TEC Custom Solutions Application 2421
VAV Cooling or Heating, Two-Inch Water Column Measurement Range — Electronic Output

This document contains the following topics:

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- Hardware inputs
- Hardware outputs
- Ordering notes
- Sequence of operation
  - Control temperature set points
  - Day and night modes
  - Night mode override switch
  - Heating/cooling switchover
  - Control loops
  - Calibration
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  - Fail-safe operation
- Application notes
- Wiring diagram
- Point database

Overview

In Application 2421, the controller modulates the supply air damper of the terminal box for cooling and heating. 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 2421-1 and 2421-2.

This Application will measure flows with differential pressure measurements up to 2 inches (up to a maximum of 5663 FPM).

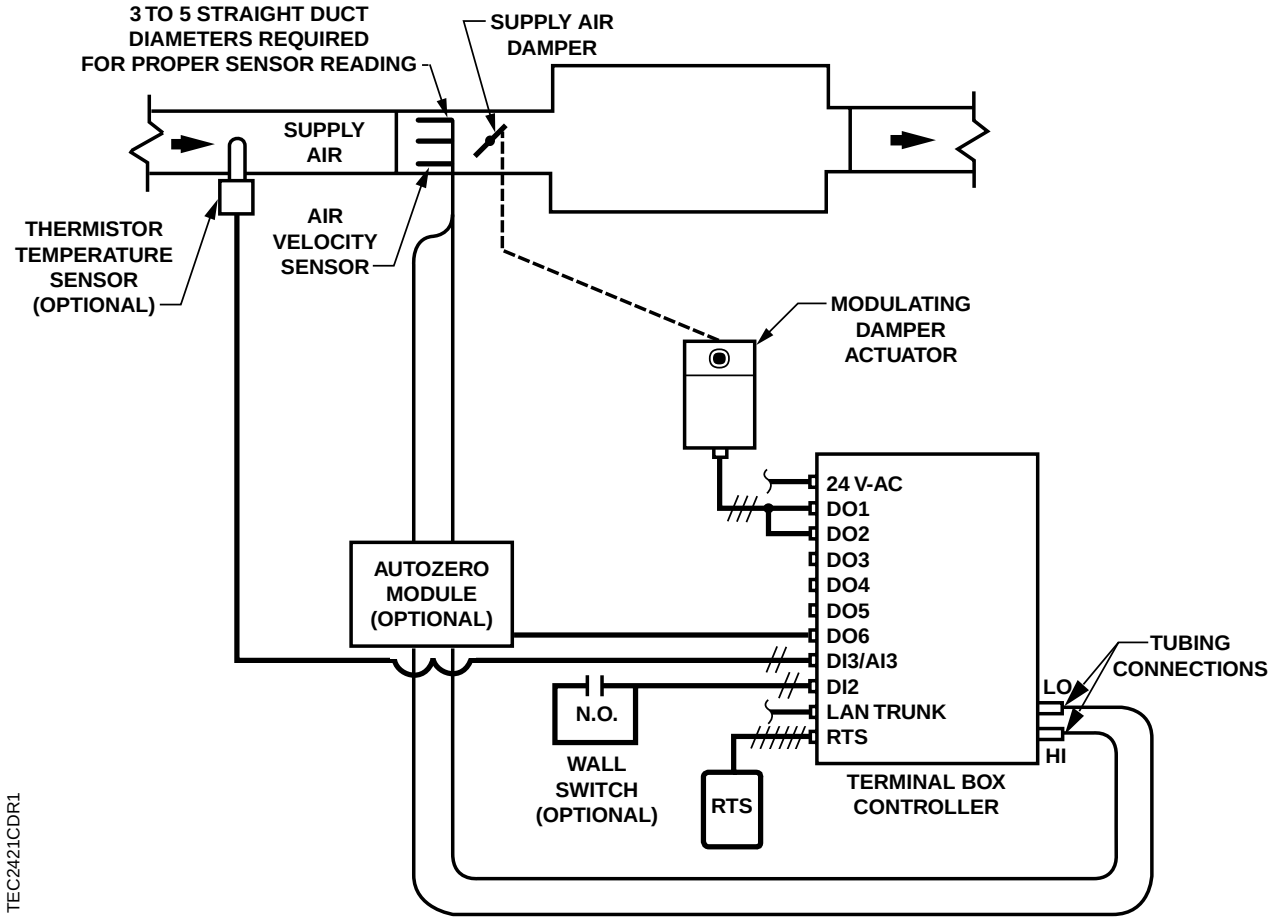
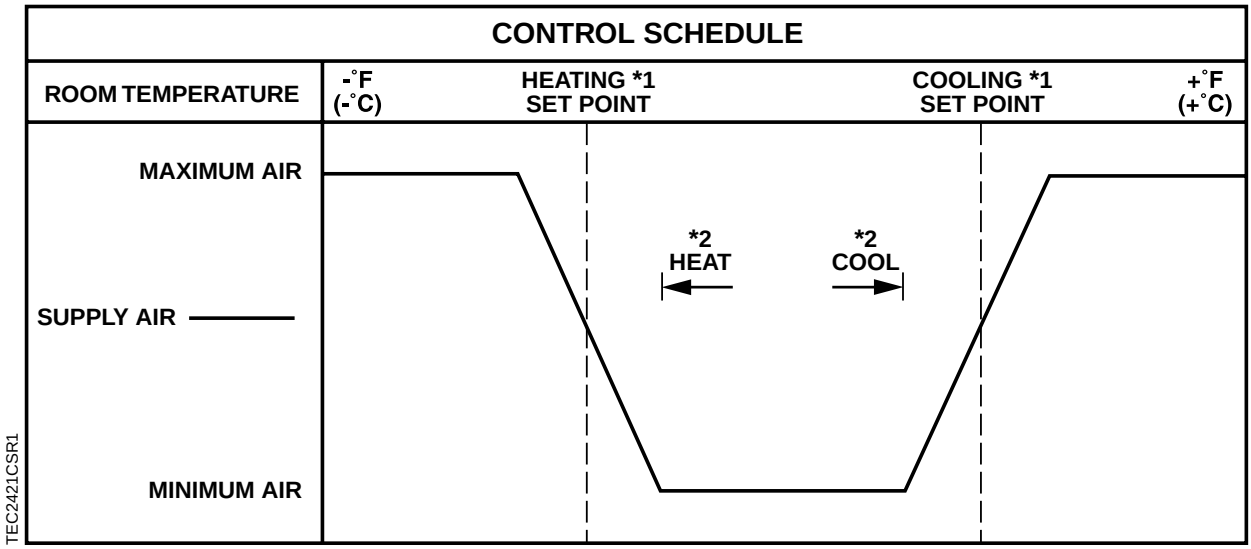


