Application 2371 VAV with Auxiliary Duct/Space Temperature Sensor, Cooling or Heating

Overview

In Application 2371, the controller modulates the supply air damper of the terminal box for cooling and heating. Duct or space temperature is controlled using a 100K Ω thermistor on AI 3. In order for it to work properly, the central air handling unit must provide cool supply air in cooling mode and warm air in heating mode. Refer to Figures 2371-1 and 2371-2.

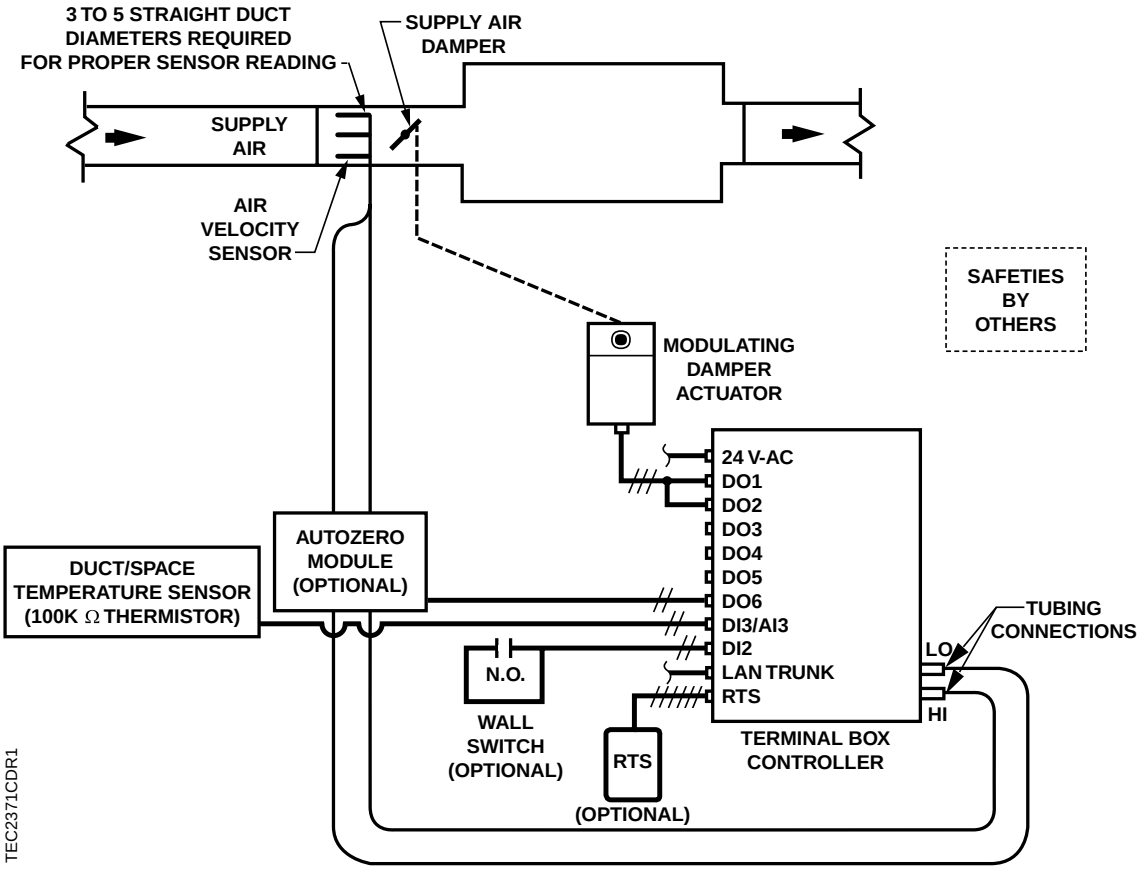
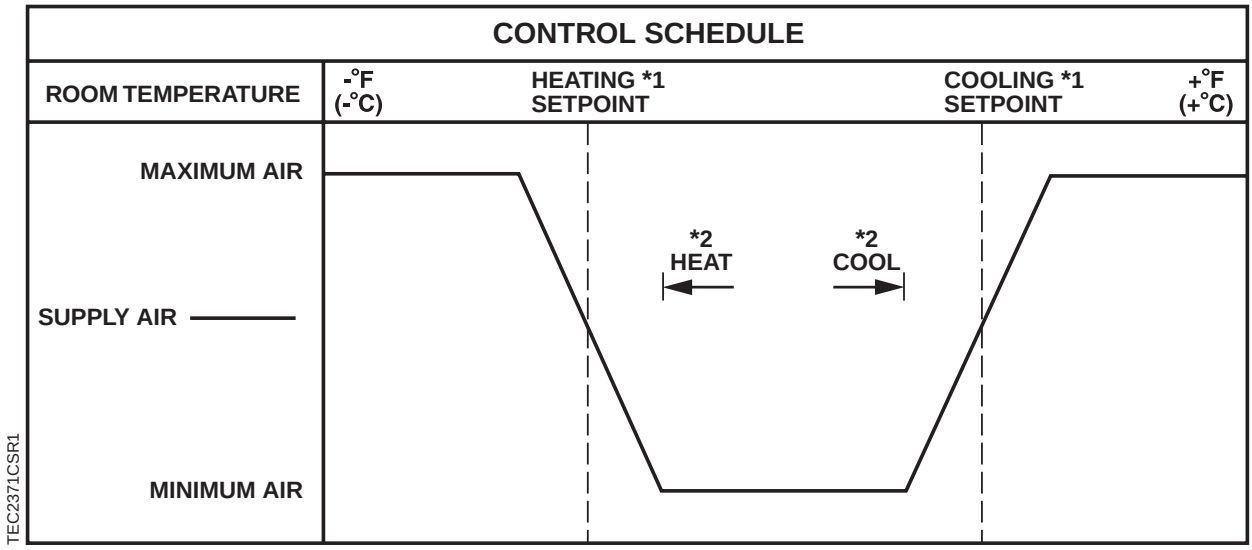


