

SIEMENS

**BACnet PTEC Terminal Box
(VAV) Controller**

**Application 6521 - VAV Heating
or Cooling**

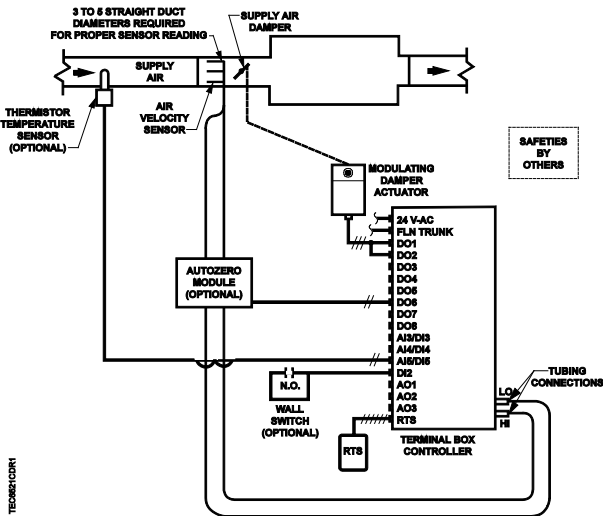
Application Note

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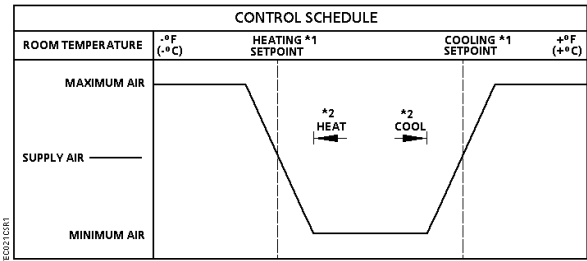
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Overview

In Application 6521, 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 during heating mode.



Application 6521 - VAV Cooling or Heating Control Diagram.



Application 6521 Control Schedule.



NOTE:
See Control Temperature Setpoints [→ 6].

BACnet

The controller communicates using BACnet MS/TP protocol for open communications on BACnet MS/TP networks.

Product	Supported BIBBs	BIBB Name
BTEC	DS-RP-B B	Data Sharing-Read Property-B
	DS-RPM-B	Data Sharing-Read Property Multiple-B

Product	Supported BIBBs	BIBB Name
	DS-WP-B	Data Sharing-Write Property-B
	DM-DDB-B	Device Management-Dynamic Device Binding-B
	DM-DOB-B	Device Management-Dynamic Object Binding-B
	DM-DCC-B	Device Management-Device Communication Control-B
	DM-RD-B	Device Management-Reinitialize Device-B
	DM-BR-B	Device Management-Backup and Restore-B
	DM-OCD-B	Device Management-Object Creation and Deletion-B

Hardware Inputs

Analog

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

Digital

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

Hardware Outputs

Analog

- None

Digital

- Damper actuator
- Autozero module

Sequence of Operation

The following paragraphs present the sequence of operation for Siemens BACnet PTEC VAV/Terminal Box Controller Application 6521, "VAV Cooling and Heating".

Control Temperature Setpoints

Depending on the controller's current operational mode (day or night), the control temperature setpoint, CTL STPT holds the value of one of the following setpoints:

Day Mode - In day mode, CTL STPT holds the value of DAY CLG STPT. If the room temperature sensor has a setpoint dial and STPT DIAL is set to YES, then CTL STPT holds the value of RM STPT DIAL.

If the setpoint dial is used and the value of RM STPT DIAL is less than the value of RM STPT MIN, 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, then CTL STPT holds the value of RM STPT MAX.

Night Mode - In night mode, CTL STPT holds the value of NGT CLG STPT.

Room Temperature Offset (Optional)

TEMP OFFSET is a user-adjustable offset that will compensate for deviations between the value of ROOM TEMP and the actual room temperature. This corrected value is displayed in CTL TEMP.

$$\text{CTL TEMP} = \text{ROOM TEMP} + \text{TEMP OFFSET}$$

Example

If the actual room temperature is 72.0°F, and the value of ROOM TEMP is 73.0°F, then the value entered into TEMP OFFSET is -1.0. In this case, the value of ROOM TEMP would read 73.0°F, but the value of CTL TEMP would read 72.0°F.

