Application 2141: Variable Air Volume Pressure Dependent with Hot Water Reheat and Secure Mode

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Overview

In Application 2141, the controller modulates the supply air damper of the terminal box for cooling and modulates a reheat valve(s) for heating. When in heating, minimum airflow (limited by a mechanical stop on the terminal box) is provided to the room. In order for the terminal box to work properly, the central air-handling unit must provide cool supply air. See Figure 2141-1 and Figure 2141-2.

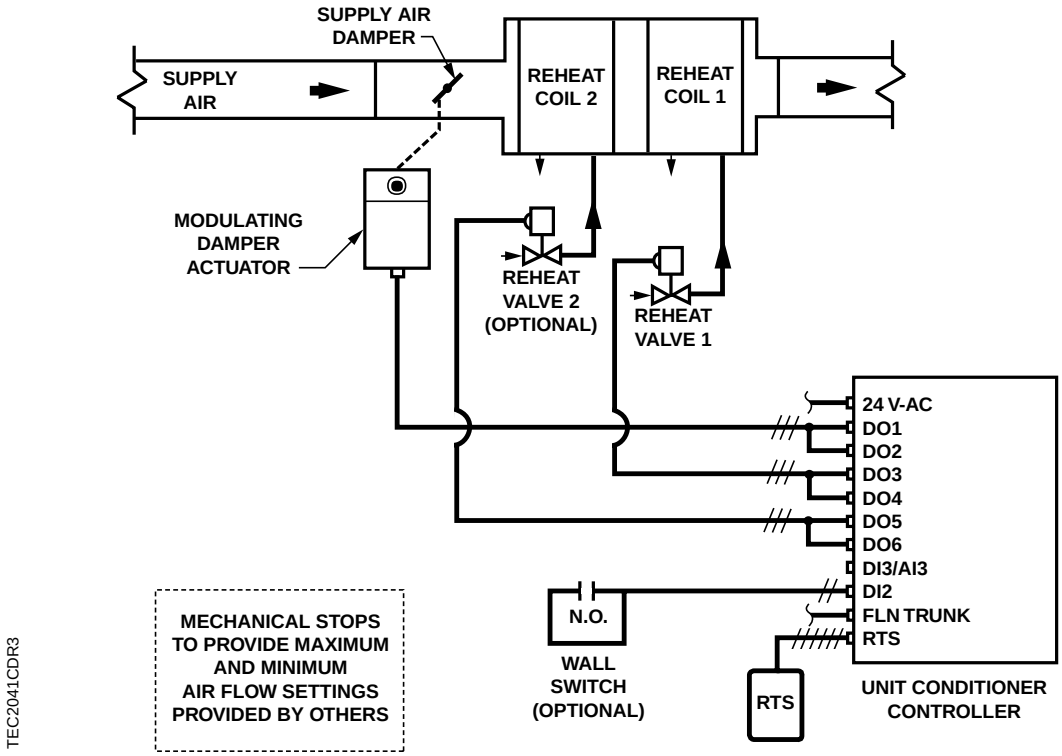
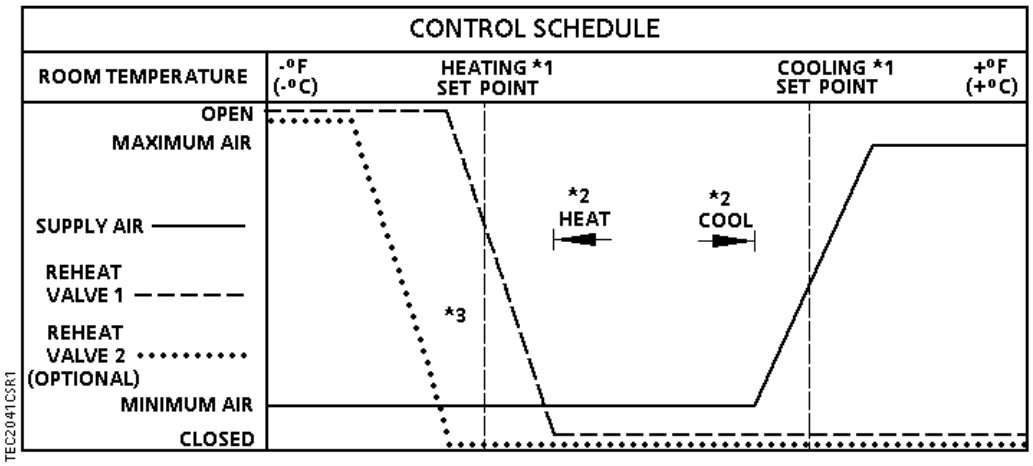


Figure 2141-1. Application 2141 Control Drawing.



