	Only those pumps not hard-wire interlocked to a corresponding boiler (e.g., those pumps controlled by the DDC system)
Pump Status**	BI	R	For all hot water pumps included in the heating plant design.
Mixing Valve	AO	R/W	
Boiler Lead/Lag Designation	BD	R/W	
Pumps Lead/Lag Designation	BD	R/W	If more than one boiler pump (and they can feed boiler chiller) or more than one building pump
Boiler System Outside Air Lockout Set Point	AD	R/W	
Lag Boiler/Pump Start/Stop Set Point	AD	R/W	
Glycol low level or Makeup water flow	BD or AD	R	Provide makeup water flow only if there is no glycol feeder
Fuel Flow	AI	R	
System Pressure Alarm	BI	R	Emergency
Carbon Monoxide Alarm	BI	R	Emergency

*On primary/secondary systems there will be boiler and building pump(s).

8. Cooling Plant*

Points	Type	R/W	Notes
Chiller System Outside Air Lockout Set Point	BD	R/W	
Chiller Start/Stop	BO	R/W	
Chiller Status	BD	R	
Chiller Alarm	BD	R	
Chiller Chilled Water Supply Temperature	AI	R	From chiller
Chiller Chilled Water Supply Temperature Set Point Reset	AO	R/W	
Chiller Supply Temperature Set Point	AD	R/W	
Chiller Chilled Water Return Temperature	AI	R	To chiller(s)
Chiller Demand Limiting	AO	R/W	
Chiller Lead/Lag Designation	AD	R/W	
Lag Chiller Start/Stop Set Point	AD	R/W	
Lead/Lag Rotation Run Time Setpoint	AD	R/W	
Chilled Water Pump Start/Stop**	BO	R/W	Only those pumps not hard-wire interlocked to a corresponding chiller (e.g., those pumps controlled by the DDC system)
Chilled Water Pump Status**	BD	R	
Chilled Water Pumps Lead/Lag Designation	BD	R/W	If more than one chiller pump (and they can feed any chiller) or more than one building pump
Building Chilled Water Pump Speed	AO	R/W	
Building Chilled Water Pump VFD Fault	BD	R	
Chilled Water Differential Pressure	AI	R	Variable speed building pump system
Chilled Water Differential Pressure Set Point	AD	R/W	Same as above
Building Chilled Water Flow	AI	R	On variable flow systems
Building Chilled Water Supply Temperature	AI	R	Primary/secondary system
Building Chilled Water Supply or Return Temperature Set Point	AD	R/W	Same as above
Building Chilled Water Return Temperature	AI	R	Same as above
Chilled water glycol low level or Makeup water flow	BD or AD	R	Provide makeup water flow only if there is no glycol feeder
Chilled Water System Pressure Alarm	BI	R	
Flat Plate Heat Exchanger Bypass Valves	BO	R/W	
Condenser Water Pump Start/Stop	BO	R/W	
Condenser Water Pump Status	BI	R	
Condenser Water Pumps Lead/Lag Designation	BO	R/W	
Condenser Water Supply Temperature	AI	R	To chiller(s)
Condenser Water Return Temperature	AI	R	From chiller One for each chiller
Condenser Water Supply Temperature Set Point	AD	R/W	
Cooling Tower Fan Start/Stop	BO	R/W	Provide two points for two-speed fan
Cooling Tower Fan Speed	AO	R/W	
Cooling Tower Fan Status	BI	R	
Cooling Tower Vibration Alarm	BI	R	
Cooling Tower VFD Fault	BI	R	
Cooling Tower Sump Level Alarm	BI	R	May be multiple points (high/low/alarm)
Cooling Tower Sump Temperature	AI	R	
Cooling Tower Sump Drain/Fill	BO	R/W	
Cooling Tower Bypass Valve	AO	R/W	
Condenser Water Makeup Flow	AI	R	
Refrigerant Alarm	BD	R	Emergency

Refrigerant Evacuation Exhaust Fan Start/Stop	BO	R/W	Or high/low for a mechanical room exhaust fan
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*This “plant” may be that used for a water source heat pump system where there may be no chillers or, possibly in the case of ground-source heat pumps, no cooling towers.