Day and Night Modes

The day/night status of the space is determined by the status of DAY.NGT. 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 DI2 (and DI2 is configured for digital input) (see the *Control Diagram* in Overview), and WALL SWITCH = YES, the controller monitors the status of DI2. When the status of DI2 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 DI2 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 = 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. See *Powers Process Control Language (PPCL) User's Manual* (125-1896) and *Field Panel User's Manual* (125-3019 or 125-3020) 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, 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 Loops

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

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. See Control Temperature Setpoints [→ 6].

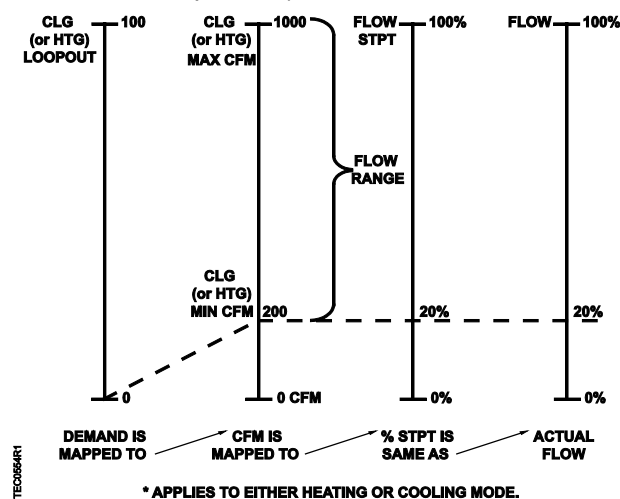
Cooling Loop – Generates cooling loopout which is then used to generate FLOW STPT. FLOW STPT is the result of scaling the cooling loopout to the appropriate range of values determined by CLG FLOW MIN and CLG FLOW MAX.

As described in the following figure, the flow setpoint is calculated by:

$$\text{FLOW STPT} = [\text{CLG LOOPOUT} \times (100\% - \% \text{ minimum setpoint})] + \% \text{ minimum setpoint}$$

Where percent minimum setpoint is:

$$\% \text{ minimum setpoint} = (\text{CLG FLOW MIN} / \text{CLG FLOW MAX}) \times 100 \%$$



FLOW STPT and FLOW % are relative to MIN and MAX STPTS of corresponding heating or cooling mode.

Example

If CLG FLOW MIN = 200 cfm, and CLG FLOW MAX = 1000 cfm, the minimum flow setpoint is
 $(200 \text{ cfm} / 1000 \text{ cfm}) \times 100\% \text{ flow} = 20\%$.

When CLG LOOPOUT is 0%, FLOW STPT = 20% flow.

$$[0\% \times (100\% - 20\%)] + 20\% = 20\%$$

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.

$$[50\% \times (100\% - 20\%)] + 20\% = 60\%$$

When CLG LOOPOUT is 100%, FLOW STPT = 100% flow.

$$[100\% \times (100\% - 20\%)] + 20\% = 100\%$$

Heating 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 HTG FLOW MIN and HTG FLOW MAX.

As described in the figure, the flow setpoint is calculated by:

$\text{FLOW STPT} = [\text{HTG LOOPOUT} \times (100\% - \% \text{ minimum setpoint})] + \% \text{ minimum setpoint}$.

Where percent minimum setpoint is:

$$\% \text{ minimum setpoint} = (\text{HTG FLOW MIN} / \text{HTG FLOW MAX}) \times 100 \%$$

Example

If HTG FLOW MIN = 100 cfm, and HTG FLOW MAX = 1000 cfm, the minimum flow setpoint is
 $(100 \text{ cfm} / 1000 \text{ cfm}) \times 100\% \text{ flow} = 10\%$.

When HTG LOOPOUT is 0%, FLOW STPT = 10% flow.

$$[0\% \times (100\% - 10\%)] + 10\% = 10\%$$

This ensures that the airflow out of the terminal box is no less than HTG FLOW MIN.

When HTG LOOPOUT is 50%, FLOW STPT = 55% flow.

$$[50\% \times (100\% - 10\%)] + 10\% = 55\%$$

When HTG LOOPOUT is 100%, FLOW STPT = 100% flow.

$$[100\% \times (100\% - 10\%)] + 10\% = 100\%$$

Flow Loop – Maintains minimum airflow and maximum airflow through CTL FLOW MIN and CTL FLOW MAX.

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

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

In Application 6521, 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, the flow loop becomes a constant volume loop and loses its ability to control temperature.

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.