Figure 2421-1. Application 2421 Control Drawing.



1. Refer to the *Control Temperature Set Points* section.
2. Refer to the *Heating/Cooling Switchover* section.

Figure 2421-2. Application 2421 Control Schedule.

Hardware Inputs

Analog

- Air velocity sensor
- Duct temperature sensor (optional)
- Room temperature sensor
- Room temperature set point dial (optional)

Digital

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

Hardware Outputs

Analog

- None

Digital

- Autozero Module (optional)
- Damper actuator

Ordering Notes

Order Custom Solution number 246.

Point Database

Table 2421-1 presents the point database information for Application 2421.

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2421, “VAV Cooling or Heating, Two-Inch Water Column Measurement Range — Electronic Output.”

Control Temperature Set Points

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

Day Mode – In 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 set point dial and STPT DIAL (Point 14) is set to YES, then CTL STPT holds the value of RM STPT DIAL (Point 13).

If the set point dial is used and the value of RM STPT DIAL is less than the value of RM STPT MIN (Point 11), then CTL STPT holds the value of RM STPT MIN. If the value of RM STPT DIAL is greater than the value of RM STPT MAX (Point 12), then CTL STPT holds the value of RM STPT MAX.

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

NOTE: The value of CTL TEMP (Point 78) is the same as the value of ROOM TEMP (Point 4), unless CTL TEMP is overridden.

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 (Figures 2421-1 and 2421-3), and WALL SWITCH (Point 18) equals YES, the controller monitors the status of DI 2. When the status of DI 2 (Point 24) is ON (the switch is closed), DAY.NGT is 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 is 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, and 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 (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 the *Powers Process Control Language (PPCL) User’s Manual* (125-1896) and the *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 and a value (in hours) other than zero has been entered into OVRD TIME (Point 20), then by pressing the override switch a room occupant can reset the controller to day operational mode for the amount of time set in OVRD TIME. The status of NGT OVRD (Point 21) changes to DAY and remains there until the override time elapses, at which point 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 sensor have any effect on the controller.

