

Application 2313 CV AHU with DX Cooling, Electric or RC Heating, Economy Cycle and CO₂ Sensor

Overview

Application 2313 controls an air-handling unit with the following features:

- Up to 2 stages of DX cooling.
- Cooling control signal, SA CLO, that is reset by return air temperature in cool-down mode and by maximum room temperature during occupied mode.
- Up to 3 stages of electric heating, **OR**, up to 2 stages of RC heating.
- Heating supply air loop with set point that is reset by return air temperature in warm-up mode and by maximum room temperature during occupied mode.
- Outside air damper that has minimum position during occupancy that is varied directly proportional to value of CO₂ sensor (if used). If a CO₂ sensor is not used or is failed, then outside air damper uses constant minimum position during occupied mode.
- Ability to use outside air as source of free cooling during night purge and cool-down modes when outside air is cool enough to use as source of cooling.
- Fan alarm.
- Ability to operate either stand-alone or with a field panel.

Refer to Figures 2313-1 through 2313-9.

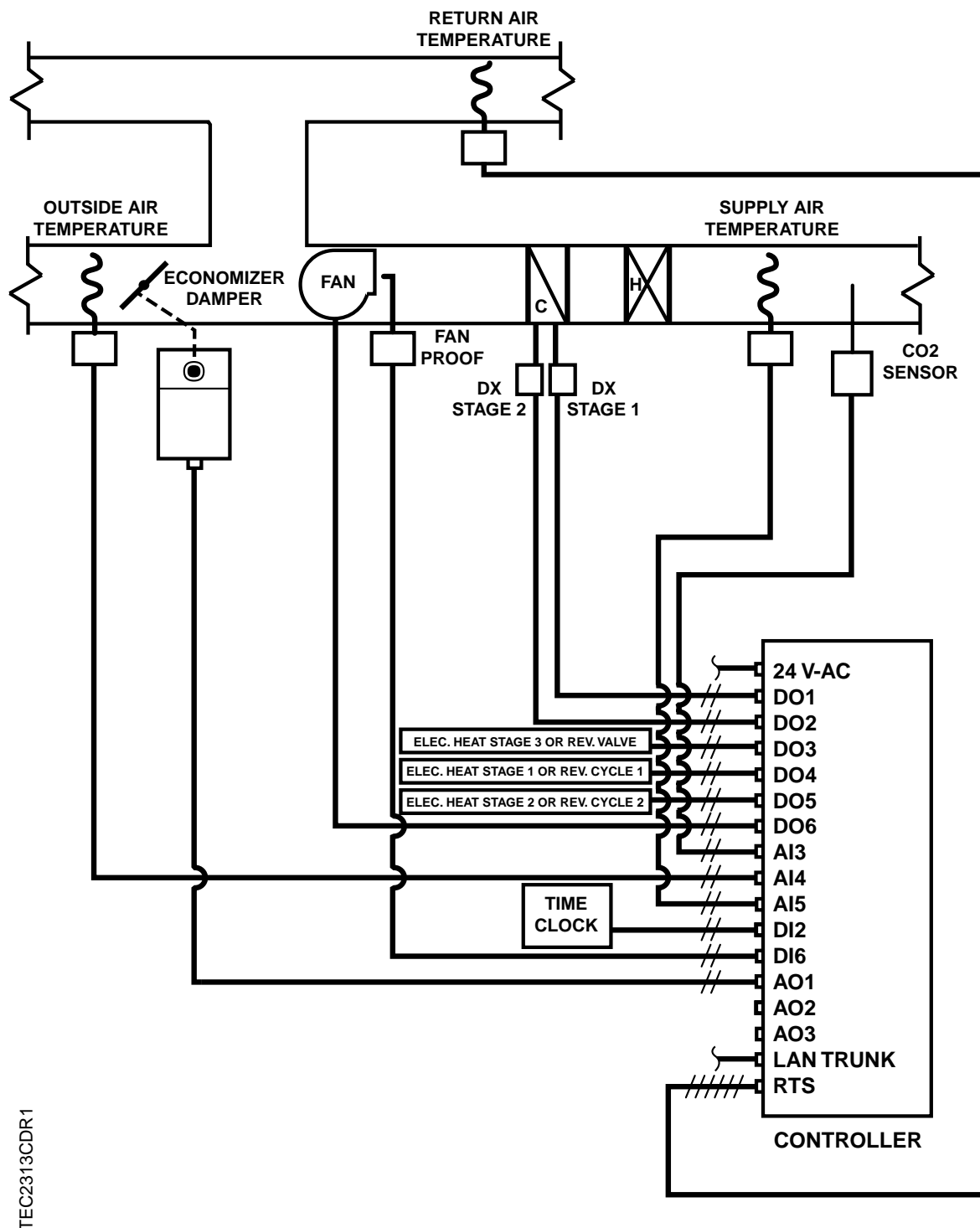


Figure 2313-1. Application 2313 Control Drawing.

CONTROL SCHEDULE - SHUTDOWN MODE		
SUPPLY TEMPERATURE	COOLER	WARMER
<div> <div>OPEN</div> <div>OUTSIDE AIR DAMPER</div> <div>-----</div> <div>CLOSED</div> </div>		
FAN	← OFF →	
ELECTRIC HEAT STAGE(S)	← OFF →	
DX COOLING STAGE(S)	← OFF →	

TEC2313ACSR1

Figure 2313-2. Application 2313 Control Schedule.

CONTROL SCHEDULE - RE-CIRCULATION AND NORMAL MODES		
SUPPLY TEMPERATURE	COOLER	WARMER
<div> <div>OPEN</div> <div>OUTSIDE AIR DAMPER</div> <div>-----</div> <div>CLOSED</div> </div>		
FAN	← ON →	
ELECTRIC HEAT STAGE(S)	← OFF →	
DX COOLING STAGE(S)	← OFF →	

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Figure 2313-3. Application 2313 Control Schedule.

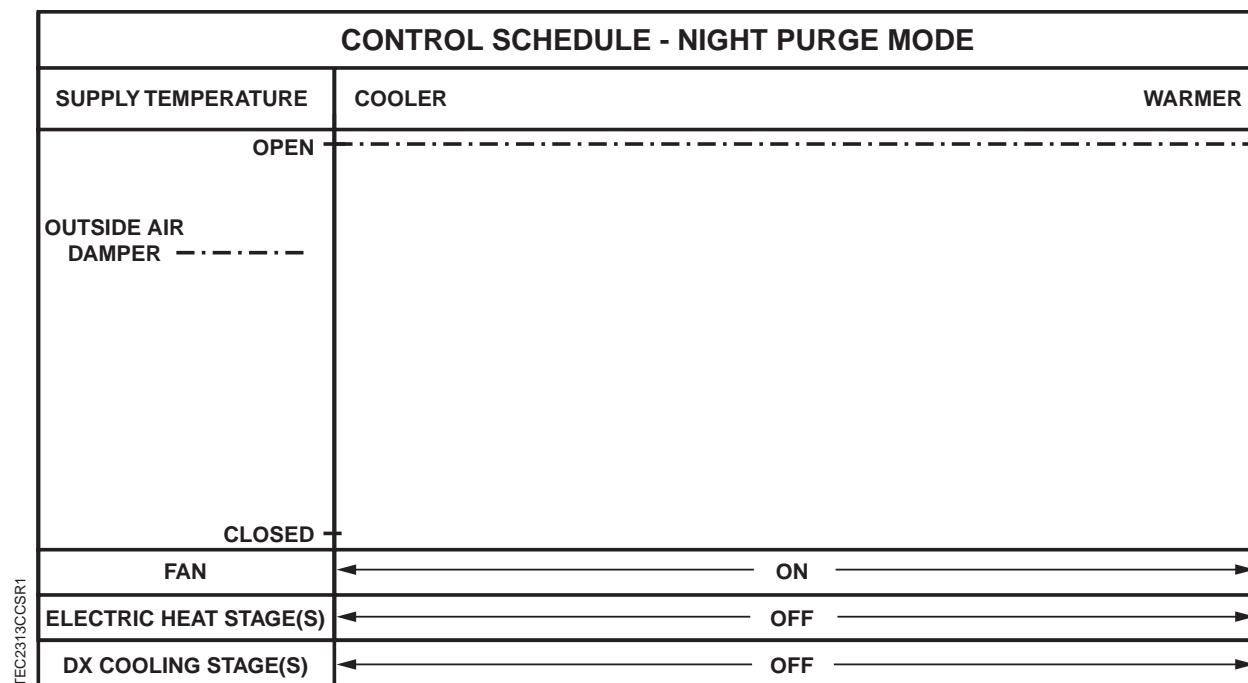
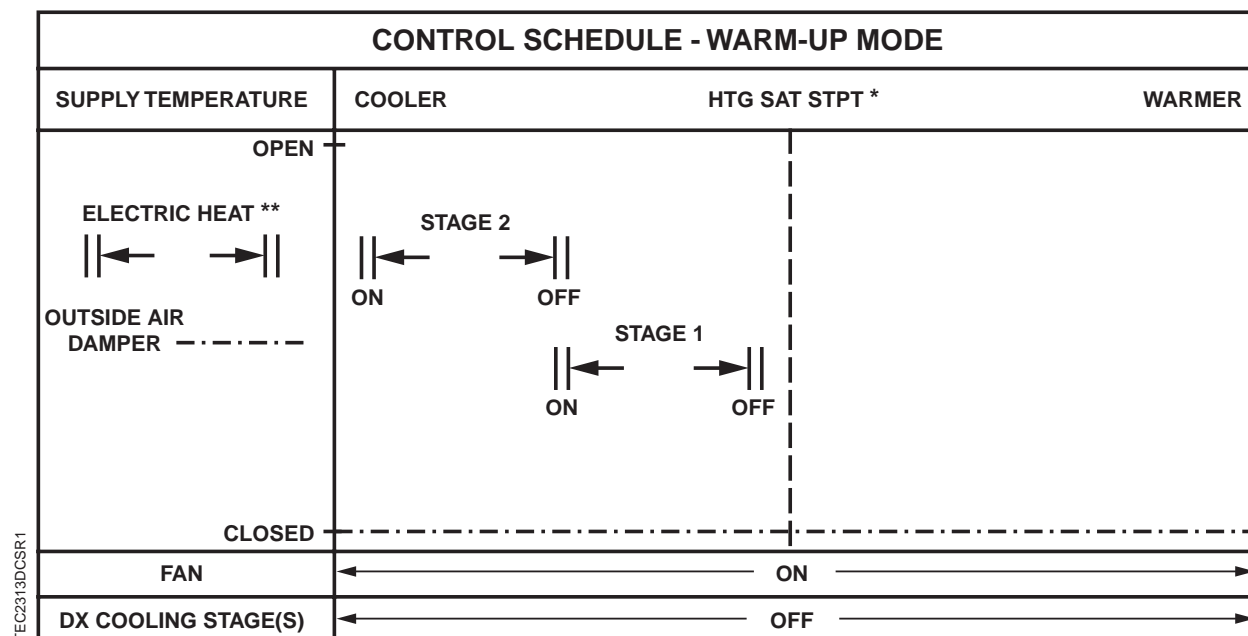