**On primary/secondary systems there will be chiller and building pump(s).

9. Fire Alarm System*

Points	Type	R/W	Notes
System Trouble	BI	R	
System Alarm	BI	R	
Water Flow Alarm	BI	R	
Low Water Pressure	BI	R	May not be available as a separate point.
Disconnect from City	BI	R	May not be available as a separate point.
Zone/Device Status (for each zone/device)	BI’s**	R	One BI for each of Alarm, Trouble and Supervisory; or all points can be communicated via one BACnet fire alarm device object for each device.

*Connect to 25 00 00 system if BACnet or other digital communications interface not provided.

**Provide only if connected via a BACnet or other digital communications interface.

10. Fire Suppression*

Points	Type	R/W	Notes
Kitchen Hood Alarm	BI	R	Only if it is not provided by the fire alarm system.
Fire Pump Status	BI	R	Same as above.

*Field devices and points provided under 25 00 00.

11. Lighting Control

Points	Type	R/W	Notes
Lighting Zone Override	BO	R/W	
Lighting Zone Status	BI	R	
Lighting Zone schedule	BACnet Schedule Object	R/W	

12. Plumbing*

Points	Type	R/W	Notes
Basement Water Alarm	BI	R	Contact provided with backflow preventer
Domestic Hot Water Temperature	AI	R	
Kitchen Domestic Hot Water Temperature	AI	R	
Swimming Pool Chemical Treatment System Alarm	BI	R	
Swimming Pool Pump Status	BI	R	
Domestic Water System Pressure alarm (downstream of regulator)	BI	R	Emergency
Natural Gas System pressure alarm (downstream of regulator)	BI	R	Emergency
Domestic Hot Water Recirculation Pump System Start/Stop	BO	R/W	
Domestic Hot Water Recirculation Pump System Status	BI	R	
Domestic Water Booster Pump(s) System	BI	R	

Status/Alarm			
Domestic Water CW line flow switch	BI	R	

*Field Devices and points provided under 25 00 00.

13. Irrigation*

Points	Type	R/W	Notes
Water Flow	AI	R	Pulse initiator on meter
Booster Pump Start/Stop	BO	R/W	
Booster Pump Status	BI	R	
Isolation Valve	BO	R/W	
Zone Valve On/Off's	BO's	R/W	One for each zone
Moisture sensor	BI	R	

*Field devices and points provided under 25 00 00.

14. Electrical (main switch gear)*

Points	Type	R/W	Notes
Phase Monitor Alarm	BI	R	Emergency
Synchronizing Trip Status	BI	R	Emergency
Phase-to-Phase Voltage or Imbalance	6 AI's or BI's**	R	Between each phase, and between each phase and neutral.
Building Electrical Meter KW	**	R	***
Building Electrical Meter KWH	**	R	***
Standby Generator Status	BI	R	
Standby Generator Exercise	BO	R/W	
Automatic Transfer Switch Position	Multiple BI's	R	Provide points for all ATS positions
Voltage Loss Alarm	AI	R	

*Points connected to 25 00 00systems if a BACnet or other digital interface is not provided.

**Point type depends on electrical monitoring system design.

***Provide pulse initiator on building meter with one BI point (to calculate both KW and KWH) if this information is not available from the electrical monitoring system.

15. Miscellaneous*

Points	Type	R/W	Notes
Exhaust Fan Start/Stop	BO	R/W	Provide point data for each exhaust fan controlled by the DDC system but not associated with an AHU/RTU/MUA
Exhaust Fan Status	BI	R	Same as above
Laboratory Fume Hood Exhaust Fan Status	BI	R	
Laboratory Dust Collection Exhaust Fan Status	BI	R	
Kiln Hood Exhaust Fan Status	BI	R	
Outside Air Temperature	AI	R	
Outside Air Relative Humidity	AI	R	
Walk-in Freezer Temperature	AI	R	
Walk-in Refrigerator Temperature	AI	R	

*Field devices and points provided under 25 00 00.

END OF SECTION 25 90 00