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:

$$(\text{CTL FLOW MIN} / \text{CTL FLOW MAX}) \times 100\% \text{ flow}$$

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 = $(250 \text{ cfm} / 1000 \text{ cfm}) \times 100\% \text{ flow}$
 $= 0.25 \times 100\% \text{ flow}$
 $= 25\% \text{ flow}.$

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

See also

■ Control Temperature Setpoints [→ 6]

Calibration

Calibration of the controller's internal air velocity transducers 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.

- For a controller used without an Autozero Module (CAL MODULE, = 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 automatically returns to NO. A status of NO indicates that the controller is not in a calibration sequence.

During normal operation: To ensure that the damper closes fully, the controller will provide additional closing time when the DMPR POS = 0%.

Damper Status Operation

Under normal operation DMPR STATUS reads CAL. It is possible, after a period of operation for the calculated damper position point, DMPR POS, 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%
- AIRVOLUME>0 cfm
- FLOW < FLOW STPT

OR

- DMPRPOS=0%
- AIRVOLUME>0 cfm
- FLOW > FLOW STPT



NOTE:

To change DMPR STATUS from RECAL back to CAL, set DMPR STATUS to CAL, and then release it.

AI4/AI5 OFFSET (Optional)

AI 4 OFFSET works like RMTMP OFFSET. It can be used to calibrate AI4 aux temp sensor input if necessary. The actual temperature plus AI 4 OFFSET will equal AI4 display temperature.

AI 5 OFFSET works the same as AI 4 OFFSET.

Room Unit Operation

Stat Supervision

STAT SUPV is a configurable, enumerated point (values are additive). This point tells the controller what kind of room unit is connected and how to respond to a loss of communication between a Series 2200 and 3200 type Room Units and the controller.

The default value for STAT SUPV is zero, no response (also for Series 1000/2000 stats). A value of 1 means that if communication is lost for at least one minute, CTL TEMP will have a status of Failed. A value of 3 means that both CTL TEMP and RM RH will be Failed after a loss of communication for at least one minute.

CO2 Monitoring

RM CO2 displays the CO₂ 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.

PPCL STATUS

PPCL STATUS displays LOADED or EMPTY.

LOADED = PPCL programming is present in the controller. A new application number must be assigned (12000 through 12999).

EMPTY = NO PPCL programming is present.

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. See the *iKnow Troubleshooting Tool* for more information.
- 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

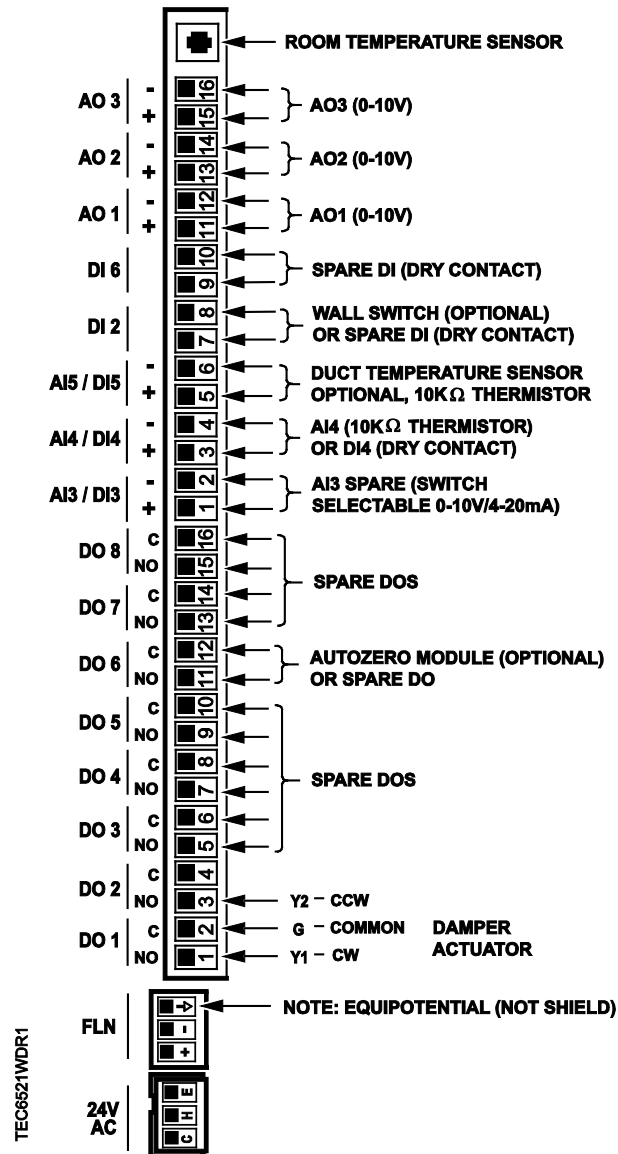


⚠ CAUTION

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 6521 - VAV Cooling and Heating

