SIEMENS

P1 TEC

VAV Cooling Only with Optional Occupancy Sensor Application 2170

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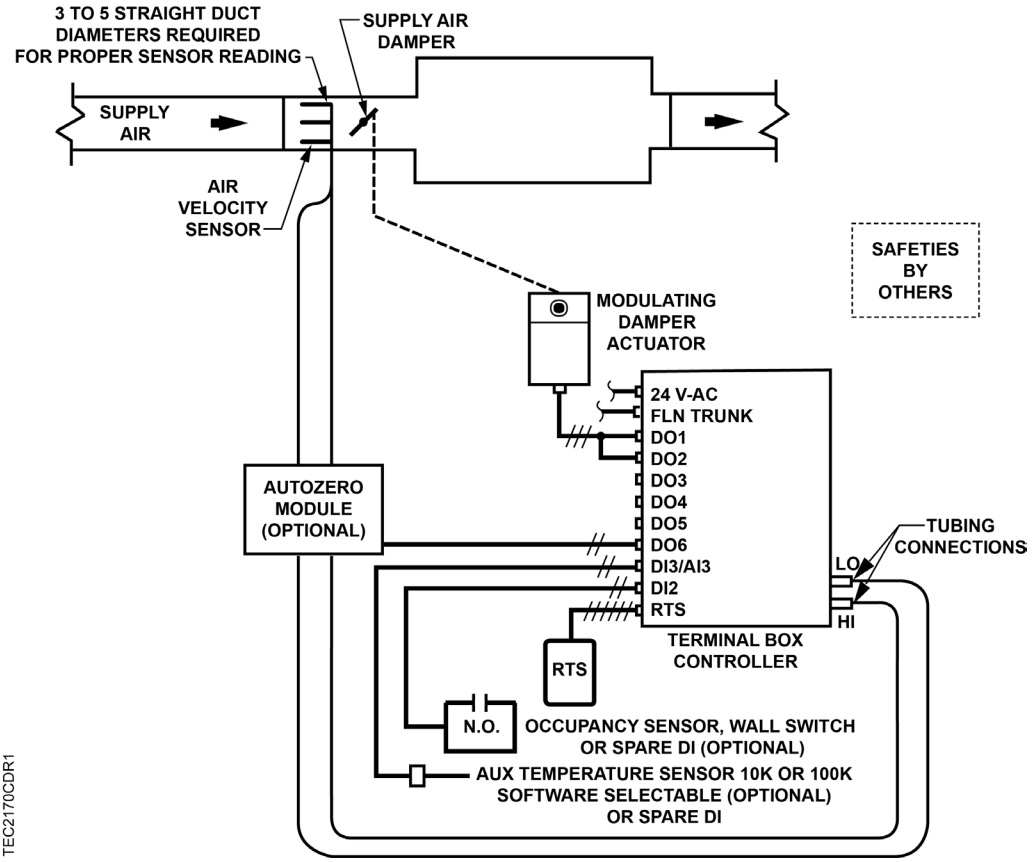
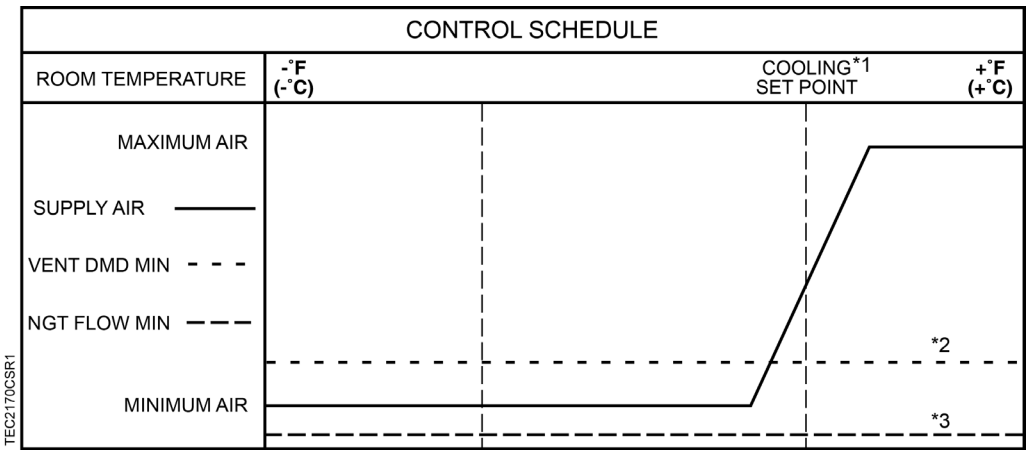
Overview