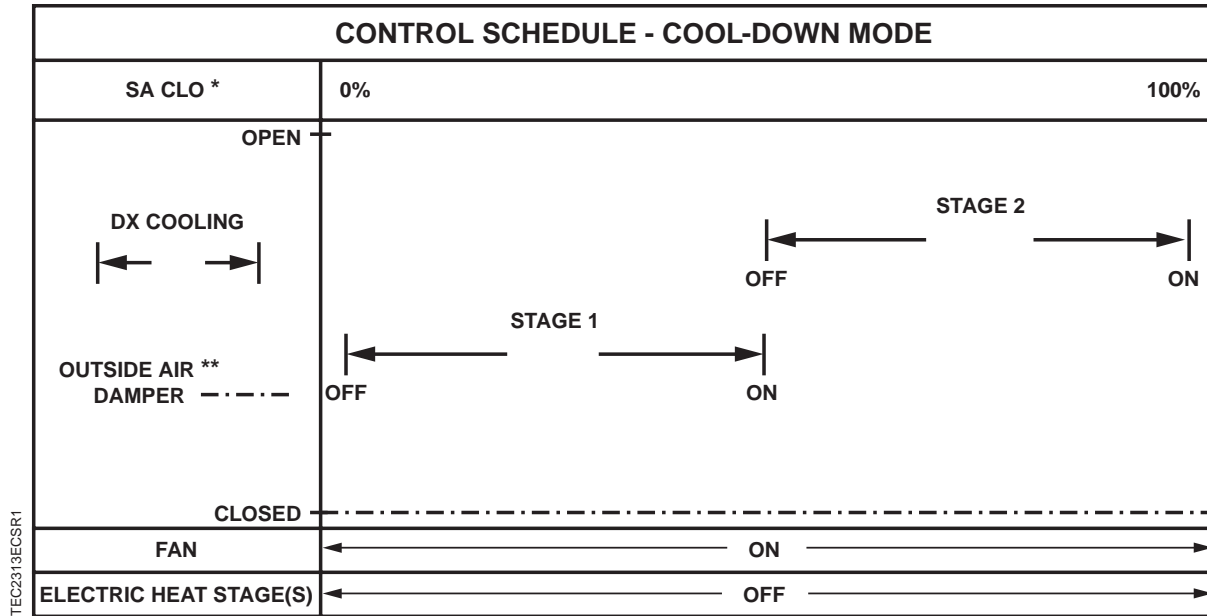
Figure 2313-4. Application 2313 Control Schedule.



* The point HTG SAT STPT (number 10) is adjusted by a table statement based on return air temperature. Refer to the *Warm-up mode* section for more information.

** Only 2 stages of electric heat are allowed when using a reversing valve. When not using a reversing valve, 3 stages of electric heat can be used.

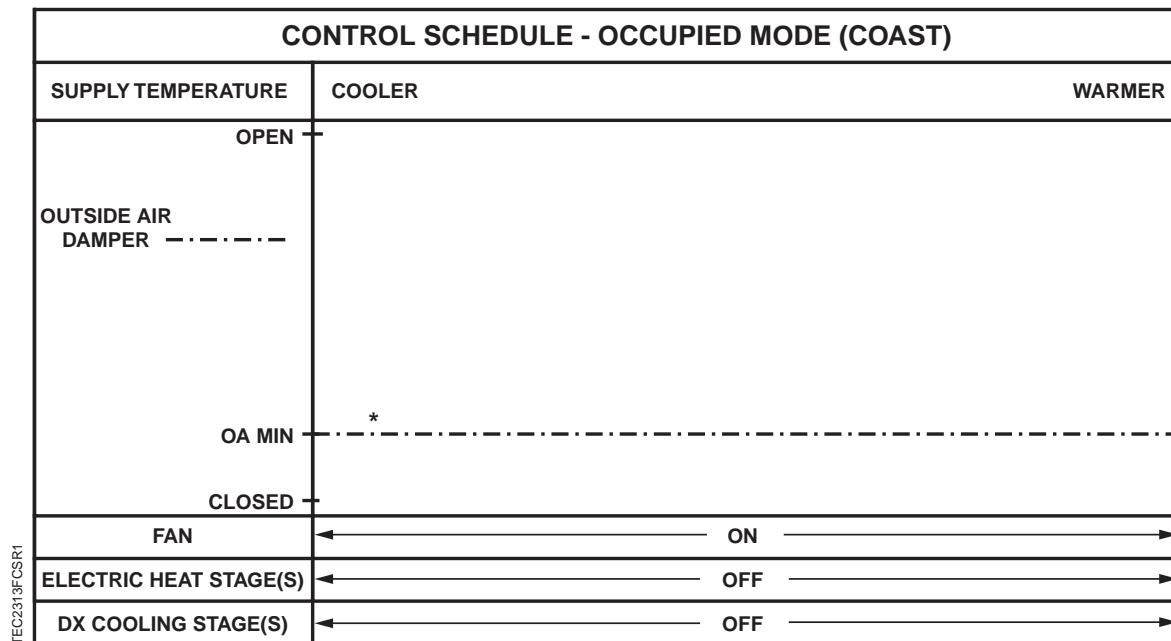
Figure 2313-5. Application 2313 Control Schedule.



* SA CLO (Point 34) is the control signal for the cooling equipment. It is adjusted by a table statement based on return air temperature. Refer to the *Cool-down mode* section for more information.

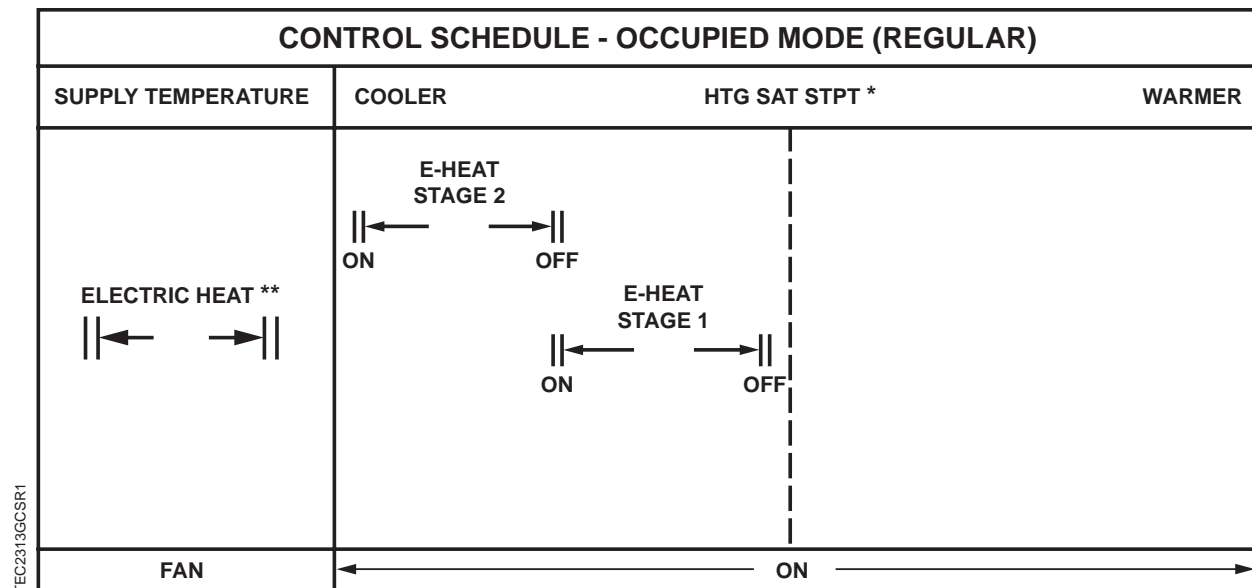
** The OA damper is modulated to take advantage of free cooling whenever the outside air is cool enough. Refer to the *Cool-down mode* section for more information.