Heating/Cooling Switchover

There are three options for the heating/cooling switchover. In order for the controller to function properly, one of the following three options must be used:

1. A temperature sensor is installed in the supply air ductwork. The controller uses the measured temperature point, SUPPLY TEMP (Point 15), to determine whether it is in heating or cooling mode.
   - When SUPPLY TEMP is below the value of the point COOL TEMP (Point 61), the controller sets the point HEAT.COOL (Point 5) to COOL, switching the controller to cooling mode.
   - When SUPPLY TEMP is above the value of the point HEAT TEMP (Point 62), the controller sets HEAT.COOL to HEAT, switching the controller to heating mode.
2. If the controller is connected to a field panel, then the field panel can command SUPPLY TEMP.
   - When SUPPLY TEMP is commanded below the value of COOL TEMP, the controller sets HEAT.COOL to COOL, switching the controller to cooling mode.
   - When SUPPLY TEMP is commanded above the value of HEAT TEMP, the controller sets HEAT.COOL to HEAT, switching the controller to heating mode.
3. 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.

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 CTL STPT (Point 92). Refer to the *Control Temperature Set Points* section.

The cooling temperature loop generates cooling loopout which is then used to generate FLOW STPT (Point 93). FLOW STPT is the result of scaling the cooling loopout to the appropriate range of values determined by CLG FLOW MIN (Point 31) and CLG FLOW MAX (Point 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, FLOW STPT does not equal CLG LOOPOUT (Point 79). The minimum flow set point is (CLG FLOW MIN ÷ CLG FLOW MAX) × 100% flow, and FLOW STPT is [CLG LOOPOUT × (100% – minimum set point)] + minimum set point.

For example:

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 from 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 FLOW STPT (Point 93). FLOW STPT is the result of scaling the heating loopout to the appropriate range of values determined by HTG FLOW MIN (Point 33) and HTG FLOW MAX (Point 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, FLOW STPT does not equal HTG LOOPOUT (Point 80). The minimum flow set point is (HTG FLOW MIN ÷ HTG FLOW MAX) × 100% flow, and 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 using CTL FLOW MIN (Point 76) and CTL FLOW MAX (Point 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 2421, 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 (Point 48). The flow loop maintains the airflow between CTL FLOW MIN and CTL FLOW MAX.

FLOW (Point 75) is the input value for the flow loop. It is calculated as a percentage based on where AIR VOLUME (Point 35) is between 0 CFM and CTL FLOW MAX. In the following text, this percentage is 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 is 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 is not less than CTL FLOW MIN.

For example:

If CTL FLOW MIN equals 250 CFM and if CTL FLOW MAX equals 1000 CFM, then the low limit of FLOW STPT equals:

(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 is 250 CFM.

Calibration

Calibration of the controller's internal air velocity transducer is periodically required to maintain accurate air velocity readings. Calibration may be set to take place automatically or manually by setting CAL SETUP (Point 95) to the desired calibration option during controller startup. If the status of CAL AIR (Point 94) is YES, then calibration is in progress.

- For a controller used without an Autozero Module (CAL MODULE (Point 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 DMPR STATUS (Point 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 (Point 49), to differ from the actual (physical) damper position.

If this occurs, the controller automatically compensates for any difference by setting DMPR STATUS to **RECAL**, which readjusts the value of DMPR POS. DMPR STATUS is set to RECAL if all of the following conditions are true:

- DMPR POS = 100%
- AIR VOLUME (Point 35) > 0 CFM
- FLOW (Point 75) < FLOW STPT (Point 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**, then release it.

The Autozero Module is enabled when it is wired to DO 6 and CAL MODULE (Point 87) equals **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 room temperature sensor 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 either the cooling loop, the heating loop or both need to be tuned. If FLOW (Point 75) is oscillating while FLOW STPT (Point 93) is constant, then the flow loop requires tuning. Refer to the *APOGEE Automation Service Procedures Manual* in InfoLink for more information.

2. The controller as shipped from the factory keeps all associated equipment OFF. Refer to the *Equipment Controllers* section in the *APOGEE Automation Start-up Procedures Manual* in 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. 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 Diagram

The point wiring for Application 2421 is shown in Figure 2421-3.