Figure 2371-1. Application 2371 Control Drawing.



*1 Refer to Sequence of Operation, “Control Temperature Set Points.”
*2 Refer to Sequence of Operation, “Heating/Cooling Switchover.”

Figure 2371-2. Application 2371 Control Schedule.

Hardware inputs

analog

- air velocity sensor
- duct/space temperature sensor (100K Ω thermistor)
- room temperature sensor (optional, for monitoring only)
- room temperature set point dial (optional, for monitoring only)

digital

- night mode override (optional)
- wall switch (optional)

Hardware outputs

analog

- none

digital

- Autozero Module (optional)
- damper actuator

Point database

Table 2371-1 presents the point database information for Application 2371. Each point number is represented on a line in the point database table.

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2371, “VAV with Auxiliary Duct/Space Temperature Sensor, Cooling or Heating.”

Control temperature set points

Depending on the controller's current operational mode (day or night), the control temperature set point, CTL STPT (number 92) holds the value of one of the following set points:

Day Mode – In day mode, CTL STPT holds the value of the point DAY CLG STPT (number 6).

Night Mode – In night mode, CTL STPT holds the value of the point NGT CLG STPT (number 8).

NOTE: The value of the point CTL TEMP (number 78) is the same as the value of the point ROOM TEMP (number 15), unless CTL TEMP is overridden.

Day and night modes

The day/night status of the space is determined by the value of the point DAY.NGT (number 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 (Figures 2371-1 and 2371-3) and the point WALL SWITCH (number 18) equals YES, the controller monitors the point DI 2 (number 24). When the value of DI 2 is ON (the switch is closed), then 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), then DAY.NGT will be set to NIGHT indicating that the controller is in night mode.