Figure 2313-6. Application 2313 Control Schedule.



* The outside air damper minimum position varies as the CO₂ level changes. Refer to the *Occupied mode* section for more information.

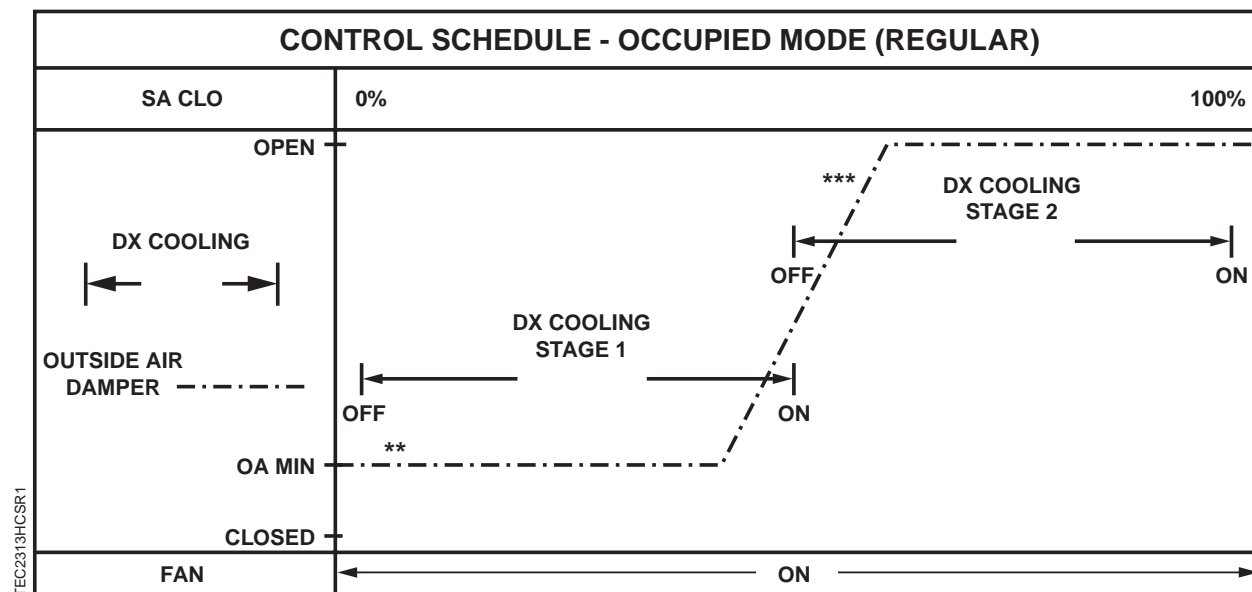
Figure 2313-7. Application 2313 Control Schedule.



* HTG SAT STPT (Point 10) is adjusted by a table statement based on MAX RM TEMP (Point 21). Refer to the *Occupied mode* section for more information.

** Only 2 stages of electric heat are allowed when using a reversing valve. When not using a reversing valve, 3 stages of electric heat can be used.

Figure 2313-8. Application 2313 Control Schedule.



* SA CLO (Point 34) is adjusted by a table statement based on MAX RM TEMP (Point 21). Refer to the *Occupied mode* section for more information.

** The outside air damper minimum position varies as the CO₂ level changes. Refer to the *Occupied mode* section for more information.

***If free cooling is not available, then the outside air damper stays at minimum position at all times. Refer to the *DX cooling and outside air damper interaction in occupied mode* section for more information.

Figure 2313-9. Application 2313 Control Schedule.

Hardware inputs

Analog

- Outside air temperature (100K Ω thermistor)
- CO₂ sensor (0-10V, 4-20 mA)
- Supply air temperature (100K Ω thermistor)

Digital

- Fan proof
- Time clock

Hardware outputs

Analog

- Outside air damper (0-10V)

Digital

- Fan
- Staged electric heat (up to 2 stages if a reversing valve is used; up to 3 stages if a reversing valve is not used)
- DX cooling (up to 2 stages)

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2313, "CV AHU with DX Cooling, Electric or RC Heating, Economy Cycle and CO₂ Sensor."

Modes

There are several modes in this application. The value of the point MODE (number 25) determines which mode the application is in. The following table lists MODE values that correspond to the different modes used by this application.

Table 2313-1. Modes and Values.

Mode	Value
shutdown	0
night purge	10
recirculation	20
normal	30
warm-up	40
cool-down	50
occupied	60
undefined	70 and greater

It is important to understand the operational modes available, what happens in them, and how the application can get into them. The following section begins with the application going from the occupied mode into the shutdown mode. It is assumed the point TIME CLOCK (number 81) is set to NO. (Later, it will be described how the application changes modes when TIME CLOCK equals YES.)

Shutdown mode

To go from occupied mode to shutdown mode, the field panel must change the point MODE (number 25) to the shutdown value of 0. After this has been done, the field panel must release MODE so the controller can change it as needed.

When shutdown takes place, the following occurs:

- The outside air damper closes (OA DAMPER, point number 84).
- All heating and cooling stages are shut OFF after they have been ON longer than the minimum on-time held in the point MIN ON (number 64).
- The cooling control signal (SA CLO, number 34) goes to zero.

The point FAN (number 46) does not turn OFF right away. Instead, it remains ON until the application has been in the shutdown mode for longer than the length of time held in the point SHUTDN TIME (number 60). Once this occurs, the fan shuts OFF, and its status goes back to normal (fan point comes out of failure) if it is not there already. The fan does not go into alarm (its status letter does not change from N to F) when the fan is OFF.

During the shutdown period the heating loop is disabled to prevent reset windup.

Shutdown to night purge

During the shutdown mode, it is possible to send the application to the night purge mode. The transition from shutdown to night purge involves an interaction between the field panel and the controller and is explained as follows:

- The field panel must set the point PURGE OK (number 82) to YES.
- The controller must determine that the point MAX RM TEMP (number 21) is greater than the point PURGE START (number 27). When this occurs, the controller (not the field panel) places the point MODE (number 25) into the night purge mode (MODE = 10).

Then the following occurs:

- The fan turns ON. This enables the fan alarm feature.
- The point OA DAMPER (number 84) is set to 100% open.

Ending night purge

Night purge usually ends with a return to shutdown mode. When the controller determines that the point MAX RM TEMP (number 21) is less than the point PURGE END (number 28), it sends the point MODE (number 25) back to the shutdown value of 0 and shutdown proceeds as before. Keep in mind that the fan does not turn OFF right away (see the *Shutdown mode* section for more information).

The other common way for night purge to end is for the application to be set to the recirculation mode as described in the following section.

NOTE: When MAX RM TEMP is between the point PURGE START (number 27) and PURGE END, MODE remains in its last commanded state. If MODE was commanded to shutdown, it remains in shutdown; if it was commanded to night purge, it remains in night purge. This deadband was put in to minimize excessive mode switching.

Recirculation mode

The most common way to get into the recirculation mode is from the shutdown mode. Another common way to enter the recirculation mode is from the night purge mode. Either way, the operation of the recirculation mode is the same.

To go to the recirculation mode, the field panel must change the point MODE (number 25) to the recirculation mode value of 20. After this has been done, the field panel must release MODE back to normal control so the controller can change it as needed. When the application is in the recirculation mode, the following occurs:

- The fan turns ON. This enables the fan alarm feature.
- Everything else remains the way it was in the shutdown mode:
 - The heating and cooling stages remain OFF
 - The outside air damper remains shut
 - The heating loop remains disabled
 - The cooling control signal remains at zero.

The application stays in the recirculation mode for the amount of time stored in the point RECIRC TIME (number 61). After RECIRC TIME is up, the controller determines what mode to send the application into next: the warm-up mode, the cool-down mode or the normal mode.

Warm-up mode

This mode can be entered from the recirculation mode. When the return air temperature, point RAT.RTS (number 04), is less than the point HTG NEEDED (number 51), the controller sets the MODE point (number 25) to the warm-up mode value of 40. During warm-up mode the following occurs:

- The point FAN (number 46) remains ON and the fan alarm remains enabled.
- The cooling stages remain OFF, the OA damper remains shut, and the cooling control signal remains at zero.
- The heating loop is enabled and the heating stages are controlled in order to maintain the heating supply air temperature set point (HTG SAT STPT, number 10). Refer to the *Electric heat control* section later in this document for details on how this application controls the heating.
- The HTG SAT STPT value is adjusted by a table statement located in the controller. When return air temperature rises, HTG SAT STPT falls and vice versa. The user can adjust this table statement with the following parameters:
 - Point RAT LOH (number 48) – The lowest return air temperature this table statement looks at.
 - Point HSTP HI (number 11) – The highest HTG SAT STPT used. This is used when RAT.RTS equals RAT LOH.
 - Point RAT HIH (number 47) – The highest return air temperature that this table statement looks at.
 - Point HSTP LO (number 12) – The lowest HTG SAT STPT used. This is used when RAT.RTS equals RAT HIH.