1. See *Sequence of Operation, Control Temperature Setpoints.*
2. See *Sequence of Operation, Heating/Cooling Switchover*.
3. The reheat valves are shown operating sequenced (optional). The reheat valves can operate sequenced, parallel, or overlapping with each other (optional). See *Sequencing Logic*.

Figure 2141-2. Application 2141 Control Schedule.

Hardware Inputs

Analog

- Room temperature sensor
- Room temperature setpoint dial (optional)

Digital

- Night mode override (optional)
- Wall switch (optional)

Hardware Outputs

Analog

- None

Digital

- Damper actuator
- 1st valve actuator (required)
- 2nd valve actuator (optional)

Ordering Notes

Unit Conditioner Controller – Electronic Output with Secure Mode 540-110C

See *APOGEE Automation Configuration and Sizing Guidelines* on InfoLink for product numbers.

Damper actuator
Terminal Equipment Controller room temperature sensor
1st valve actuator (required)
2nd valve actuator (optional)

Point Database

Table 2141-1 presents the point database information for Application 2141.

Secure Mode Operation

Secure Mode prevents unauthorized users from making changes to the TEC through the MMI port or room sensor. This mode can only be enabled/disabled through an Insight command. When Secure Mode is enabled, any attempts to make point changes in the TEC will be rejected and result in an error message indicating that the priority is too low.

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2141, “Variable Air Volume Pressure Dependent with Hot Water Reheat and Secure Mode”.

Control Temperature Setpoints

Depending on the controller’s current operational mode (day or night), CTL STPT (Point 92) holds the value of one of the following setpoints:

Day Mode – CTL STPT holds the value of DAY CLG STPT (Point 6) or DAY HTG STPT (Point 7). If the room temperature sensor has a setpoint dial and STPT DIAL (Point 14) = YES, CTL STPT holds the value of RM STPT DIAL (Point 13).

If the setpoint dial is used and RM STPT DIAL < RM STPT MIN (Point 11), CTL STPT holds the value of RM STPT MIN. If RM STPT DIAL > RM STPT MAX (Point 12), CTL STPT holds the value of RM STPT MAX.

Night Mode – CTL STPT holds the value of NGT CLG STPT (Point 8) or NGT HTG STPT (Point 9).

Room Temperature Offset

Room Temperature Offset, RMTMP OFFSET (Point 3), is a user-adjustable offset that will compensate for deviations between the value of ROOM TEMP (Point 4) and the actual room temperature. This corrected value is displayed in CTL TEMP (Point 78).

CTL TEMP (Point 78) = ROOM TEMP (Point 4) + RMTMP OFFSET (Point 3).

Day and Night Modes

The day/night status of the space is determined by the status of DAY.NGT (Point 29). The control of this point differs depending on whether the controller is monitoring the status of a wall switch or if the controller is connected to a field panel.

When a wall switch is physically connected to the termination strip on the controller at DI 2 (Figure 2141-1 and Figure 2141-4), and WALL SWITCH (Point 18) = YES, the controller monitors DI 2. When the status of DI 2 (Point 24) is ON (the switch is closed), DAY.NGT will be set to DAY, indicating that the controller is in day mode. When the status of DI 2 is OFF (the switch is open), DAY.NGT will be set to NIGHT indicating that the controller is in night mode.

When WALL SWITCH = NO, the controller does not monitor the status of the wall switch, even if one is connected to it. In this case, the controller is operating stand-alone and stays in day mode all the time. If the controller is operating with centralized control, connected to a field panel, the field panel can send an operator or PPCL command to override the status of DAY.NGT. See *APOGEE Powers Process Control Language (PPCL) User's Manual* (125-1896) and *APOGEE Field Panel User's Manual* (125-3000) for more information.