When WALL SWITCH equals NO, the controller does not monitor the status of the wall switch, even if one is connected to it. In this case, if the controller is operating stand-alone, then the controller stays in day mode all the time. If the controller is operating with centralized control (that is, it is connected to a field panel), then the field panel can send an operator or PPCL command to override the status of DAY.NGT. Refer to *Powers Process Control Language (PPCL) User’s Manual* (125-1896) and *Field Panel User’s Manual* (125-1895) for more information.

Night mode override switch

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

Only when the controller is in night mode will the override switch on the room temperature sensor have any effect on the controller.

Heating/cooling switchover

If the controller is connected to a field panel, then the field panel can switch the controller between heating and cooling modes by commanding HEAT.COOL to HEAT or COOL. Otherwise, the mode will not change.

Control loops

The terminal box is controlled by three Proportional, Integral, and Derivative (PID) control loops; two temperature loops and a flow loop.

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 the point CTL STPT (number 92). Refer to *Control Temperature Set Points*.

The cooling temperature loop generates cooling loopout which is then used to generate the point FLOW STPT (number 93). FLOW STPT is the result of scaling the cooling loopout to the appropriate range of values determined by the points CLG FLOW MIN (number 31) and CLG FLOW MAX (number 32). In order to scale it, the loopout is multiplied by the range (MAX – MIN) and then added to the minimum set point.

When CLG FLOW MIN does not equal 0 CFM, then FLOW STPT does not equal the point CLG LOOPOUT (number 79). The minimum flow set point is (CLG FLOW MIN ÷ CLG FLOW MAX) × 100% flow. FLOW STPT is [CLG LOOPOUT × (100% – minimum set point)] + minimum set point.

Examples:

If CLG FLOW MIN = 200 CFM, and CLG FLOW MAX = 1000 CFM,

then, the minimum flow set point is
(200 CFM ÷ 1000 CFM) × 100% flow = 20%

When CLG LOOPOUT is 0%, FLOW STPT equals 20% flow.
[0% × (100% – 20%)] + 20% = 20%
This ensures that the airflow out of the terminal box is no less than CLG FLOW MIN.

When CLG LOOPOUT is 50%, FLOW STPT equals 60% flow.
[50% × (100% – 20%)] + 20% = 60%

When CLG LOOPOUT is 100%, FLOW STPT equals 100% flow.
[100% × (100% – 20%)] + 20% = 100%

The heating temperature loop generates heating loopout which is then used to generate the FLOW STPT. FLOW STPT is the result of scaling the heating loopout to the appropriate range of values determined by the points HTG FLOW MIN (number 33) and HTG FLOW MAX (number 34). In order to scale it, the loopout is multiplied by the range (MAX – MIN) and then added to the minimum set point.

When HTG FLOW MIN does not equal 0 CFM, then FLOW STPT does not equal the point HTG LOOPOUT (number 80). The minimum flow set point is (HTG FLOW MIN ÷ HTG FLOW MAX) × 100% flow. FLOW STPT is [HTG LOOPOUT × (100% – minimum set point)] + minimum set point.

For example:

If HTG FLOW MIN = 100 CFM, and HTG FLOW MAX = 1000 CFM,

then, the minimum flow set point is
(100 CFM ÷ 1000 CFM) × 100% flow = 10%

When HTG LOOPOUT is 0%, FLOW STPT equals 10% flow.
[0% × (100% – 10%)] + 10% = 10%
This ensures that the airflow out of the terminal box is no less than HTG FLOW MIN.

When HTG LOOPOUT is 50%, FLOW STPT equals 55% flow.
[50% × (100% – 10%)] + 10% = 55%

When HTG LOOPOUT is 100%, FLOW STPT equals 100% flow.
[100% × (100% – 10%)] + 10% = 100%

Flow Loop – The flow loop maintains minimum airflow and maximum airflow through the points CTL FLOW MIN (number 76) and CTL FLOW MAX (number 77).