The controller will set MODE to the normal mode value of 30 if the return air temperature (RAT.RTS) rises above HTG NEEDED + OFFSET (OFFSET is an internal point equal to 1.11°C).

NOTE: If RAT.RTS is between the values of HTG NEEDED and HTG NEEDED + OFFSET, then MODE will remain in its last known state. If it was commanded to warm-up, then it remains in warm-up; if it was commanded to normal mode, it remains in normal mode.

Cool-down mode

This mode can be entered from the recirculation mode. If the return air temperature, point RAT.RTS (number 04), is greater than point CLG NEEDED (number 52), then the controller sends MODE (number 25) to the cool-down value of 50. The following occurs during cool-down:

- The point FAN (number 46) remains ON and the fan alarm remains enabled.
- The heating stages remain OFF and the heating loop remains disabled.
- The cooling control signal (SA CLO) is active and controls both the cooling stages and the outside air damper in sequence to maintain the return air temperature (RAT.RTS, number 04). Refer to the *DX cooling control* section later in this document for a more detailed explanation of how the cooling stages are controlled. A detailed explanation of how the cooling stages and outside air damper interact during the cool-down mode is given in the section *DX cooling and outside air damper interaction in the cool-down mode*.
- The value of point SA CLO (number 34) is adjusted by a table statement located in the controller. When the return air temperature rises, SA CLO will rise and vice versa. The table statement uses four parameters, two of which are adjustable (the 0% and 100% cannot be changed):
 - Point RAT LOC (number 17) – The lowest return air temperature that this table statement looks at.
 - 0% – The lowest SA CLO used. SA CLO = 0% when RAT.RTS = RAT LOC.
 - Point RAT HIC (number 16) – The highest return air temperature that this table statement looks at.
 - 100% – The highest SA CLO used. SA CLO = 100% when RAT.RTS = RAT HIC.

The controller will set MODE to the normal mode value of 30 if the return air temperature point (RAT.RTS) drops below CLG NEEDED – OFFSET (OFFSET is an internal point equal to 1.11°C).

NOTE: If RAT.RTS is between the values of CLG NEEDED and CLG NEEDED – OFFSET, then MODE remains in its last known state. If it was commanded to cool-down, then it remains in cool-down; if it was commanded to normal mode, then it remains in normal mode.

Normal mode

There are three common ways to get to the normal mode (MODE = 30). In each case, it is the controller that determines when to go into normal mode.

- The controller sends the application from recirculation mode to normal mode if both of the following are true:
 - The application has been in the recirculation mode for the amount of time in the point RECIRC TIME (number 61).
 - The value of point RAT.RTS (number 04) is between HTG NEEDED (number 51) and CLG NEEDED (number 52) when the amount of time held in RECIRC TIME is over.
- The controller sends the application from warm-up mode to normal mode if RAT.RTS is less than CLG NEEDED – OFFSET and greater than HTG NEEDED + OFFSET (OFFSET is an internal point equal to 1.11°C). If RAT.RTS is between the values of HTG NEEDED and HTG NEEDED + OFFSET, then MODE (number 25) remains in its last known state. If it was commanded to warm-up, then it remains in warm-up; if it was commanded to normal mode, it remains in normal mode.
- The controller sends the application from cool-down mode to normal mode if the RAT.RTS is less than CLG NEEDED – OFFSET and greater than HTG NEEDED + OFFSET. If RAT.RTS is between the values of CLG NEEDED and CLG NEEDED – OFFSET, then MODE remains in its last known state. If it was commanded to cool-down, then it remains in cool-down; if it was commanded to normal mode, it remains in normal mode.

When the application is in the normal mode:

- The point FAN (number 46) remains ON and the fan alarm remains enabled.
- The heating and cooling stages are OFF.
- The outside air damper remains shut.

The warm-up, cool-down and normal modes are pre-conditioning modes. They place the building at a proper temperature level before normal occupancy.

Occupied mode

After pre-conditioning is done (warm-up, cool-down or normal mode), the application is set to the occupied mode (value 60). This requires a field panel. The field panel must change the value of the point MODE (number 25) to the occupied mode value of 60. The field panel must then release MODE back to normal control so the controller can change it as needed.

The occupied mode has two distinct parts to it: the coast period and the regular occupied period. When the application is first sent into the occupied mode, the controller starts the coast period which stays in effect for the amount of time stored in the point OCC TIME (number 62). After the amount of time stored in OCC TIME has elapsed, the controller places the application into the regular occupied period.

The following occurs during the coast period:

- The point FAN (number 46) remains ON and the fan alarm remains enabled.
- The heating and cooling stages remain OFF.

- The outside air damper is set to minimum position. (If CO2 SEN USED (number 88) equals YES, then this minimum position changes with the value of CO2 SENSOR (number 15) and is controlled by a table statement located in the application's firmware. If CO2 SEN USED equals NO, then the outside air damper will go to a constant minimum position that is stored in the point DPR MIN POS (number 97). The outside air damper will also go to this constant minimum position if a CO₂ sensor is used but is failed.)

When a CO₂ sensor is used and operating normally and CO2 SEN USED equals YES, the outside air damper will open more as the CO₂ level increases, and vice versa. The table statement that is used to drive the position of the damper can be adjusted with the following parameters:

- Point CO2 LO (number 90) – The lowest CO₂ level this table statement looks at.
- Point OA DPR HI (number 91) – The highest minimum OA DAMPER position used. This is used when CO2 SENSOR = CO2 LO.
- Point CO2 HI (number 89) – The highest CO₂ level this table statement looks at.
- Point OA DPR LO (number 92) – The lowest minimum OA DAMPER position used. This is used when CO2 SENSOR = CO2 HI.

The application does the following during the regular occupied period:

- FAN remains ON and fan alarm remains enabled.
- The heating loop is enabled and the heating stages are controlled in order to maintain the HTG SAT STPT (number 10). Refer to the *Electric heating control* section for a more detailed explanation of how this application controls the heating.
- The HTG SAT STPT value is adjusted by a table statement that is located in the controller. When the MAX RM TEMP (number 21) rises, HTG SAT STPT falls and vice versa. The user can adjust this table statement with the following parameters:
 - Point RM LOH (number 50) – The lowest maximum room temperature that this table statement looks at.
 - Point HSTP HIO (number 13) – The highest HTG SAT STPT used. This is used when MAX RM TEMP equals RM LOH.
 - Point RM HIH (number 49) – The highest maximum room temperature that this table statement looks at.
 - Point HSTP LOO (number 14) – The lowest HTG SAT STPT used. This is used when MAX RM TEMP equals RM HIH.
- The cooling control signal (SA CLO) is active and controls both the cooling stages and the outside air damper in sequence to maintain the MAX RM TEMP (point 21). Refer to the *DX cooling control* section later in this document for a more detailed explanation of how the cooling stages are controlled. A detailed explanation of how the cooling stages and outside air damper interact during the regular period of the occupied mode is given in the section *DX cooling and outside air damper interaction during the regular period of the occupied mode*.
- The value of point SA CLO (number 34) is adjusted by a table statement located in the controller. When MAX RM TEMP rises, SA CLO will rise and vice versa. The table statement uses four parameters, two of which are adjustable (the 0% and 100% cannot be changed):
 - Point RM LOC (number 19) – The lowest maximum room temperature that this table statement looks at.
 - 0% – The lowest value of SA CLO. SA CLO = 0% when MAX RM TMP = RM LOC.

- Point RM HIC (number 18) – The highest maximum room temperature that this table statement looks at.
- 100% – The highest value of SA CLO. SA CLO = 100% when MAX RM TMP = RM HIC.

NOTE: Since the heating loop and cooling control signal SA CLO are both fully operational during the regular occupied period, the user must choose the parameters in the table statements carefully to avoid simultaneous heating and cooling. Refer to the *Set point and control signal selection* section for further explanation.

Undefined mode

It is possible to adjust the point MODE (number 25) to be in an undefined mode (for example, a value of 80). When this occurs, the following happens:

- The point FAN (number 46) turns ON.
- SA CLO (number 34) equals 0.
- The cooling stages are OFF.
- The heating loop is disabled, and the point SA HLO (number 33) equals 0.
- The heating stages are OFF.
- The outside air damper is set to minimum position. (If CO2 SEN USED (number 88) equals YES, then this minimum position changes with the value of CO2 SENSOR (number 15), and is controlled by a table statement located in the controller application. If CO2 SEN USED equals NO, then the outside air damper will go to a constant minimum position that is stored in the point DPR MIN POS (number 97). The outside air damper will also go to this constant minimum position if a CO₂ sensor is used but is failed.) (The OA damper behaves exactly like it does in the coast period of the occupied mode.)