Night Mode Override Switch

If an override switch is present on the room temperature sensor and a value (in hours) other than zero has been entered into OVRD TIME (Point 20), pressing the override switch will reset the controller to day mode for the amount of time set in OVRD TIME. The status of NGT OVRD (Point 21) changes to DAY. After the override time elapses, the controller returns to night mode and NGT OVRD changes back to NIGHT.

The override switch on the room temperature sensor will only affect the controller when in night mode.

Heating/Cooling Switchover

The heating/cooling switchover determines whether the controller is in heating or cooling mode by monitoring the room temperature and the demand for heating and cooling (as determined by the temperature control loops).

If the following conditions are met for the length of time set in SWITCH TIME (Point 86), the controller switches from heating to cooling mode by setting HEAT.COOL (Point 5) to COOL:

- HTG LOOPOUT (Point 80) < SWITCH LIMIT (Point 85).
- CTL TEMP (Point 78) > CTL STPT (Point 92) by at least the value set in SWITCH DBAND (Point 90).
- CTL TEMP > the appropriate cooling setpoint minus SWITCH DBAND.

If the following conditions are met for the length of time set in SWITCH TIME, the controller switches from cooling to heating mode by setting HEAT.COOL to HEAT:

- CLG LOOPOUT (Point 79) < SWITCH LIMIT.
- CTL TEMP < CTL STPT by at least the value set in SWITCH DBAND.
- CTL TEMP < the appropriate heating setpoint plus SWITCH DBAND.

Control Loops

The unit conditioner is controlled by two Proportional, Integral, and Derivative (PID) temperature loops.

Temperature Loops – The two temperature loops are a cooling loop and a heating loop. The active temperature loop maintains room temperature at the value in CTL STPT (Point 92). See *Sequence of Operation, Control Temperature Setpoints*.

Cooling Operation

In cooling mode, the controller uses CTL STPT (Point 92) and CTL TEMP (Point 78) as inputs for the cooling loop. The central air-handling unit must provide cool supply air. The output of the cooling loop is CLG LOOPOUT (Point 79), which modulates the supply air damper, DMPR COMD (Point 48). HTG LOOPOUT (Point 80) is set to 0%.

Heating Operation

In heating mode, the controller uses CTL STPT (Point 92) and CTL TEMP (Point 78) as inputs for the heating loop. The output of the heating loop is HTG LOOPOUT (Point 80), which modulates the hot water reheat. CLG LOOPOUT (Point 79) is set to 0%.

Hot Water Reheat

The heating loop modulates the heating valve(s) in order to warm-up the space as follows:

- If there is only one heating valve, VALVE CNT (Point 88) = 1. The position of the heating valve, point VLV 1 COMD (Point 52), is calculated using the following formula:

  (HTG LOOPOUT – VLV 1 START) ÷ (VLV 1 END – VLV 1 START) × 100%, limited between 0 and 100%.

  As the demand for heating rises, the valve will begin opening when HTG LOOPOUT (Point 80) rises above VLV 1 START (Point 16), and will be fully open when HTG LOOPOUT reaches VLV 1 END (Point 17). VLV 2 COMD (Point 37) will not be used.

- If there are two heating valves, VALVE CNT = 2. The position of the first heating valve, VLV 1 COMD, is calculated as above. Similarly, the position of the second heating valve, VLV 2 COMD, is calculated using the following formula:

  (HTG LOOPOUT – VLV 2 START) ÷ (VLV 2 END – VLV 2 START) × 100%, limited between 0 and 100%.

  As the demand for heating rises, the second valve will begin opening when HTG LOOPOUT rises above VLV 2 START (Point 22), and will be fully open when HTG LOOPOUT reaches VLV 2 END (Point 23). See *Sequencing Logic* for information on how the two heating valves can be sequenced.

NOTE: If a valve's start and end point values are set to the same value, the valve will not be used.

