SIEMENS

TEC Custom Solutions Application 2401 VAV Series Fan Powered Cooling Only — Electronic Output

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Overview

NOTE: In this document, the duct that comes from the AHU and ends at the entrance of the series fan is called the supply duct. The duct leaving the series fan is called the discharge duct. Refer to Figure 2401-1.

Application 2401 uses cascaded control to maintain the proper return air temperature. That is, the return air temperature controller adjusts the set point of the discharge air temperature controller. The discharge air temperature controller then modulates the supply air damper of the terminal box for cooling.

The terminal box also has a series fan for air circulation. In order for the terminal box to work properly, the central air handling unit must provide cold supply air. Also, the recirculated air must be warmer than the supply air. Refer to Figures 2401-1 through 2401-3.

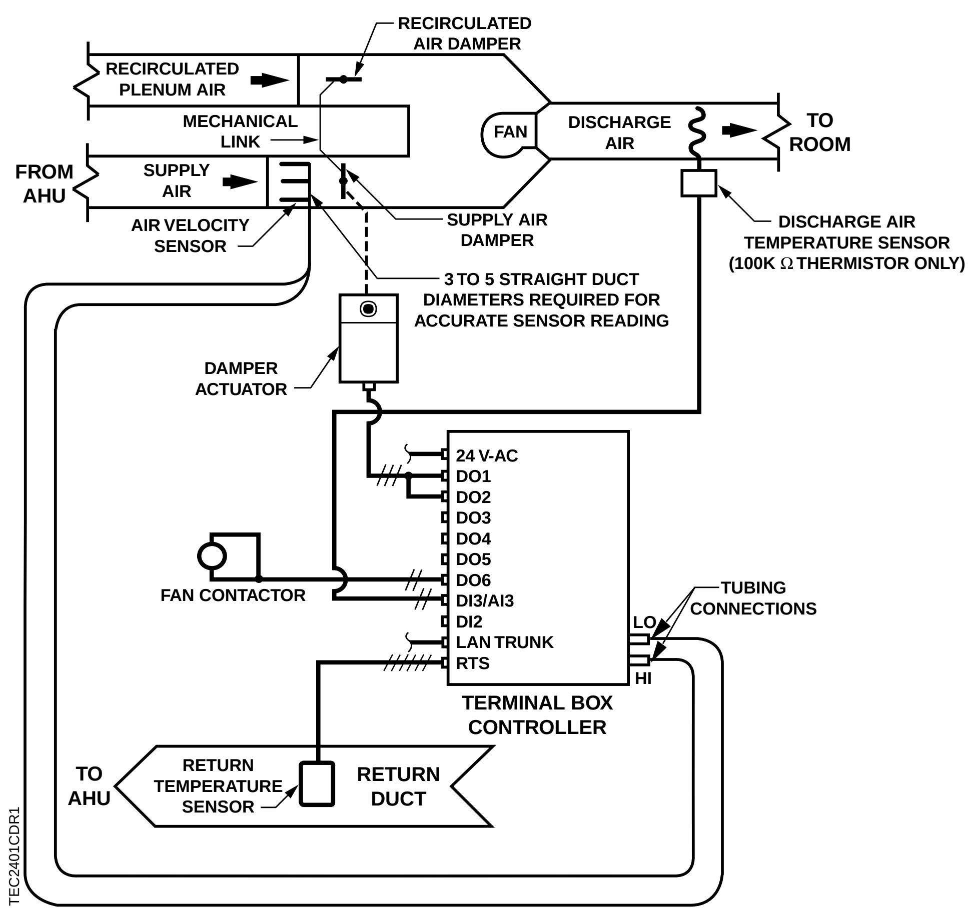


Figure 2401-1. Application 2401 Control Drawing.