Application mode operation when TIME CLOCK equals YES

Up until now, all explanations of mode operation have shared the assumption that the point TIME CLOCK (number 81) equals NO. Mode operation will now be explained with TIME CLOCK equal to YES.

When TIME CLOCK equals YES, the application mode is determined by the point TIME CLK DI2 (number 24). A field panel is not needed to change the value of the point MODE (number 25). Since TIME CLK DI2 has just two states (open and closed), only two modes are used when TIME CLOCK equals YES. When TIME CLK DI2 is open, MODE is set to the shutdown mode (value 0); when TIME CLK DI2 is closed, MODE is set to the occupied mode (value 60). The operation of the shutdown and occupied modes is identical to that explained previously, the only exception being the regular period of the occupied mode.

In the regular period of the occupied mode (when TIME CLOCK equals YES), both the points HTG SAT STPT (number 10) and SA CLO (number 34) are set from table statements driven by the point MAX RM TEMP (number 21). When TIME CLOCK equals NO, MAX RM TEMP is a temperature value that is adjusted by a field panel. When TIME CLOCK equals YES, MAX RM TEMP is a temperature *differential* value between the point RAT.RTS (number 04) and the set point dial. Refer to the *Set point and control signal selection* section for more information.

Fan alarm

The fan is considered to be in alarm if airflow is not detected a short while after the fan has been turned ON. Air detection comes from a fan proof connected to the point FAN PROOF (number 26). The amount of time that is allowed to pass before airflow must be detected is user adjustable and held in the point ALARM TIME (number 63). When an alarm condition occurs, the fan's status changes from normal to failed (status letter of the FAN point (number 46) changes from N to F). The fan's status then remains failed (even if the alarm condition goes away) for at least the amount of time stored in the point OCC TIME (number 62). After the fan's status has been failed for the amount of time stored in OCC TIME, this module checks the status of the fan proof DI. If it is ON, then the fan's status is returned to normal (FAN status changes from F to N). If it is still OFF (while the fan DO is ON), then the fan's status remains failed (again) for at least the amount of time stored in OCC TIME.

When FAN is OFF, the fan's status is reset to normal.

When the fan's status is failed, this application operates as follows:

- FAN is ON.
- The cooling stages are OFF and SA CLO is set to zero.
- The heating loop is disabled and the heating stages are OFF.
- The OA damper will be in one of four positions:
 - CO₂ adjusted minimum position: if MODE (number 25) equals occupied (value 60) or undefined (value 70).
 - Constant minimum position from value held in DPR MIN POS: if MODE = occupied or undefined **and** the CO₂ sensor is not being used (or is failed).
 - Fully open: if MODE equals night purge (value 10).
 - Fully closed: if MODE equals shutdown (value 0), recirculation (value 20), warm-up (value 40), normal (value 30) or cool-down (value 50).

Electric heating control

This application can control up to 2 stages of heat if a reversing valve is used, and up to 3 stages of heat if a reversing valve is not used. The point RV USED (number 87) determines whether a reversing valve is used. Electric heat stages are controlled using the following DOs:

- First stage – DO 4 (point number 44)
- Second stage – DO 5 (point number 45)
- Third stage – DO 3 (point number 43), RV USED = NO
- Reversing valve – DO 3 (point number 43), RV USED = YES

The number of heating stages available is stored in the point HTG STAGES (number 85). If a heating stage is not available, the application will not try to control it. For example, no attempt will be made to control the second stage of electric heat, DO 5, if HTG STAGES is 1 or 0. This allows for spare digital outputs that may be used for other things.

A heating stage will be OFF if at least one of the following 4 items is true:

- The fan is OFF.
- The fan is in alarm.
- A reversing valve is used and the point REV VALVE (number 83) = COOL.
- The heat load is small enough that this stage of heat can be shut OFF (see *SA HLO FALLING* below). In this case, the heat stage will shut OFF after it has been ON longer than MIN ON (point 64).

A heating stage may turn back ON only if **all** of the following are true:

- The fan is ON.
- The fan's status is normal.
- The heating stage has been OFF longer than MIN OFF (point 65).
- The heat load is large enough to justify turning ON this particular stage of electric heat. (See *SA HLO RISING* below.)
- The reversing valve (if one is used) is in the heating state (REV VALVE = HEAT).

The heat load is determined by the heating loop's output, SA HLO as follows:

SA HLO RISING

- When SA HLO rises above the point HTG STG1 ON (number 30), the first heating stage (DO 4) turns ON.
- When SA HLO rises above the point HTG STG2 ON (number 31), the second heating stage (DO 5) turns ON.
- When SA HLO rises above 96%, the third heating stage (DO 3) turns ON.

SA HLO FALLING

- When SA HLO drops below HTG STG2 ON, the third heating stage (DO 3) turns OFF.
- When SA HLO drops below HTG STG1 ON, the second heating stage (DO 5) turns OFF.
- When SA HLO drops below 5%, the first heating stage (DO 4) turns OFF.

A deadband is included in those calculations that determine, on the basis of heat load, whether a stage of electric heat should be turned ON or OFF (this prevents digital ON/OFF points from wearing out due to excessive toggling). For example, if SA HLO drops below 5% and then rises to a value halfway between 5% and HTG STG1 ON, then the first stage of heat will be OFF. However, if SA HLO rises above HTG STG1 ON and then drops to a value halfway between 5% and HTG STG1 ON, then the first stage of heat will be ON.

DX cooling control

This application can control up to 2 stages of DX cooling using the following DOs:

- First stage – DO 1 (point 41)
- Second stage – DO 2 (point 42)

The number of DX cooling stages available is stored in the point CLG STAGES (number 86). If a cooling stage is not available, the application will not try to control it. For example, no attempt will be made to control the second stage of DX cooling, DO 2, if CLG STAGES is 1 or 0. This allows for spare digital outputs that may be used for other things.

An application controlled cooling stage will be OFF if at least one of the following 5 items is true:

- The fan is OFF.
- The fan is in alarm.
- The supply air temperature is too low (SUPPLY TEMP (number 56) is less than LLIMIT (number 53)).
- A reversing valve is used and the point REV VALVE (number 83) = HEAT.
- The cooling load is small enough that this stage of cooling can be shut OFF (see *SA CLO FALLING* below). In this case, the cooling stage will shut OFF after it has been ON longer than MIN ON (point 64).

A cooling stage may turn back ON only if **all** of the following are true:

- The fan is ON.
- The fan's status is normal.
- The supply air temperature is not too cold (SUPPLY TEMP is greater than LLIMIT + 1.11°C).
- The cooling stage has been OFF longer than MIN OFF (point 65).
- The cooling load is large enough to justify turning ON this particular stage of cooling. (See *SA CLO RISING* below.)
- The reversing valve (if one is used) is in the cooling state (REV VALVE = COOL).

The cooling load is determined by the cooling control signal, SA CLO as follows:

SA CLO RISING

- When SA CLO rises above the point CLG STG1 ON (number 32), the first stage of DX cooling (DO 1) turns ON.
- When SA CLO rises above 96%, the second stage of DX cooling (DO 2) turns ON.

SA CLO FALLING

- When SA CLO drops below CLG STG1 ON, the second stage of DX cooling (DO 2) turns OFF.
- When SA CLO drops below 32%, the first stage of DX cooling (DO 1) turns OFF.

A deadband is included in those calculations that determine, on the basis of cooling load, whether a stage of DX cooling should be turned ON or OFF (this prevents digital ON/OFF points from wearing out due to excessive toggling). For example, if SA CLO drops below 32% and then rises to a value halfway between 32% and CLG STG1 ON, then the cooling load is considered small enough to justify turning OFF the first stage of DX cooling. However, if SA CLO rises above CLG STG1 ON and then drops to a value halfway between 32% and HTG STG1 ON, then the first stage of DX cooling will be turned ON.

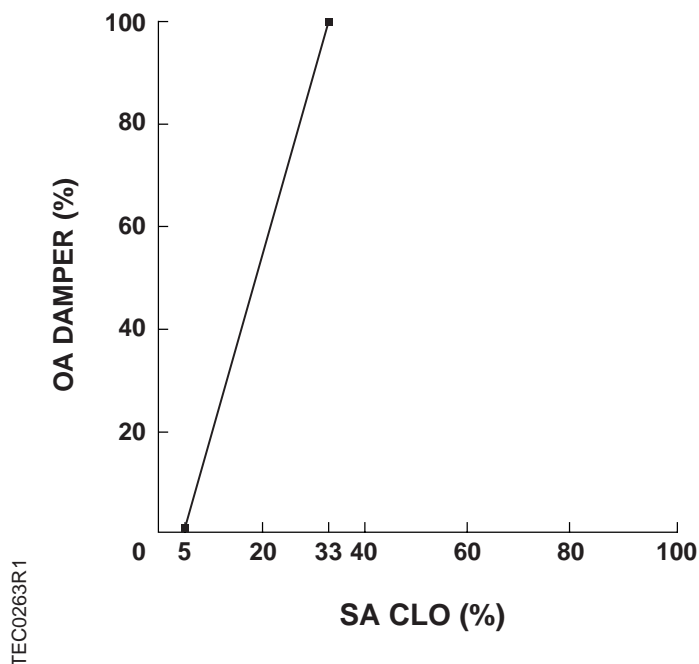
If the DX cooling stages shut OFF because the supply air temperature (SUPPLY TEMP, number 56) drops below the low limit (LLIMIT, number 53), they will not be allowed to turn ON again until SUPPLY TEMP rises above LLIMIT + 1.11°C. Once this happens and DX cooling begins again, it (DX cooling) will not be forced to turn OFF due to a low temperature condition until SUPPLY TEMP drops below LLIMIT. This deadband helps prevent excessive toggling of the DX cooling stages.