Sequencing Logic (optional)

In heating mode, this application includes logic that allows two heating valves to operate in sequence, parallel, or overlapping. This algorithm is very similar to the spring range sequencing of valves and dampers. Portions of the output of the heating loop, point HTG LOOPOUT (Point 80), will drive the two heating valves from 0 to 100%. See the following three examples. The ladder diagrams in Figure 2141-3 show sequenced, parallel, and overlapping valve operations. The vertical bars show the output of heating loopout from 0 to 100%. The horizontal bars (valve 1 start, valve 1 end, etc.) show the action that occurs when the loop output rises above the horizontal bar. The relative positions shown on the graphs are for illustration purposes only and may differ from the examples.

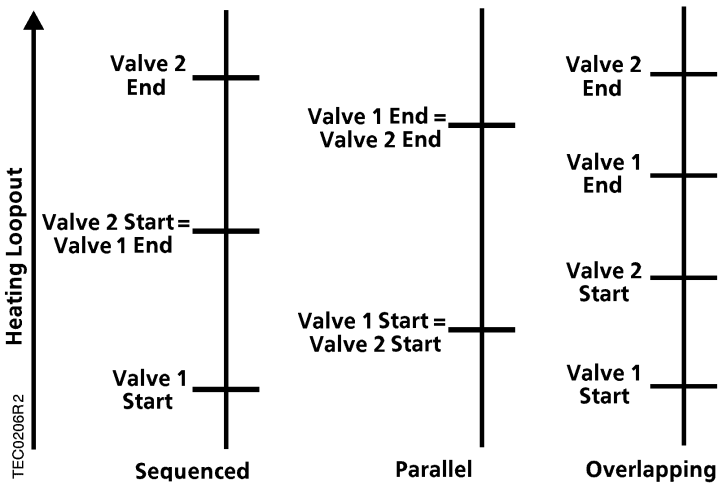


Figure 2141-3. Sequenced, Parallel, and Overlapping Loop Operations with Hot Water Reheat.

Example 1

Assume that your system has two hot water valves that are to operate in *sequence*. If:

- VLV 1 START (Point 16) = 0%
- VLV 1 END (Point 17) = 50%
- VLV 2 START (Point 22) = 50%
- VLV 2 END (Point 23) = 100%

then,

- When HTG LOOPOUT = 0%, VLV 1 COMD (Point 52) will equal 0% open and VLV 2 COMD (Point 37) will equal 0% open.
- When HTG LOOPOUT = 25%, VLV 1 COMD will equal 50% open and VLV 2 COMD will equal 0% open.
- When HTG LOOPOUT = 50%, VLV 1 COMD will equal 100% open and VLV 2 COMD will equal 0% open.
- When HTG LOOPOUT = 75%, VLV 1 COMD will equal 100% open and VLV 2 COMD will equal 50% open.
- When HTG LOOPOUT = 100%, VLV 1 COMD will equal 100% open and VLV 2 COMD will equal 100% open.

Example 2

Assume that your system has two hot water valves that are to operate in *parallel*. If:

- VLV 1 START = 0%
- VLV 1 END = 100%
- VLV 2 START = 0%
- VLV 2 END = 100%

then,

- When HTG LOOPOUT = 0%, VLV 1 COMD and VLV 2 COMD will equal 0% open.
- When HTG LOOPOUT = 50%, VLV 1 COMD and VLV 2 COMD will equal 50% open.
- When HTG LOOPOUT = 100%, VLV 1 COMD and VLV 2 COMD will equal 100% open.

Example 3

Assume that your system has two hot water valves that are to operate *overlapping*. If:

- VLV 1 START = 0%
- VLV 1 END = 75%
- VLV 2 START = 25%
- VLV 2 END = 100%

then,

- When HTG LOOPOUT = 0%, VLV 1 COMD and VLV 2 COMD will equal 0% open.
- When HTG LOOPOUT = 37.5%, VLV 1 COMD will equal 50% open and VLV 2 COMD will equal 17% open.
- When HTG LOOPOUT = 62.5%, VLV 1 COMD will equal 83% open and VLV 2 COMD will equal 50% open.
- When HTG LOOPOUT = 100%, VLV 1 COMD and VLV 2 COMD will equal 100% open.