When the controller is in cooling mode, CTL FLOW MIN equals CLG FLOW MIN and CTL FLOW MAX equals CLG FLOW MAX.

When the controller is in heating mode, CTL FLOW MIN equals HTG FLOW MIN and CTL FLOW MAX equals HTG FLOW MAX.

In Application 2371, you can set CLG FLOW MIN equal to, but not greater than, CLG FLOW MAX and set HTG FLOW MIN equal to, but not greater than, HTG FLOW MAX. If the minimum and maximum values are set equal, then the flow loop becomes a constant volume loop and its ability to control temperature is lost.

The flow loop maintains FLOW STPT by modulating the supply air damper point, DMPR COMD (number 48). The flow loop maintains the airflow between CTL FLOW MIN and CTL FLOW MAX.

The point FLOW (number 75) is the input value for the flow loop. It is calculated as a percentage based on where the point AIR VOLUME (number 35) is between 0 CFM and CTL FLOW MAX. In the following text, this percentage will be referred to as % flow.

- If AIR VOLUME equals 0 CFM, then FLOW is 0% flow.
- If AIR VOLUME equals CTL FLOW MAX, then FLOW is 100% flow.

The low limit of FLOW STPT will be the percentage that corresponds to the volume given in CTL FLOW MIN. This percentage can be calculated as: (CTL FLOW MIN ÷ CTL FLOW MAX) × 100% flow. The flow loop ensures that the supply air will not be less than CTL FLOW MIN.

Example:

If CTL FLOW MIN equals 250 CFM, and if CTL FLOW MAX equals 1000 CFM,

then,

the low limit of FLOW STPT = (250 CFM ÷ 1000 CFM) × 100% flow
= 0.25 × 100% flow
= 25% flow

Since 25% of 1000 CFM equals 250 CFM, the minimum airflow out of the terminal box will be 250 CFM.

Calibration

Calibration of the controller's internal air velocity transducers is periodically required to maintain accurate air velocity readings. The point CAL SETUP (number 95) is set with the desired calibration option during controller start-up. Depending upon the value of CAL SETUP, calibration may be set to take place automatically or manually. If the status of the point CAL AIR (number 94) is YES, then calibration is in progress.

- For a controller used without an Autozero Module (point CAL MODULE, (number 87) = NO), the damper is commanded closed to get a zero airflow reading during calibration.
- For a controller used with an Autozero Module (CAL MODULE = YES), calibration occurs without closing the damper.

At the end of a calibration sequence, CAL AIR returns to NO automatically. A status of NO indicates that the controller is not in a calibration sequence.

Damper status operation

Under normal operation the point DMPR STATUS (number 84) reads “CAL.” However, if using an Autozero Module, it is possible after a period of operation for the calculated damper position point, DMPR POS (number 49), to differ from the actual (physical) damper position.

If this occurs, the controller will automatically compensate for any difference by setting DMPR STATUS to “RECAL” which readjusts the value of DMPR POS. DMPR STATUS will be set to “RECAL” if all of the following conditions are true:

DMPR POS = 100%
AIR VOLUME (number 35) > 0 CFM
FLOW (number 75)< FLOW STPT (number 93)

-or-

DMPR POS = 0%
AIR VOLUME > 0 CFM
FLOW > FLOW STPT

NOTE: To change the value of DMPR STATUS from “RECAL” back to “CAL”, set DMPR STATUS to CAL, and then release it.

The Autozero Module is enabled when it is wired to DO 6 and the point CAL MODULE (number 87) is set to YES.

Fail-safe operation

If the air velocity sensor fails, then the controller uses pressure dependent control. The temperature loop controls the operation of the damper.

If the duct/space temperature sensor (AI 3) fails, then the controller operates using the last known temperature value.

Application notes

1. If the temperature swings in the room are excessive or if there is trouble in maintaining the set point, then the cooling loop, the heating loop, or both need to be tuned. If the point FLOW (number 75) is oscillating while the point FLOW STPT (number 93) is constant, then the flow loop requires tuning. Refer to *APOGEE Automation Service Procedures Manual* (125-3013) for more information.