DX cooling and outside air damper interaction in cool-down mode

During the cool-down mode, the cooling control signal (SA CLO) is varied off a table statement to control the return air temperature as measured by RAT.RTS. SA CLO must control the DX cooling stages and outside air damper to do this.

The first stage of DX cooling, DO 1, will not turn ON until SA CLO rises above CLG STG1 ON. When SA CLO drops below 32%, the first stage of DX cooling turns OFF. By controlling the first stage of DX cooling this way, the outside air damper can be used as a source of free cooling (weather permitting) before any mechanical cooling is used.

During cool-down, the outside air damper is either a source of free cooling or it is shut. When the outside air temperature (OA TEMP, number 22) is greater than the point TOO HOT (number 23), free cooling is unavailable and the outside air damper is shut. When OA TEMP is less than TOO HOT – 1.11°C, free cooling is available, and the cooling control signal (SA CLO) modulates the outside air damper to control the return air temperature, with the damper scaled from 0% to 100% open as SA CLO goes from 5% to 33%. Refer to Figure 2313-10.



NOTE: As the point SA CLO (number 34) goes from 5% to 33%, the point OA DAMPER (number 84) goes from 0% open to 100% open.

Figure 2313-10. Control of OA Damper in Cool-Down Mode.

When the outside air temperature is less than TOO HOT and greater than TOO HOT – 1.11°C, the operation of the outside air damper remains unchanged. If it was closed before, it remains closed, while if it was used as a source of free cooling before, it continues as a source of free cooling.

DX cooling and outside air damper interaction in occupied mode

In this mode, unlike the cool-down mode, the outside air damper does not shut completely when the outside air temperature is too warm to be used as a source of free cooling (OA TEMP > TOO HOT). Instead, the damper will be used for ventilation and adjusted to the CO₂ level adjusted minimum position if a CO₂ sensor is used and functioning normally. This CO₂ level adjusted minimum position comes from the following table statement which is built into the application:

TABLE(CO2 SENSOR, OA DAMPER, CO2 LO, OA DPR LO, CO2 HI, OA DPR HI)

This table statement operates the same as a PPCL table statement. Its parameters were explained earlier in the *Occupied mode* section.

When the outside air damper is not being used as a source of free cooling in this mode, and a CO₂ sensor is either not being used or is failed, the OA damper will go to the constant minimum position that is stored in the point DPR MIN POS (number 97).

Except for the action of the outside air damper when it is not being used as a source of free cooling, the interaction of the DX cooling and the outside air damper during the occupied mode (regular period) is identical to their interaction during the cool-down mode.

Set point and control signal selection

This application changes the heating supply air temperature set point and the cooling supply air temperature control signal as the mode changes. The selection process differs depending on whether a physical set point dial is used with the room/return air temperature sensor.

NOTE: Whether or not the temperature sensor is used in a room or in the return air, its point is called RAT.RTS (number 04) for *return air temperature/room temperature sensor* (this conserves points).

The temperature set point and control signal selection process is explained in 3 parts:

- Set point and control signal selection that does not depend on the presence or absence of a physical set point dial
- Set point and control signal selection unique to the absence of a physical set point dial
- Set point and control signal selection unique to the presence of a physical set point dial

Set point and control signal selection that does not depend on the presence or absence of a physical set point dial.

The heating supply air temperature set point (HTG SAT STPT, number 10) and the cooling supply air temperature control signal (SA CLO, number 34) are set to turn the heating and cooling stages OFF when at least one of the following conditions is in effect (regardless of whether a physical set point dial is used):

- The point FAN (number 46) is OFF.
- The point MODE (number 25) is in shutdown (value 0), night purge (value 10), recirculation (value 20) or normal (value 30).
- The application is in the coast period of the occupied mode.

To ensure that the heating and cooling stages are turned OFF, HTG SAT STPT is set to SAT – 5°C, and SA CLO is set to 0%.

Set point and control signal selection that is unique to the absence of a physical set point dial.

A room/return air temperature sensor without a physical set point dial is only used when a field panel is available to assist the controller in setting the value of MODE. In such cases the temperature sensor is more likely to be located in the return air rather than in a room. If TIME CLOCK (number 81) equals NO, then the application assumes a physical set point dial is not being used.

When MODE equals warm-up (value 40), the cooling control signal SA CLO is set to 0% and the HTG SAT STPT is set from a table statement driven by the point RAT.RTS. When MODE equals cool-down (value 50), both the cooling control signal SA CLO and the HTG SAT STPT are set from a table statement driven by the point RAT.RTS. Refer to the *Warm-up mode* section for a description of the parameters from the table statement that sets HTG SAT STPT. Refer to the *Cool-down mode* section for a description of the parameters from the table statement that sets SA CLO.

The cooling control signal, SA CLO, is not active during the warm-up mode; likewise, the heating supply air temperature loop is not active during the cool-down mode. Therefore, the cooling table statement and heating table statement can be set as desired for the cool-down and warm-up modes without worrying about simultaneous heating and cooling.

When the application is in the regular period of the occupied mode, HTG SAT STPT and SA CLO are set from table statements driven by the point MAX RM TEMP (number 21). Unless the field panel changes the value of MAX RM TEMP, the table statements are worthless because MAX RM TEMP will remain constant, as will HTG SAT STPT and SA CLO. The specific forms of these two table statements are:

TABLE(MAX RM TEMP, SA CLO, RM LOC, 0%, RM HIC, 100%)

TABLE(MAX RM TEMP, HTG SAT STPT, RM LOH, HSTP HIO, RM HIH, HSTP LOO)

During the regular period of the occupied mode, both the heating supply air temperature loop and the cooling control signal (SA CLO) are active. Therefore, care must be taken when setting up these table statements to avoid simultaneous heating and cooling. The user adjustable parameters are explained here for a better understanding of how to do this:

HTG SAT STPT (when MAX RM TEMP rises, HTG SAT STPT falls and vice versa):

- Point RM LOH (number 50) – The lowest value of MAX RM TEMP that this table statement looks at.
- Point HSTP HIO (number 13) – The highest HTG SAT STPT used. This is used when MAX RM TEMP equals RM LOH.
- Point RM HIH (number 49) – The highest value of MAX RM TEMP that this table statement looks at.
- Point HSTP LOO (number 14) – The lowest HTG SAT STPT used. This is used when MAX RM TEMP equals RM HIH.

Cooling control signal, SA CLO (when MAX RM TEMP rises, SA CLO will rise and vice versa):

- Point RM LOC (number 19) – The lowest value of MAX RM TEMP that this table statement looks at.
- 0% – The lowest value of SA CLO. SA CLO will equal 0% when MAX RM TEMP equals RM LOC. **(This parameter is not adjustable.)**
- Point RM HIC (number 18) – The highest value of MAX RM TEMP that this table statement looks at.
- 100% – The highest value of SA CLO. SA CLO will equal 100% when MAX RM TEMP equals RM HIC. **(This parameter is not adjustable.)**

A recommended way of setting up the parameters of the two table statements to avoid simultaneous heating and cooling is as follows:

1. Set RM HIC greater than RM LOC.
2. Set RM HIH less than RM LOC.
3. Set RM LOH less than RM HIH.

Figure 2313-11 graphically illustrates the table statements with parameters set as suggested.

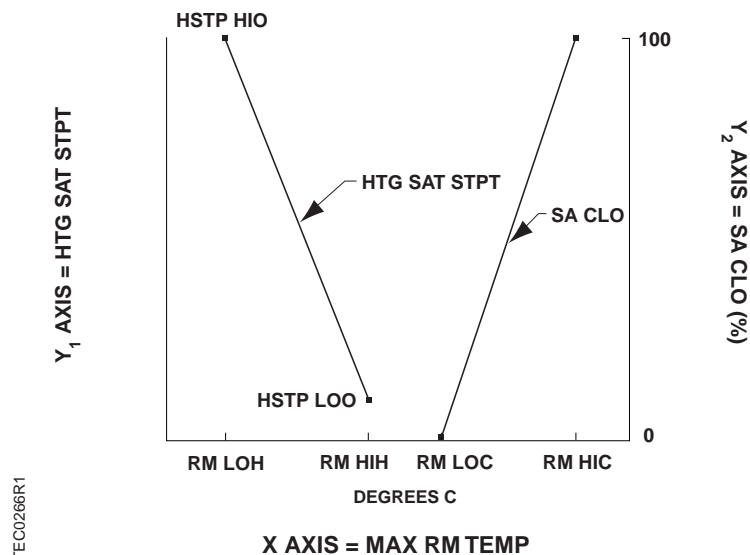


Figure 2313-11. Setting Up Table Statement Parameters to Avoid Simultaneous Heating and Cooling (Set Point Dial Not Used).