Calibration

The controller regularly calibrates the damper and the valve(s) based on the value of CAL TIMER (Point 96). A value of 12 indicates that the controller will calibrate the actuators once every 12 hours.

The calibration consists of driving the damper and the valve(s) closed, and then resetting the values of DMPR POS (Point 49) and VLV 1 POS (Point 53) to 0. If a second valve is used, VLV 2 POS (Point 38) is also set to zero. The actuators are then released to normal control.

NOTE: If mechanical stops are installed to provide minimum airflow, the damper cannot be correctly calibrated.

Fail-Safe Operation

If the room temperature sensor fails, the controller operates using the last known temperature value.

Application Notes

1. If temperature swings in the room are excessive or there is trouble maintaining the setpoint, the cooling loop, the heating loop, or both need to be tuned. See *iKnow Troubleshooting Tool* for more information.
2. The Unit Conditioner Controller – Electronic Output, as shipped from the factory, keeps all associated equipment OFF. See the *Equipment Controllers* section in the *APOGEE Automation Start-up Procedures* on InfoLink for information on how to release the controller and its equipment to application control.
3. Spare DOs can be used as auxiliary points that are controlled by the field panel after being defined in the field panel's database. If a second heating valve is not being controlled by the application, DO 5 and DO 6 may be used as auxiliary motor points. If using the pair of spare DOs to control a motor, you must make sure that the motor setup, motor timing, and motor rotation angle are enabled correctly before you unbundle VLV 2 COMD (Point 37). See *APOGEE Automation Start-up Procedures* on InfoLink for more information.

Wiring Diagram

The point wiring for Application 2141 is shown in Figure 2141-4.

CAUTION:

The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. Use an interposing 220V 4-relay module for any of the following:

- VA requirements higher than the maximum
- 110 or 220 Vac requirements
- DC power requirements
- Separate transformers used to power the load

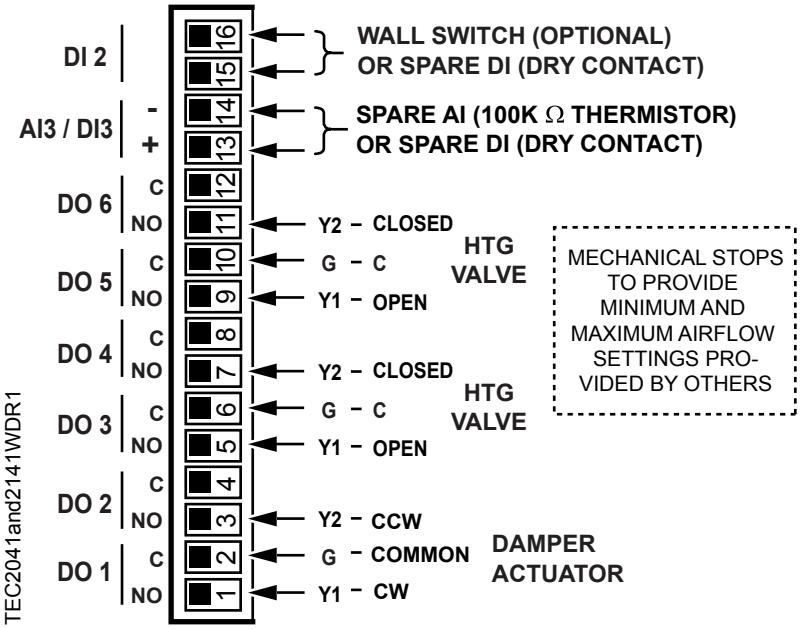


Figure 2141-4. Application 2141 Wiring Diagram.