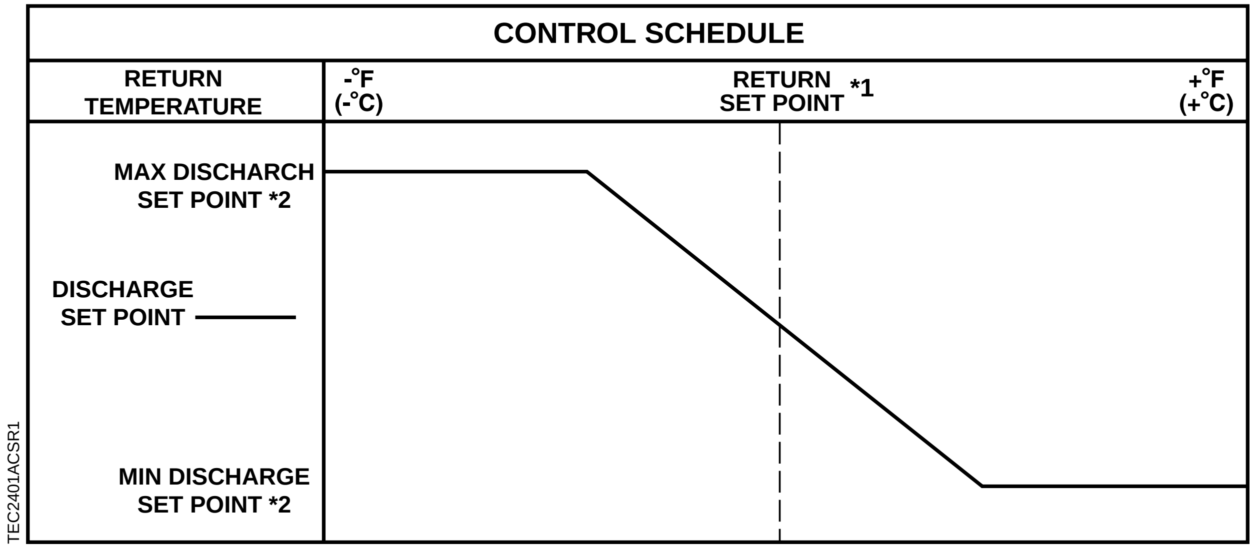


Figure 2401-2. Application 2401 Control Schedule.