In Application 2170, the controller modulates the supply air damper of the terminal box for cooling. In order for it to work properly, the central air-handling unit must provide cool supply air.



Application 2170 – VAV Cooling Only with Optional Occupancy Sensor Control Diagram.



Application 2170 Control Schedule.

NOTES:
1. See *Control Temperature Setpoints*.
2. VENT DMD MIN can be set above, equal to, or below the cooling minimum flow setpoint (CLG FLOW MIN) and can be controlled (reset) externally for ventilation demands. Minimum airflow will be the larger of CLG FLOW MIN and the ventilation demand flow setpoint VENT DMD MIN.
3. NGT FLOW MIN can be set equal or below the cooling minimum flow setpoints, or to zero, to be used for minimum flow during night modes.

Hardware Inputs

Analog

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

Digital

- Night / Unocc mode override (optional)
- Wall switch (optional)
- Occupancy sensor (optional)

Hardware Outputs

Analog

- None

Digital

- Damper actuator (DO 1/DO 2)
- Autozero module (optional)
- Spare DOs (DO 3, DO 4, DO 5)

Ordering Notes

540-100MD	Application 2170: VAV Cooling Only with Optional Occupancy Sensor Application 2174: VAV Series Fan with Electric Reheat and Optional Occupancy Sensor

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2170, VAV Cooling Only with Optional Occupancy Sensor.

Day and Night Modes

The operational status of the space is determined by the DAY.NGT point. Control of this point differs depending on whether it is being controlled by a wall switch or by a field panel. If a wall switch is controlling this point, it should not also be controlled by a field panel.

When a wall switch is physically connected to the controller at DI 2 and WALL SWITCH = YES, the controller monitors the status of DI 2. When DI 2 is ON (switch is closed), DAY.NGT will be set to DAY. When DI 2 is OFF (switch is open), DAY.NGT will be set to NIGHT.

When WALL SWITCH = NO, the controller will not monitor the status of a wall switch, even if one is connected at DI 2. 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 (connected to a field panel), then the field panel can send an operator or PPCL command to override the status of DAY.NGT. See *Powers Process Control Language (PPCL) User's Manual* (125-1896) and the *APOGEE P2 ALN Field Panel User's Manual* (125-3020) for more information.

In addition to DAY.NGT, OCC STBY (occupied standby) will also affect control if an optional occupancy sensor is being used. OCC STBY works in conjunction with DAY.NGT to reduce airflow when no one is present in the zone during occupied times. See *Occupancy Sensor* for more information.

Occupancy Sensor

The occupancy sensor option provides a means to reduce airflow while using the occupied temperature setpoints. To enable this option, set WALL SWITCH = NO and OCC SWITCH = YES, and connect an occupancy sensor to the controller at DI 2.

When a zone is in a normal occupancy state (DAY.NGT = DAY) and people are present, the enabled occupancy sensor will keep OCC STBY equal to NO (space is occupied). If at some point people leave and the occupancy sensor senses no activity, OCC STBY will be set to YES. With OCC STBY set to YES, zone temperature setpoint(s) will equal their occupied value (or an optional configurable offset) while airflow setpoints change to the unoccupied NGT FLOW MIN. If people return and the occupancy sensor senses activity, OCC STBY changes to NO and the zone returns to normal occupied control. See the table below for additional information.

Delay of activation and deactivation for detection of occupancy is not controlled by the application. If required, occupancy sensors should be selected to provide any of these delays.