If the table statement parameters are set as suggested, then the following happens:

- When HTG SAT STPT increases, SA CLO will be at 0%.
- When SA CLO increases, HTG SAT STPT will be set to its lowest desired value.

Set point and control signal selection that is unique to the presence of a physical set point dial.

A room/return air temperature sensor with a physical set point dial is only used when a field panel is not available and the controller is stand-alone. In such cases the temperature sensor is located in a room rather than in the return air duct. (If it were located in the return air duct, the customer would have to climb into this duct to change the set point dial.) Even though the sensor is located in a room it is still called RAT.RTS. If TIME CLOCK (number 81) equals YES, then the application assumes a physical set point dial is being used.

When a physical set point dial is being used and TIME CLOCK equals YES, only two modes are used: shutdown (value 0) and occupied (value 60). If MODE is accidentally set to either warm-up (value 40) or cool-down (value 50) when a physical set point dial is present, then HTG SAT STPT (number 10) and SA CLO (number 34) are set to turn the heating and cooling stages OFF. This is done by setting HTG SAT STPT equal to SAT – 5°C and SA CLO equal to 0%.

The physical set point dial affects HTG SAT STPT and SA CLO only when the application is in the regular period of the occupied mode. During this period, the application will not use all of the physical set point dial's range — both high and low limits are placed on the range of the physical set point dial. Two points are used to achieve this. The physical set point dial uses the point RM STPT DIAL (number 95). The application uses an internal point (one that is not visible to the user) called RTS_DIAL_USED.

- When RM STPT DIAL is between the values of 18°C and 26°C, RTS_DIAL_USED = RM STPT DIAL.
- If RM STPT DIAL is less than 18°C, then RTS_DIAL_USED = 18°C.
- If RM STPT DIAL is greater than 26°C, then RTS_DIAL_USED = 26°C.

During the occupied mode (regular period) with a physical set point dial present, HTG SAT STPT and SA CLO are set from table statements driven by the point MAX RM TEMP. MAX RM TEMP differs depending on whether a set point dial is present or absent. In the absence of a set point dial, MAX RM TEMP is a temperature value. When a set point dial is present, MAX RM TEMP is **a differential plus a constant**:

$$\text{MAX RM TEMP} = \text{RAT.RTS} - \text{RTS_DIAL_USED} + 22.5^{\circ}\text{C}$$

The functional part of MAX RM TEMP is the differential (RAT.RTS – RTS_DIAL_USED). The 22.5°C is added to conserve points (it allows the differential to be stored in MAX RM TEMP because the slope and intercept of MAX RM TEMP do not need to be changed even though MAX RM TEMP is now being used as a differential and not a temperature).

The specific forms of the table statements driven by MAX RM TEMP are as follows:

TABLE(MAX RM TEMP, SA CLO, RM LOC, 0%, RM HIC, 100%)

TABLE(MAX RM TEMP, HTG SAT STPT, RM LOH, HSTP HIO, RM HIH, HSTP LOO)

Because both the heating supply air temperature loop and the cooling control signal, SA CLO, are active during the regular period of the occupied mode, care must be taken when setting up the table statements to avoid simultaneous heating and cooling. The user adjustable parameters are explained here again for a better understanding of how to do this:

HTG SAT STPT (when MAX RM TEMP rises, HTG SAT STPT falls and vice versa):

- Point RM LOH (number 50) – The lowest value of MAX RM TEMP that this table statement looks at.
- Point HSTP HIO (number 13) – The highest HTG SAT STPT used. This is used when MAX RM TEMP equals RM LOH.
- Point RM HIH (number 49) – The highest value of MAX RM TEMP that this table statement looks at.
- Point HSTP LOO (number 14) – The lowest HTG SAT STPT used. This is used when MAX RM TEMP equals RM HIH.

Cooling control signal, SA CLO (when MAX RM TEMP rises, SA CLO will rise and vice versa):

- Point RM LOC (number 19) – The lowest value of MAX RM TEMP that this table statement looks at.
- 0% – The lowest value of SA CLO. SA CLO will equal 0% when MAX RM TEMP equals RM LOC. **(This parameter is not adjustable.)**
- Point RM HIC (number 18) – The highest value of MAX RM TEMP that this table statement looks at.
- 100% – The highest value of SA CLO. SA CLO will equal 100% when MAX RM TEMP equals RM HIC. **(This parameter is not adjustable.)**

The following is a recommended way of setting up these table statement parameters to avoid simultaneous heating and cooling. Keep in mind that MAX RM TEMP is a differential and not a normal temperature value.

1. Determine how far below the set point dial you want the room temperature to be for maximum heating to occur. Add 22.5°C to this value and store it in RM LOH. For example, if you want HTG SAT STPT to equal HSTP HIO when RAT.RTS is 3°C less than RTS_DIAL_USED, then RM LOH equals $-3^{\circ}\text{C} + 22.5^{\circ}\text{C}$, or 19.5°C.
2. Set RM HIH greater than RM LOH.
3. Set RM LOC greater than RM HIH.
4. Determine how far above the set point dial you want the room temperature to be for maximum cooling to occur. Add 22.5°C to this value and store it in RM HIC. For example, if you want SA CLO to equal 100% when RAT.RTS is 3°C greater than RTS_DIAL_USED, then RM HIC equals $3^{\circ}\text{C} + 22.5^{\circ}\text{C}$, or 25.5°C.

Figure 2313-12 graphically illustrates the table statements with parameters set as suggested.

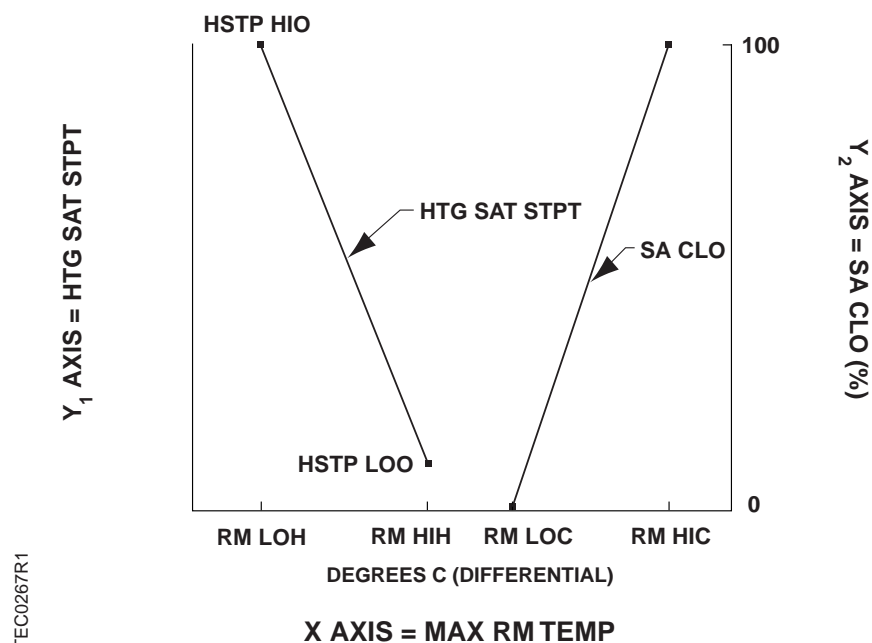


Figure 2313-12. Setting Up Table Statement Parameters to Avoid Simultaneous Heating and Cooling (Set Point Dial Used).

If the table statement parameters are set this way, then the following happens:

- When HTG SAT STPT increases, SA CLO will be at 0%.
- When SA CLO increases, HTG SAT STPT will be set to its lowest desired value.

When a physical set point dial is used, MAX RM TEMP changes in value if either the room temperature sensor or the set point dial change in value. However, the table statement values are constant; they do not change in value as the room temperature sensor and the set point dial change. (Table statement parameters are RM LOC, RM HIC, RM LOH, RM HIH, HSTP HIO, and STP LOO).

Application notes

1. The point FAN (number 46) can be commanded directly. When FAN is commanded OFF, the application behaves as though it were in shutdown mode (the application shuts down immediately without waiting for the shutdown timer to time out). The value of MODE (number 25) is not affected, so that when FAN is released to normal control, the application resumes regular operation according to the value held in MODE.
2. This application uses the point PURGE OK (number 82) to determine whether to go into the night purge mode. However, the application does not command PURGE OK; that must be done using PPCL in a field panel.
3. When the point TIME CLOCK (number 81) equals NO, the point MAX RM TEMP (number 21) must be set by PPCL in a field panel.