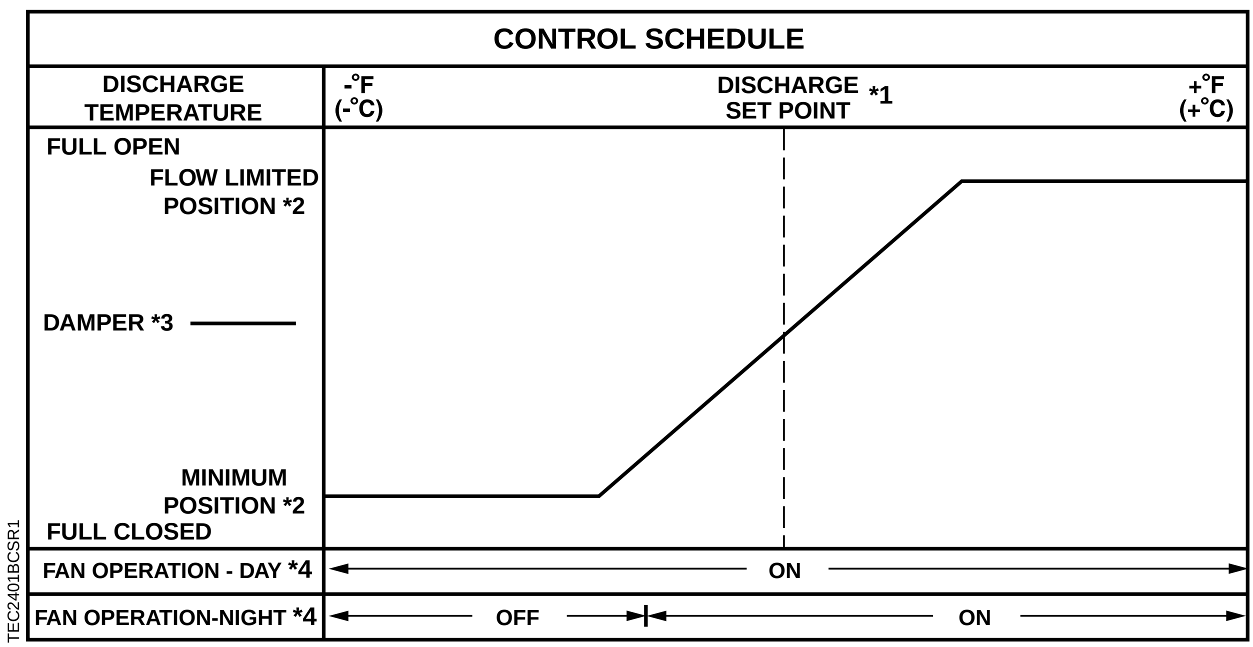


Figure 2401-3. Application 2401 Control Schedule

Hardware Inputs

Analog

- Air velocity sensor
- Return temperature sensor
- Return temperature set point dial (optional)

Digital

- Night mode override (optional)

Hardware Outputs

Analog

- None

Digital

- Damper actuator
- Fan

Ordering Notes

Part number of the TEC for Application 2401 (VAV Series Fan Powered Cooling Only — Electronic Output) is 550-018.

Part number of the RTS sensor that is installed in the return air duct is 540-128.

Custom Solution number 249.

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2401, “VAV Series Fan Powered Cooling Only — 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).

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

NOTE: The value of CTL TEMP (Point 78) is the same as the value of RETURN 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). 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.

FLOW Calculation

This application measures the supply air CFM and stores the value in AIR VOLUME (Point 35). However, AIR VOLUME is not used directly to control airflow. Instead, FLOW (Point 75) is used. FLOW is a value calculated by AIR VOLUME and MAX CFM (Point 32). Specifically:

FLOW = 100% x (AIR VOLUME ÷ MAX CFM).

- When FLOW = 100%, AIR VOLUME = MAX CFM.
- When FLOW = 50%, AIR VOLUME = 0.5 x MAX CFM.
- When FLOW is greater than 100%, AIR VOLUME is greater than MAX CFM.

Using FLOW instead of AIR VOLUME simplifies the fan logic and the discharge air temperature cooling loop control.

Control Loops

The terminal box is controlled by two Proportional, Integral, and Derivative (PID) control loops: a return air temperature cooling loop and a discharge air temperature cooling loop.

Return Air Temperature Cooling Loop

The return air temperature cooling loop maintains the return temperature at the value in CTL STPT (Point 92). Refer to the *Control Temperature Set Points* section.

CLG LOOPOUT (Point 79) is the output of the return air temperature cooling loop. CLG LOOPOUT is used to generate the set point of the discharge air temperature cooling loop, DISCH STPT (Point 7). This is done in a table statement and is explained in the next section.

Table Statement for the Discharge Air Temperature Set Point – This application contains a built-in table statement that adjusts the discharge air temperature set point, (DISCH STPT), based on the output of the return air cooling PID loop (CLG LOOPOUT).

- When CLG LOOPOUT is 0%, DISCH STPT equals MAX DIS STPT (Point 10).
- When CLG LOOPOUT is 100%, DISCH STPT equals MIN DIS STPT (Point 9).
- When CLG LOOPOUT is 50%, DISCH STPT is set halfway between MAX DIS STPT and MIN DIS STPT.

This table statement will never set DISCH STPT greater than MAX DIS STPT or less than MIN DIS STPT.

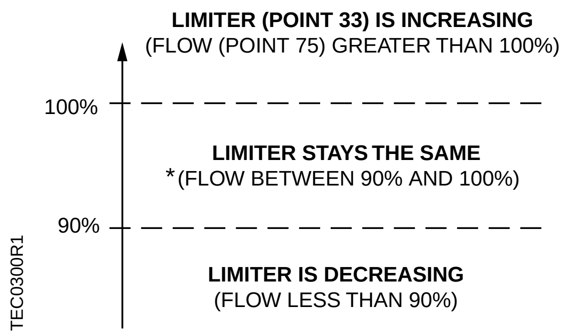
Discharge Air Temperature Cooling Loop

The discharge air-temperature cooling loop maintains the discharge temperature, DISCH TEMP (Point 15), at the value in DISCH STPT (Point 7) by modulating the supply damper via DMPR COMD (Point 48). This damper modulation has both high and low limits. Although DMPR COMD does not have a fixed maximum position, the airflow in the supply duct is not allowed to become greater than MAX CFM (Point 32). This is accomplished as follows:

When FLOW (Point 75) is greater than or equal to 100% (AIR VOLUME (Point 35) ≥ MAX CFM (Point 32)), the application uses a control signal (LIMITER, Point 33) to reduce the value of DMPR COMD until the value of FLOW is less than 100%. LIMITER behaves similar to an integrator in a PID airflow loop—the longer FLOW remains above 100%, the larger LIMITER becomes. As long as FLOW is equal to or greater than 100%, LIMITER increases by the value of OFFSET (Point 34) once each LOOP TIME (Point 99). As LIMITER gets bigger, DMPR COMD becomes smaller, because LIMITER is subtracted from DIS LOOPOUT. Once FLOW drops below 100%, LIMITER stops increasing (LIMITER will not decrease until FLOW drops below 90%).

The relationship between FLOW and LIMITER is shown in *Figure 2401-4*.

As long as LIMITER is greater than zero, the discharge air-temperature cooling loop is prevented from commanding DMPR COMD more open than it already is, even if DISCH TEMP gets too warm. If DISCH TEMP gets too cold, the discharge air-temperature cooling loop can still command DMPR COMD more closed.



* Actually, LIMITER stays the same if FLOW is *equal to* or greater than 90% and *equal to* or less than 100%.

Figure 2401-4. Relationship between FLOW (Point 75) and LIMITER (Point 33).

Once DMPR COMD closes to the point where FLOW is less than 90% (AIR VOLUME < (0.9 x MAX CFM)), the application decreases the value of LIMITER. Specifically, LIMITER is decreased once each LOOP TIME by the value stored in OFFSET for as long as FLOW is less than 90%. If FLOW then rises back above 90%, LIMITER stops decreasing. Decreasing the value of LIMITER is similar to “unwinding” an integrator in a PID loop. It resets LIMITER so that it is available for use during the next high flow situation.

When FLOW is less than 90% and LIMITER is equal to zero, the discharge air-temperature cooling loop can once again control DMPR COMD normally, with DMPR COMD being commanded more open if DISCH TEMP gets too warm and more closed if DISCH TEMP gets too cold.

Under normal operation, the supply damper cannot be set below DMPR MIN POS (Point 50). (See the following NOTE for an exception.) If DIS LOOPOUT (Point 80) becomes less than DMPR MIN POS, DMPR COMD (Point 48) is set equal to DMPR MIN POS. This means that the discharge air-temperature cooling loop cannot command DMPR COMD more closed than DMPR MIN POS even if DISCH TEMP gets too cold. The discharge air-temperature cooling loop can still command DMPR COMD more open if DISCH TEMP gets too warm.

Once DMPR COMD opens greater than DMPR MIN POS + 5, the discharge air-temperature cooling loop controls DMPR COMD normally, with DMPR COMD commanded more closed if DISCH TEMP gets too cold or more open if DISCH TEMP gets too warm.

NOTE: In the above explanation, it is assumed that DMPR MIN POS is set low enough that when the supply damper is at minimum position, the supply airflow is less than MAX CFM (this is usually the case). If supply airflow is *greater* than MAX CFM with the supply air damper at minimum position, then the discharge air-temperature cooling loop (and the point, LIMITER, if necessary) will command DMPR COMD below DMPR MIN POS to decrease the supply airflow to an acceptable level. In other words, this application places a higher priority on keeping FLOW less than or equal to 100% than ensuring that DMPR COMD is greater than or equal to DMPR MIN POS.

CAUTION:

If AIR VOLUME (Point 35) is greater than MAX CFM (Point 32) when the supply air damper is at minimum position, then either MAX CFM must be increased or DMPR MIN POS (Point 50) must be decreased.