Additional energy reduction can be achieved by changing the STBY OFFSET default of 0.0 deg to an offset that will be used to increase the cooling temperature setpoint. For example, with STBY OFFSET set to 1.0 deg, a cooling setpoint of 76 deg will be incremented to 77 deg.

WALL SWITCH and OCC SWITCH Operation							
Conditions				Result			Comment
WALL SWITCH	OCC SWITCH	DAY.NGT	DI2	OCC STBY	Airflow minimum	Temp. control	
= NO Note WALL SWITCH must equal NO for occupancy sensor option.	= YES	DAY	OFF (no presence detected)	= YES	Minimum airflow setpoint changed from occupied calculation to NGT FLOW MIN	Remains at occupied temperature setpoints	Optional shift of temperature setpoints can be achieved by setting STBY OFFSET. For example, setting STBY OFFSET to 1.0 deg would raise a cooling setpoint of 76 deg to 77 deg (and lower a heating setpoint by 1.0 deg).
			ON (presence detected)	= NO	Minimum airflow setpoint, larger of VENT DMD MIN and minimum flow setpoint	Occupied temperature setpoints	
		NIGHT	Status of DI2 does not affect control	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	
	= NO	DAY	Status of DI2 does not affect control	= NO	Minimum airflow setpoint, larger of VENT DMD MIN and minimum flow setpoint	Occupied temperature setpoints	
		NIGHT	Status of DI2 does not affect control	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	
= YES	na (ignored)	DAY	ON	= NO	Minimum airflow setpoint, larger of VENT DMD MIN and minimum flow setpoint	Occupied temperature setpoints	Wall switch connected to DI2 sets DAY.NGT to DAY
		NIGHT	OFF	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	Wall switch connected to DI2 sets DAY.NGT to NIGHT

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, pressing the override switch will reset the controller to DAY operational mode for the time period that is set in OVRD TIME. The status of NGT OVRD changes to DAY. After the override time elapses, the controller returns to night mode and the status of NGT OVRD changes back to NIGHT.

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

Control Temperature Setpoints

This application has a number of different room temperature setpoints (DAY CLG STPT, NGT CLG STPT, RM STPT DIAL, etc.). The application actually controls to CTL STPT. CTL STPT is set to different values depending on its override status, time of day, and occupancy standby mode.

CTL STPT Overridden – If CTL STPT is overridden, that value is used regardless of any other settings.

CTL STPT not Overridden – CTL STPT holds the value of one of the occupied, unoccupied, or standby cooling setpoints, or it holds the value of the room setpoint dial calculation.

When STPT DIAL equals NO (default), CTL STPT holds the value of DAY CLG STPT if DAY.NGT equals DAY (or NGT OVRD = DAY) and OCC STBY equals NO.

When the controller is in night mode (DAY.NGT = NGT or NGT OVRD = NGT), CTL STPT holds the value of NGT CLG STPT. When the controller is in night mode the value of RM STPT DIAL is ignored.

With setpoint dial – When the controller is in day mode and STPT DIAL = YES and OCC STBY = NO, CTL STPT is based on the value of RM STPT DIAL.

NOTE:
RM STPT DIAL must stay between the values of RM STPT MIN and RM STPT MAX or CTL STPT will use those values instead.

NOTE:
If RM STPT DIAL is failed, it maintains the last known value.

Optional Occupied Standby HTG / CLG Setpoints

When an occupancy sensor is present and enabled and no one is currently in the zone (OCC STBY = YES), the cooling and heating setpoints will be the day setpoints with the optional STBY OFFSET applied (cooling setpoint increased by the STBY OFFSET and heating setpoint decreased by the STBY OFFSET). For example, with STBY OFFSET set to 1.0 deg, a cooling setpoint of 76 deg will be incremented to 77.

Room Temperature, Room Temperature Offset and CTL TEMP

ROOM TEMP is the temperature that is being sensed by the room temperature sensor (the RTS).