2. The Terminal Box Controller with Auxiliary Duct/Space Temperature Sensor, Cooling or Heating – Electronic Output, as shipped from the factory, keeps all associated equipment OFF. Refer to the Start-up document for this controller 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. DO 3 and DO 4 or DO 5 and DO 6 may be used as auxiliary motor points. If using a pair of spare DOs to control a motor, you must unbundle the corresponding motor command point.

Wiring diagrams

The point wiring for Application 2371 is shown in Figure 2371-3.

CAUTION:

The Controller's Digital Outputs (Dos) control 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 (P/N 540-147).

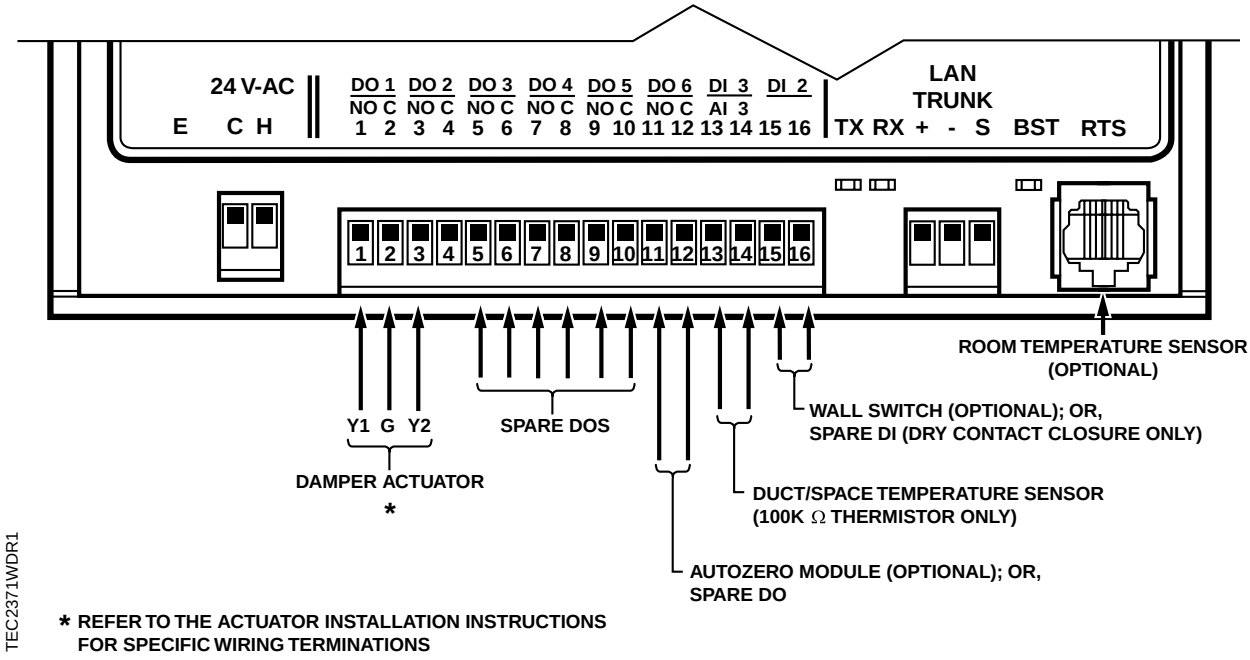


Figure 2371-3. Application 2371 Wiring Diagram.

Table 2371-1. Point Database for Application 2371.