Calibration

Calibration of the controller's internal air velocity transducer is periodically required to maintain an accurate air velocity reading. The point CAL SETUP (Point 95) is set with the desired calibration option during controller startup. 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 (Point 94) is YES, then calibration is in progress.

The damper is commanded closed to get a zero airflow reading during calibration.

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. Once calibration is done, the damper is released to normal control.

Fan Operation

CAUTION:

On series fan powered terminal boxes, the terminal box fan must be controlled/interlocked to start either before or at the same time as the central air handler. Failure to do so may cause the terminal box fan to rotate backwards and cause consequent damage at start up.

In day mode, FAN (Point 46) is ON all of the time.

In night mode, the fan is controlled as follows:

- The fan will turn ON when the airflow out of the supply duct, point FLOW (Point 75), is greater than the value stored in the point SERIES ON (Point 26).
- The fan will turn OFF when the airflow out of the supply duct, FLOW, is less than the value stored in the point SERIES OFF (Point 27).
- If FLOW is between SERIES ON and SERIES OFF, the fan remains in its last commanded state.

At night, SERIES ON must be greater than SERIES OFF for proper fan control. As a safety precaution, if SERIES ON is less than or equal to SERIES OFF, the fan remains on at night.

NOTE: If you want to command the fan from PPCL, then you must unbundle the FAN point (Point 46). (You should also unbundle DMPR COMD (Point 48)). If the unbundled points are given the names FAN and DAMPER respectively, then the PPCL is written as follows:

For the Fan to remain OFF when the AHU is OFF, the PPCL should read:

- `100 IF (AHU.EQ.OFF) THEN OFF (FAN)`
- `200 IF (AHU.EQ.OFF) THEN SET (0, DAMPER)`

For the Fan to remain ON when the AHU is ON, the PPCL should read:

- `100 IF (AHU.EQ.ON) THEN ON (FAN)`
- `200 IF (AHU.EQ.ON) THEN RELEAS (DAMPER)`
  (By using the RELEAS statement, you allow the TEC to resume normal control of the damper.)

For the TEC to resume normal control when the AHU is on, the PPCL should read:

- `100 IF (AHU.EQ.ON) THEN RELEAS (FAN, DAMPER)`
  (This code is useful at night because it allows the fan to cycle ON and OFF based on return temperature.)

Fail-Safe Operation

If the air velocity sensor fails, then the FAN will be ON and the supply damper will be sent to minimum position (DMPR COMD will equal DMPR MIN POS).

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

If the discharge air temperature sensor fails, the supply damper will be sent to minimum position. This will prevent cold air from flooding the space when DISCH TEMP fails.

Application Notes

1. If the temperature swings in the return duct are excessive or if there is trouble maintaining the return air temperature set point, then the return air temperature cooling loop needs to be tuned. If the temperature swings in the discharge duct are excessive or if there is trouble maintaining the discharge air temperature set point, then the discharge air temperature cooling loop needs to be tuned. Refer to the *APOGEE Automation Service Procedures* on InfoLink for more information.

2. The Terminal Box Controller, as shipped from the factory, keeps all associated equipment OFF. Refer to 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. DO 3 and DO 4 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.

4. The air velocity sensor that the TEC uses to measure the airflow in the supply duct has an accuracy of ± 5% when the air velocity is between 400 FPM (Feet Per Minute) and 4000 FPM. From 300 FPM to 400 FPM, the air velocity sensor has an accuracy of ± 10% to ± 30%. The air velocity sensor is unable to reliably read air velocity below 300 FPM.

Wiring Diagram

CAUTION:

The Controller's DOs control 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 requirements
- DC power requirements
- Separate transformers used to power the load

NOTE: Consult with the local Siemens Building Technologies, Inc. representative if terminations are missing or are different.