RMTMP OFFSET (or TEMP OFFSET) is a user-adjustable offset that will compensate for deviations between the value of ROOM TEMP and the actual room temperature.

CTL TEMP is the room temperature that is used for control purposes. In other words, what the application is trying to do is to maintain CTL TEMP at CTL STPT.

When CTL TEMP is not overridden, CTL TEMP and ROOM TEMP are related by the following equation:

CTL TEMP = ROOM TEMP + RMTMP OFFSET (or TEMP OFFSET)

If CTL TEMP is not overridden, then:

- The current value of ROOM TEMP (normal or overridden) will be used to determine the value of CTL TEMP.
- If ROOM TEMP has a status of Failed the last known good value of ROOM TEMP will be used to determine the value of CTL TEMP.

If CTL TEMP is overridden then:

- CTL TEMP equals its overridden value and the points ROOM TEMP and TEMP (RMTMP) OFFSET have no effect on the value of CTL TEMP.

Ventilation Demand Minimum

For flexible ventilation control, a ventilation demand minimum setpoint (VENT DMD MIN) is provided. If used, VENT DMD MIN operates only during occupied modes.

VENT DMD MIN can be controlled externally using demand control ventilation (DCV) or an indoor air quality (IAQ) program (from a field panel or PPCL). The regular minimum airflow setpoint (CLG FLOW MIN) can be set lower than VENT DMD MIN or to zero, and VENT DMD MIN can modulate in response to CO_2 or other indoor air quality ventilation requirements.

Note that the control maximum flow setpoints are not affected by VENT DMD MIN.

NOTE:
If using optional occupancy sensor, the occupied minimum airflow is defined as above when OCC STBY = NO. When OCC STBY = YES (occupied mode but no one in the zone), the occupied minimum airflow will be set to NGT FLOW MIN.

Night Flow Minimum

Some applications do not provide a distinction between day/occupied and night/unoccupied modes for the minimum air flow setpoints. For day/occupied operation, the cooling minimum flow setpoint is designed to be the air flow for minimum cooling and ventilation. At night the air handling unit was typically not running, making night/unoccupied airflow setpoints unnecessary.

The use of this additional flow setpoint, NGT FLOW MIN, in place of cooling flow min, addresses this limitation. As the flow at night/unoccupied times does not require the ventilation needs for personnel, it can be set below other minimums or at zero. The configured maximum cooling flow setpoint will still be used when the zone temperature exceeds (goes out of bounds) the night cooling setpoint.

Control Loops

Advanced PID algorithm for the temperature control loops is employed to provide stability and to reduce unnecessary changes in the Flow setpoint when the room temperature is at or near the room temperature setpoint.

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

The temperature loop is a cooling loop that maintains room temperature at the value in CTL STPT.

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

Flow minimum (CTL FLOW MIN) for the cooling mode is set in DAY mode to the larger of CLG FLOW MIN and VENT DMD MIN. In Night mode (or DAY mode when OCC STBY = YES) the flow minimum is set to NGT FLOW MIN.

When CLG FLOW MIN ≠ 0 CFM, FLOWSTPT ≠ CLG LOOPOUT . The minimum flow setpoint is (CLG FLOW MIN / CLG FLOW MAX) × 100% flow. And FLOW STPT is [CLG LOOPOUT × (100% – minimum setpoint)] + minimum setpoint.

Example

If CLG FLOW MIN = 200 cfm, and CLG FLOW MAX = 1000 cfm, the minimum flow setpoint is (200 cfm / 1000 cfm) × 100% flow = 20%.

When CLG LOOPOUT is 0%, FLOW STPT = 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 = 60% flow.
[50% × (100% – 20%)] + 20% = 60%

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

Flow Loop – The flow loop maintains FLOW STPT by modulating the supply air damper, DMPR COMD. The flow loop maintains the airflow between CTL FLOW MIN and CTL FLOW MAX.

You can set CLG FLOW MIN equal to, but not greater than, CLG FLOW MAX. If the minimum and maximum values are set equal, the flow loop becomes a constant volume loop and loses its ability to control temperature.