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	2091	--	1	0	--	--
{04}	RTS TEMP	74.00 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48(8.88888)	--	--
{05}	HEAT.COOL	COOL	--	--	--	HEAT	COOL
06	DAY CLG STPT	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
07	DAY HTG STPT	70.0 (21.255556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
08	NGT CLG STPT	82.0 (27.975556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
09	NGT HTG STPT	65.0 (18.455556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
{13}	RTS STPT	74.00 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48(8.88888)	--	--
{15}	ROOM TEMP	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
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
{24}	DI 2	OFF	--	--	--	ON	OFF
{29}	DAY.NGT	DAY	--	--	--	NIGHT	DAY
31	CLG FLOW MIN	220 (103.8180)	CFM (LPS)	4 (1.8876)	0	--	--
32	CLG FLOW MAX	2200 (1038.1800)	CFM (LPS)	4 (1.8876)	0	--	--
33	HTG FLOW MIN	220 (103.8180)	CFM (LPS)	4 (1.8876)	0	--	--
34	HTG FLOW MAX	2200 (1038.1800)	CFM (LPS)	4 (1.8876)	0	--	--
{35}	AIR VOLUME	0 (0.0000)	CFM (LPS)	4 (1.8876)	0	--	--
36	FLOW COEFF	1.00	--	0.01	0	--	--
{37}	MTR3 COMD	0.0	PCT	0.4	0	--	--
{38}	MTR3 POS	0.0	PCT	0.4	0	--	--
39	MTR3 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	--	--
{49}	DMPR POS	0.0	PCT	0.4	0	--	--
51	MTR1 TIMING	95	SEC	1	0	--	--
{52}	MTR2 COMD	0.0	PCT	0.4	0	--	--
{53}	MTR2 POS	0.0	PCT	0.4	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.

Table 2371-1. Point Database for Application 2371.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
55	MTR2 TIMING	130	SEC	1	0	--	--
56	DMPR ROT ANG	90	--	1	0	--	--
58	MTR SETUP	0	--	1	0	--	--
59	DO DIR. REV	0	--	1	0	--	--
63	CLG P GAIN	20.00 (36.00)	--	0.25 (0.45)	0	--	--
64	CLG I GAIN	0.010 (0.0180)	--	0.001 (0.0018)	0	--	--
65	CLG D GAIN	0 (0.0)	--	2 (3.6)	0	--	--
66	CLG BIAS	0.0	PCT	0.4	0	--	--
67	HTG P GAIN	10.00 (18.00)	--	0.25 (0.45)	0	--	--
68	HTG I GAIN	0.010 (0.0180)	--	0.001 (0.0018)	0	--	--
69	HTG D GAIN	0 (0.0)	--	2 (3.6)	0	--	--
70	HTG BIAS	0.0	PCT	0.4	0	--	--
71	FLOW P GAIN	0.00	--	0.05	0	--	--
72	FLOW I GAIN	0.010	--	0.001	0	--	--
73	FLOW D GAIN	0	--	2	0	--	--
74	FLOW BIAS	50.0	PCT	0.4	0	--	--
{75}	FLOW	0.00	PCT	0.25	0	--	--
{76}	CTL FLOW MIN	220 (103.8180)	CFM (LPS)	4 (1.8876)	0	--	--
{77}	CTL FLOW MAX	2200 (1038.1800)	CFM (LPS)	4 (1.8876)	0	--	--
{78}	CTL TEMP	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
{79}	CLG LOOPOUT	0.0	PCT	0.4	0	--	--
{80}	HTG LOOPOUT	0.0	PCT	0.4	0	--	--
{84}	DMPR STATUS	CAL	--	--	--	RECAL	CAL
87	CAL MODULE	NO	--	--	--	YES	NO
{91}	TOTAL VOLUME	0 (0)	CF (L)	4 (113)	0	--	--
{92}	CTL STPT	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
{93}	FLOW STPT	0.00	PCT	0.25	0	--	--
{94}	CAL AIR	NO	--	--	--	YES	NO
95	CAL SETUP	4	--	1	0	--	--
96	CAL TIMER	12	HRS	1	0	--	--
97	DUCT AREA	1.000 (0.092920)	SQ. FT (SQ M)	0.025 (0.002323)	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.