Table 2141-1. Point Database for Application 2127

Point Number	Descriptor	Factory Default (SI Units)	Eng. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
01	CTLR ADDRESS	99	–	1	0	–	–
02	APPLICATION	2188	–	1	0	–	–
03	RMTMP OFFSET	0.0 (0.0)	DEG F (DEG C)	0.25 (0.14)	-31.75 (-17.78)	–	–
{04}	ROOM TEMP	74.0 (23.449)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
{05}	HEAT.COOL	COOL	–	–	–	HEAT	COOL
06	DAY CLG STPT	74.0 (23.449)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
07	DAY HTG STPT	70.0 (21.209)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
08	NGT CLG STPT	82.0 (27.929)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
09	NGT HTG STPT	65.0 (18.409)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
11	RM STPT MIN	55.0 (12.809)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
12	RM STPT MAX	90.0 (32.409)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
{13}	RM STPT DIAL	74.0 (23.449)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
14	STPT DIAL	NO	–	–	–	YES	NO
{15}	AUX TEMP	74.0 (23.496)	DEG F (DEG C)	0.5 (0.28)	37.5 (3.056)	–	–
16	VLV 1 START	0.0	PCT	0.4	0.0	–	–
17	VLV 1 END	100.0	PCT	0.4	0.0	–	–
18	WALL SWITCH	NO	–	–	–	YES	NO
{19}	DI OVRD SW	OFF	–	–	–	ON	OFF
20	OVRD TIME	0	HRS	1	0	–	–
{21}	NGT OVRD	NIGHT	–	–	–	NIGHT	DAY
22	VLV 2 START	0.0	PCT	0.4	0.0	–	–
23	VLV 2 END	0.0	PCT	0.4	0.0	–	–
{24}	DI 2	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 2141-1. Point Database for Application 2127

Point Number	Descriptor	Factory Default (SI Units)	Eng. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{25}	DI 3	OFF	–	–	–	ON	OFF
{29}	DAY.NGT	DAY	–	–	–	NIGHT	DAY
{37}	VLV 2 COMD	0.0	PCT	0.4	0.0	–	–
{38}	VLV 2 POS	0.0	PCT	0.4	0.0	–	–
39	MTR 3 TIMING	130	SEC	1	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
{46}	DO 6	OFF	–	–	–	ON	OFF
{48}	DMPR COMD	0.0	PCT	0.4	0.0	–	–
{49}	DMPR POS	0.0	PCT	0.4	0.0	–	–
51	MTR 1 TIMING	130	SEC	1	0	–	–
{52}	VLV 1 COMD	0.0	PCT	0.4	0.0	–	–
{53}	VLV 1 POS	0.0	PCT	0.4	0.0	–	–
55	MTR 2 TIMING	130	SEC	1	0	–	–
56	MTR1 ROT ANG	90	–	1	0	–	–
57	MTR2 ROT ANG	90	–	1	0	–	–
58	MTR SETUP	0	–	1	0	–	–
59	DO DIR. REV	0	–	1	0	–	–
63	CLG P GAIN	20.0 (36.0)	–	0.25 (0.45)	0.0	–	–
64	CLG I GAIN	0.01 (0.018)	–	0.001 (0.0018)	0.0	–	–
65	CLG D GAIN	0 (0.0)	–	2 (3.6)	0	–	–
66	CLG BIAS	0.0	PCT	0.4	0.0	–	–
67	HTG P GAIN	10.0 (18.0)	–	0.25 (0.45)	0.0	–	–

1. Points not listed are not used in this application.
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3. Point numbers that appear in brackets { } may be unbundled at the field panel.

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Table 2141-1. Point Database for Application 2127

Point Number	Descriptor	Factory Default (SI Units)	Eng. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
68	HTG I GAIN	0.01 (0.018)	–	0.001 (0.0018)	0.0	–	–
69	HTG D GAIN	0 (0.0)	–	2 (3.6)	0	–	–
70	HTG BIAS	0.0	PCT	0.4	0.0	–	–
{78}	CTL TEMP	74.0 (23.449)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
{79}	CLG LOOPOUT	0.0	PCT	0.4	0.0	–	–
{80}	HTG LOOPOUT	0.0	PCT	0.4	0.0	–	–
85	SWITCH LIMIT	5.2	PCT	0.4	0.0	–	–
86	SWITCH TIME	10	MIN	1	0	–	–
88	VALVE CNT	1	–	1	0	–	–
90	SWITCH DBAND	1.0 (0.56)	DEG F (DEG C)	0.25 (0.14)	0.0	–	–
{92}	CTL STPT	74.0 (23.449)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.889)	–	–
96	CAL TIMER	12	HRS	1	0	–	–
98	LOOP TIME	5	SEC	1	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.