FLOW is the input value for the flow loop. It is calculated as a percentage based on where AIR VOLUME is between 0 cfm and CTL FLOW MAX. This percentage is referred to as % flow.

- If AIR VOLUME = 0 cfm, FLOW is 0% flow.
- If AIR VOLUME = CTL FLOW MAX, 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 = 250 cfm, and CTL FLOW MAX = 1000 cfm,
the low limit of FLOW STPT = (250 cfm / 1000 cfm) × 100% flow
= 0.25 × 100% flow
= 25% flow.
Since 25% of 1000 cfm = 250 cfm, the minimum airflow out of the terminal box will be 250 cfm.

Room Unit Operation

Stat Supervision

STAT SUPV is a configurable point (values are additive). Configuration will differ depending on the type of room unit (stat) being used. (Note: If the room unit is analog, STAT SUPV is used **only** to specify thermistor inputs as 10K or 100K.Therefore for analog room units the only values possible for STAT SUPV are 0, 8, or 16. See the table below.

If the room unit is digital, STAT SUPV defines the thermistors **and also** enables the room unit temperature, humidity and/or CO_2 points to be read by the controller. For digital room units, if a temperature, humidity, or CO_2 value (see table) is not included in the configured value for STAT SUPV, then the related point cannot be read (or ever display as failed). Conversely, if you enable supervision for a feature that the room unit does not support, then the related point will always display as failed.

Example: If you are using a digital room unit and need temperature and CO_2 sensing and a 100K thermistor on AI 5, you would set STAT SUPV = 13 (1 + 4 + 8 = 13). See the table below.

STAT SUPV Additive Values	
Value	**Description**
0 (default)	10K Ω thermistor(s)
1	Temperature sensing [1]
2	Relative Humidity (RH) sensing [1]
4	CO_2 sensing [1]
8	If short board: 100K Ω thermistor on AI 3 If long board: 100K Ω thermistor on AI 5
16	Long board only: 100K Ω thermistor on AI 4 (AI 4 must be a thermistor input, not a 0-10V/4-20 mA input.)

1) Additive values 1, 2, 4 **must not** be used with Series 1000 / 2000 analog room units.

See *Sensors and Transducers Configuration and Sizing* for part numbers and ordering information.

CO2 Monitoring

RM CO2 displays the CO_2 value in units of parts-per-million (PPM). RM CO2 can be unbundled for monitoring purposes.

Room RH

RM RH displays the relative humidity value in percent. RM RH can be unbundled for monitoring purposes.

Calibration

Calibration of the controller's internal air velocity sensor(s) is periodically required to maintain accurate air velocity readings. CAL SETUP is set with the desired calibration option during controller startup.

Depending on the value of CAL SETUP, calibration may be set to take place automatically or manually. If CAL AIR = YES, calibration is in progress.

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

Floating Control Actuation Auto-correct

In addition to the existing options for floating control actuator full stroke actions; all floating control actuators are provided with additional logic to fully drive open or closed when commanded to 100% or 0%.