CAUTION:

The Terminal Box Controller controls 24 Vac loads only. The maximum rating is 12 VA for each DO. Use an interposing 220 V 4-relay module for any of the following:

- VA requirements higher than the maximum
- 110 or 220 Vac
- DC power requirements

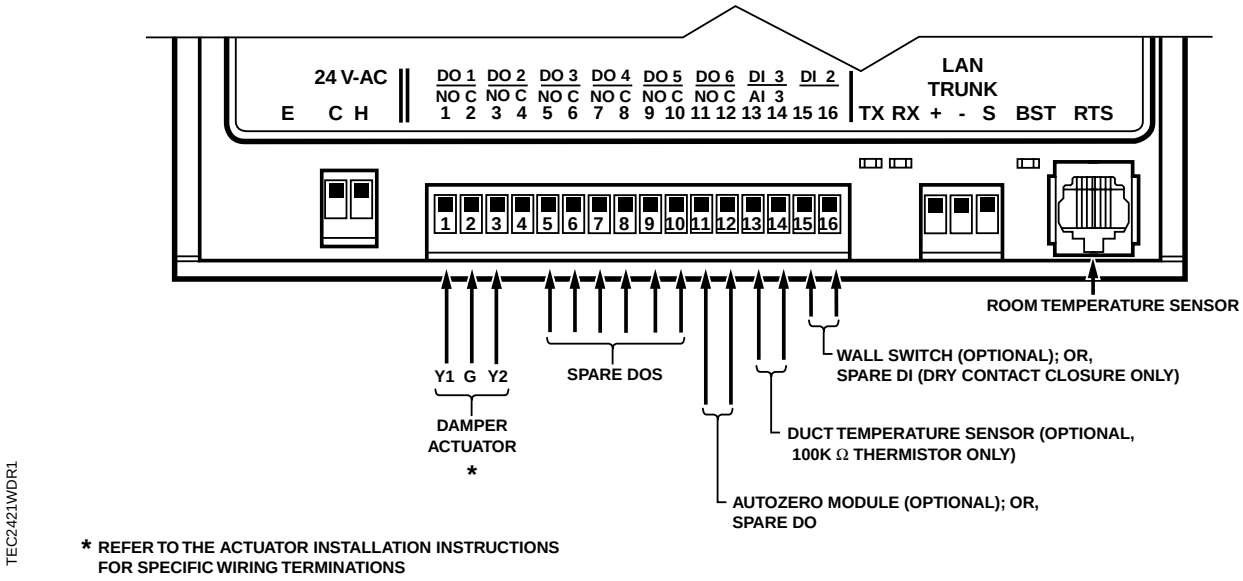


Figure 2421-3. Application 2421 Wiring Diagram.

Table 2421-1. Point Database for Application 2421.

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}	ROOM TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{05}	HEAT.COOL	COOL	--	--	--	HEAT	COOL
06	DAY CLG STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
07	DAY HTG STPT	70.0 (21.20888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
08	NGT CLG STPT	82.0 (27.92888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
09	NGT HTG STPT	65.0 (18.40888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
11	RM STPT MIN	55.0 (12.80888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
12	RM STPT MAX	90.0 (32.40888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{13}	RM STPT DIAL	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
14	STPT DIAL	NO	--	--	--	YES	NO
{15}	SUPPLY 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 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
32	CLG FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
33	HTG FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
34	HTG FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{35}	AIR VOLUME	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
36	FLOW COEFF	1.0	--	0.01	0.0	--	--
{37}	MTR3 COMD	0.0	PCT	0.4	0.0	--	--
{38}	MTR3 POS	0.0	PCT	0.4	0.0	--	--
39	MTR3 TIMING	130	SEC	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.

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Table 2421-1. Point Database for Application 2421.

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{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	MTR1 TIMING	95	SEC	1	0	--	--
{52}	MTR2 COMD	0.0	PCT	0.4	0.0	--	--
{53}	MTR2 POS	0.0	PCT	0.4	0.0	--	--
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	--	--
61	COOL TEMP	65.0 (18.455556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
62	HEAT TEMP	80.0 (26.855556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
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	--	--
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	--	--
71	FLOW P GAIN	0.0	--	0.05	0.0	--	--
72	FLOW I GAIN	0.01	--	0.001	0.0	--	--
73	FLOW D GAIN	0	--	2	0	--	--

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Table 2421-1. Point Database for Application 2421.

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
74	FLOW BIAS	50.0	PCT	0.4	0.0	--	--
{75}	FLOW	0.0	PCT	0.25	0.0	--	--
{76}	CTL FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
{77}	CTL FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{78}	CTL TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{79}	CLG LOOPOUT	0.0	PCT	0.4	0.0	--	--
{80}	HTG LOOPOUT	0.0	PCT	0.4	0.0	--	--
{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 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{93}	FLOW STPT	0.0	PCT	0.25	0.0	--	--
{94}	CAL AIR	NO	--	--	--	YES	NO
95	CAL SETUP	4	--	1	0	--	--
96	CAL TIMER	12	HRS	1	0	--	--
97	DUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0.025 (0.002323)	0.0	--	--
98	LOOP TIME	5	SEC	1	0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--

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