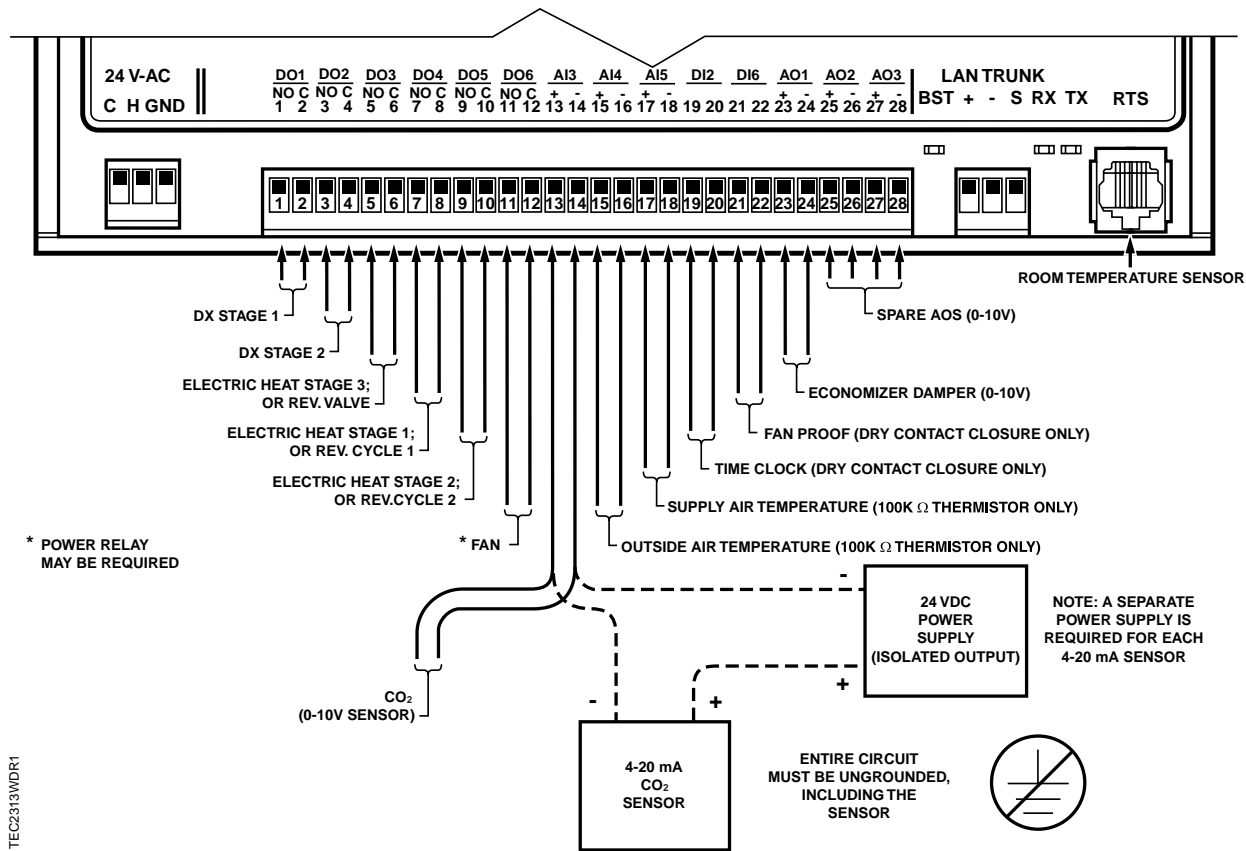
Wiring diagram

The point wiring for Application 2313 is shown in Figure 2313-13.



CAUTION:

The Australian Small Point Controller controls 24 Vac loads only. The maximum rating is 12 VA for each DO. For higher VA requirements, 110 or 220 Vac requirements, or DC power requirements, use an interposing 220 V 4-relay module.



NOTE: If AI 3 monitors a 0-10 V CO₂ sensor, then dip-switch located behind AI 3 on controller's circuit board must be set to the left (*voltage* position). If AI 3 monitors a 4-20 mA CO₂ sensor, then dip-switch must be set to the right (*current* position).

Figure 2313-13. Application 2313 Wiring Diagram.

Table 2313-2. Point Database for Application 2313.

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
01	CTLR ADDRESS	99	--	1	0	--	--
02	APPLICATION	2393	--	1	0	--	--
{04}	RAT.RTS	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
{10}	HTG SAT STPT	70.0 (21.256)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
11	HSTP HI	86.0 (30.216)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
12	HSTP LO	74.0 (23.496)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
13	HSTP HIO	86.0 (30.216)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
14	HSTP LOO	74.0 (23.496)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
{15}	CO2 SENSOR	0	PPM	1	0	--	--
16	RAT HIC	82.5 (28.21)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
17	RAT LOC	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
18	RM HIC	72.5 (22.656)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
19	RM LOC	68.0 (20.136)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
{21}	MAX RM TEMP	85.0 (29.656)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
{22}	OA TEMP	74.0 (23.496)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
23	TOO HOT	72.0 (22.376)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
{24}	TIME CLK DI2	OFF	--	--	--	ON	OFF
{25}	MODE	0	--	1	0	--	--
{26}	FAN PROOF	OFF	--	--	--	ON	OFF
27	PURGE START	80.0 (26.856)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
28	PURGE END	75.0 (24.056)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
30	HTG STG1 ON	32.0	PCT	0.4	0.0	--	--
31	HTG STG2 ON	64.0	PCT	0.4	0.0	--	--
32	CLG STG1 ON	64.0	PCT	0.4	0.0	--	--
{33}	SA HLO	0.0	PCT	0.4	0.0	--	--
{34}	SA CLO	0.0	PCT	0.4	0.0	--	--
37	AO DIR.REV	0	--	1	0	--	--
{38}	AOV 1	0.0	VOLTS	0.01	0.0	--	--
{39}	AOV 2	0.0	VOLTS	0.01	0.0	--	--
{40}	AOV 3	0.0	VOLTS	0.01	0.0	--	--
{41}	DO 1	OFF	--	--	--	ON	OFF
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	DO 3	OFF	--	--	--	ON	OFF
{44}	DO 4	OFF	--	--	--	ON	OFF
{45}	DO 5	OFF	--	--	--	ON	OFF

1. Points not listed are not used in this application.
2. A single value in a column means that the value is the same in English units and in SI units.
3. Point numbers that appear in brackets {} may be unbundled at the field panel.

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Table 2313-2. Point Database for Application 2313.

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{46}	FAN	OFF	--	--	--	ON	OFF
47	RAT HIH	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
48	RAT LOH	64.5 (18.13)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
49	RM HIH	68.0 (20.136)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
50	RM LOH	64.5 (18.176)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
51	HTG NEEDED	64.5 (18.13)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
52	CLG NEEDED	77.0 (25.13)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
53	LLIMIT	53.5 (12.016)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
{56}	SUPPLY TEMP	74.0 (23.496)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
59	DO DIR.REV	0	--	1	0	--	--
60	SHUTDN TIME	15	MIN	1	0	--	--
61	RECIRC TIME	15	MIN	1	0	--	--
62	OCC TIME	15	MIN	1	0	--	--
63	ALARM TIME	30	SEC	1	0	--	--
64	MIN ON	60	SEC	5	0	--	--
65	MIN OFF	60	SEC	5	0	--	--
66	HTG P GAIN	10.0	--	0.5	0.0	--	--
67	HTG I GAIN	0.01	--	0.002	0.0	--	--
{70}	MTR1 COMD	0.0	PCT	0.4	0.0	--	--
{71}	MTR1 POS	0.0	PCT	0.4	0.0	--	--
72	MTR1 TIMING	95	SEC	1	0	--	--
73	DPR1 ROT ANG	90	--	1	0	--	--
{74}	MTR2 COMD	0.0	PCT	0.4	0.0	--	--
{75}	MTR2 POS	0.0	PCT	0.4	0.0	--	--
76	MTR2 TIMING	95	SEC	1	0	--	--
77	DPR2 ROT ANG	90	--	1	0	--	--
78	MTR SETUP	0	--	1	0	--	--
80	CO2 RANGE	2000	PPM	1	0	--	--
81	TIME CLOCK	NO	--	--	--	YES	NO
{82}	PURGE OK	NO	--	--	--	YES	NO
{83}	REV VALVE	HEAT	--	--	--	COOL	HEAT
{84}	OA DAMPER	0.0	PCT	0.4	0.0	--	--
85	HTG STAGES	0	--	1	0	--	--
86	CLG STAGES	0	--	1	0	--	--
87	RV USED	NO	--	--	--	YES	NO

1. Points not listed are not used in this application.
2. A single value in a column means that the value is the same in English units and in SI units.
3. Point numbers that appear in brackets {} may be unbundled at the field panel.

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Table 2313-2. Point Database for Application 2313.

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
88	CO2 SEN USED	NO	--	--	--	YES	NO
89	CO2 HI	2500	PPM	10	0	--	--
90	CO2 LO	1000	PPM	10	0	--	--
91	OA DPR HI	25.2	PCT	0.4	0.0	--	--
92	OA DPR LO	10.0	PCT	0.4	0.0	--	--
{94}	CAL DPR	NO	--	--	--	YES	NO
{95}	RM STPT DIAL	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
96	CAL TIMER	12	HOURS	1	0	--	--
97	DPR MIN POS	20.0	PCT	0.4	0.0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--

1. Points not listed are not used in this application.
2. A single value in a column means that the value is the same in English units and in SI units.
3. Point numbers that appear in brackets {} may be unbundled at the field panel.