Fail Mode Operation

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

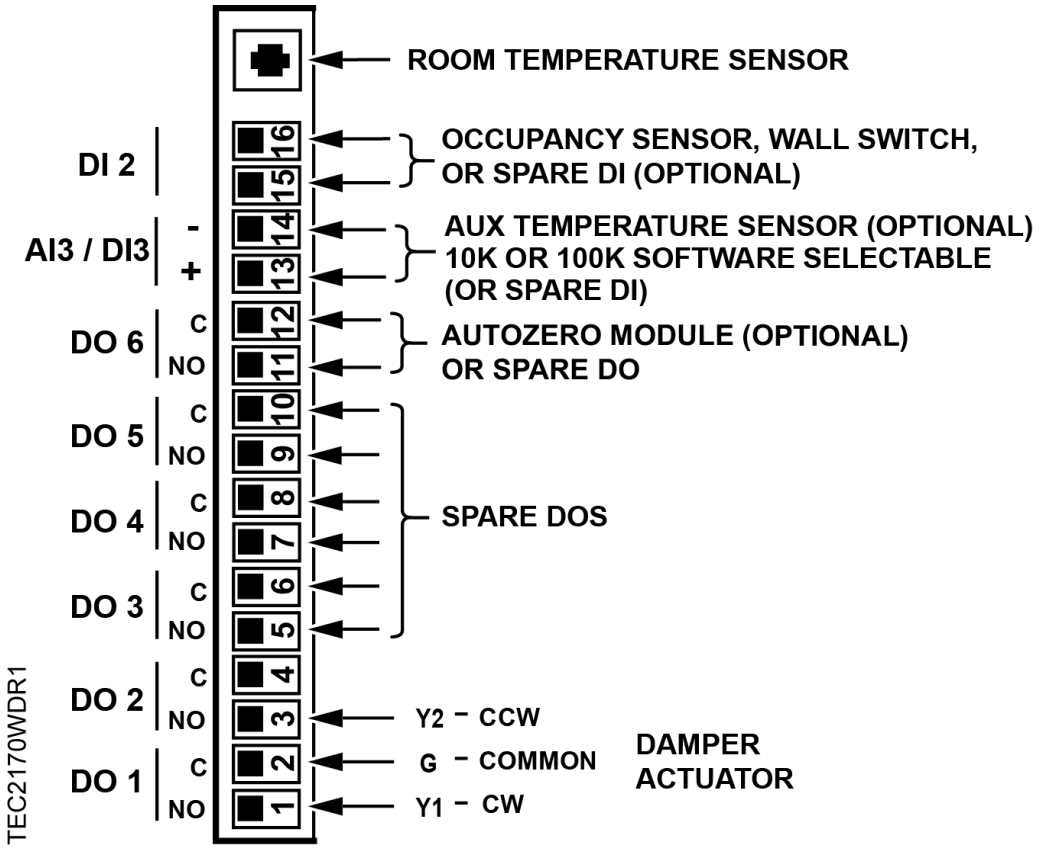
If the room temperature sensor fails, the controller operates using the last known temperature value.

Application Notes

- If temperature swings in the room are excessive or there is trouble maintaining the setpoint, the cooling loop needs to be tuned. If FLOW is oscillating while FLOW STPT is constant, the flow loop requires tuning.
- The controller, as shipped from the factory, keeps all associated equipment OFF. See the appropriate *Start-up Procedures* for information on how to release the controller and its equipment to application control.
- Spare DOs can be used as auxiliary points that are controlled by the field panel after being defined in the field panel's database.

Wiring Diagram

⚠	**⚠ CAUTION**
	The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. An external interposing relay is required 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 (for example part number 540-147, Terminal Equipment Controller Relay Module)



Application 2170 – Variable Air Volume Cooling Only with Optional Occupancy Sensor.

Application 2170 Point Database

Point Number [1]	Descriptor	Factory Default (SI Units)[2]	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
01	CTLR ADDRESS	99	--	1	0	--	--
02	APPLICATION	2178	--	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 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
06	DAY CLG STPT	74.0 (23.44888)	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)	--	--
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}	AUX TEMP AI3	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
{25}	DI 3	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	--	--
{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	--	--
{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	--	--

Point Number [1]	Descriptor	Factory Default (SI Units)[2]	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{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	--	--
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	--	--
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	--	--
87	CAL MODULE	NO	--	--	--	YES	NO
{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	--	--
104	NGT FLOW MIN	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
{105}	VENT DMD MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
106	OCC SWITCH	NO	--	--	--	YES	NO
{107}	OCC STBY	NO	--	--	--	YES	NO
108	STBY OFFSET	0.0 (0.0)	DEG F (DEG C)	0.25 (0.14)	0.0	--	--
124	STAT SUPV	0	--	1	0	--	--
{125}	RM CO2	1000	PPM	1	0	--	--
{126}	RM RH	50.0	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.

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