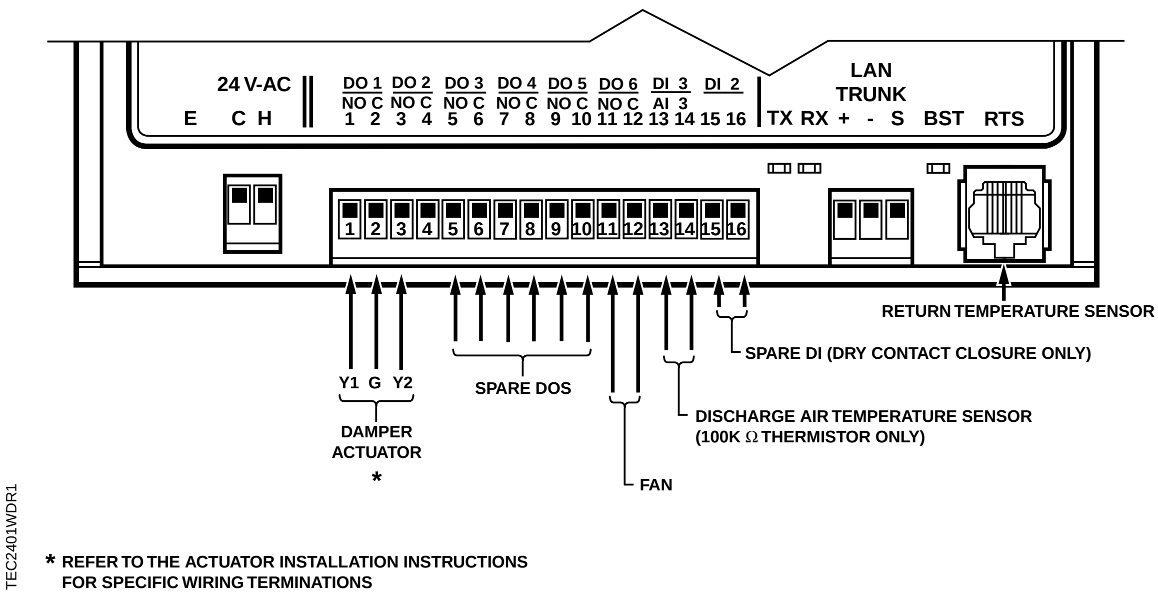


Figure 2401-5. Application 2401 Wiring Diagram.

Point Database

Point Database for Application 2401.

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}	RETURN TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
06	DAY CLG STPT	71.0 (21.76888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{07}	DISCH STPT	71.0 (21.815556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
08	NGT CLG STPT	85.0 (29.60888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
09	MIN DIS STPT	63.0 (17.335556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
10	MAX DIS STPT	71.0 (21.815556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
{15}	DISCH TEMP	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
26	SERIES ON	20.0	PCT	0.4	0.0	--	--
27	SERIES OFF	10.0	PCT	0.4	0.0	--	--
{29}	DAY.NGT	DAY	--	--	--	NIGHT	DAY
32	MAX CFM	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{33}	LIMITER	0.0	PCT	0.4	0.0	--	--
34	OFFSET	2.0	PCT	0.4	0.0	--	--
{35}	AIR VOLUME	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
36	FLOW COEFF	1.0	--	0.01	0.0	--	--
{40}	FLOW LIMIT	OFF	--	--	--	ON	OFF
{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}	FAN	OFF	--	--	--	ON	OFF
{47}	DMPR LIMIT	OFF	--	--	--	ON	OFF
{48}	DMPR COMD	0.0	PCT	0.4	0.0	--	--

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.

continued on the next page…

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{49}	DMPR POS	0.0	PCT	0.4	0.0	--	--
50	DMPR MIN 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	--	--
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	DIS P GAIN	10.0 (18.0)	--	0.25 (0.45)	0.0	--	--
68	DIS I GAIN	0.01 (0.018)	--	0.001 (0.0018)	0.0	--	--
69	DIS D GAIN	0 (0.0)	--	2 (3.6)	0	--	--
70	DIS BIAS	0.0	PCT	0.4	0.0	--	--
{75}	FLOW	0.0	PCT	0.25	0.0	--	--
{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}	DIS LOOPOUT	0.0	PCT	0.4	0.0	--	--
{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)	--	--
{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	--	--

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.