Application 6521 Point Database

Object Type a)	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units) ^{b)}	Eng Units (SI Units)	Range	Active Text	Inactive Text
AO	1	CTLR ADDRESS	99	--	0-255	--	--
AO	2	APPLICATION	6587	--	0-32767	--	--
AO	3	RMTMP OFFSET	0.0 (0.0)	DEG F (DEG C)	-63.75	--	--
AI	{04}	ROOM TEMP	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
BO	{05}	HEAT.COOL	COOL	--	Binary	HEAT	COOL
AO	6	DAY CLG STPT	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	7	DAY HTG STPT	70.0 (21.20888)	DEG F (DEG C)	48-111.75	--	--
AO	8	NGT CLG STPT	82.0 (27.92888)	DEG F (DEG C)	48-111.75	--	--
AO	9	NGT HTG STPT	65.0 (18.40888)	DEG F (DEG C)	48-111.75	--	--
BI	{10}	DI 6	OFF	--	Binary	ON	OFF
AO	11	RM STPT MIN	55.0 (12.80888)	DEG F (DEG C)	48-111.75	--	--
AO	12	RM STPT MAX	90.0 (32.40888)	DEG F (DEG C)	48-111.75	--	--
AI	{13}	RM STPT DIAL	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
BO	14	STPT DIAL	NO	--	Binary	YES	NO
AI	{15}	SUPPLY TEMP	74.0 (23.495556)	DEG F (DEG C)	37.5-165	--	--
BO	18	WALL SWITCH	NO	--	Binary	YES	NO
BI	{19}	DI OVRD SW	OFF	--	Binary	ON	OFF
AO	20	OVRD TIME	0	HRS	0-255	--	--
BO	{21}	NGT OVRD	NIGHT	--	Binary	NIGHT	DAY
BI	{24}	DI 2	OFF	--	Binary	ON	OFF
BI	{25}	DI 5	OFF	--	Binary	ON	OFF
BO	{29}	DAY.NGT	DAY	--	Binary	NIGHT	DAY

Object Type a)	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units) ^{b)}	Eng Units (SI Units)	Range	Active Text	Inactive Text
AO	31	CLG FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	32	CLG FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AO	33	HTG FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	34	HTG FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AI	{35}	AIR VOLUME	0 (0.0)	CFM (LPS)	0-131068	--	--
AO	36	FLOW COEFF	1	--	0-2.55	--	--
AO	{37}	MTR3 COMD	0	PCT	0-102	--	--
AO	{38}	MTR3 POS	0	PCT	0-102	--	--
AO	39	MTR3 TIMING	130	SEC	0-511	--	--
BI	{40}	DI 4	OFF	--	Binary	ON	OFF
BO	{41}	DO 1	OFF	--	Binary	ON	OFF
BO	{42}	DO 2	OFF	--	Binary	ON	OFF
BO	{43}	DO 3	OFF	--	Binary	ON	OFF
BO	{44}	DO 4	OFF	--	Binary	ON	OFF
BO	{45}	DO 5	OFF	--	Binary	ON	OFF
BO	{46}	DO 6	OFF	--	Binary	ON	OFF
AO	{48}	DMPR COMD	0	PCT	0-102	--	--
AO	{49}	DMPR POS	0	PCT	0-102	--	--
AI	{50}	AI 4	74.0 (23.495556)	DEG F (DEG C)	37.5-165	--	--
AO	51	MTR1 TIMING	95	SEC	0-511	--	--
AO	{52}	MTR2 COMD	0	PCT	0-102	--	--
AO	{53}	MTR2 POS	0	PCT	0-102	--	--
AI	{54}	AI3	0	PCT	0-102	--	--
AO	55	MTR2 TIMING	130	SEC	0-511	--	--
AO	56	DMPR ROT ANG	90	--	0-255	--	--
AO	58	MTR SETUP	0	--	0-255	--	--
AO	59	DO DIR. REV	0	--	0-255	--	--
AO	61	COOL TEMP	65.0 (18.455556)	DEG F (DEG C)	37.5-165	--	--
AO	62	HEAT TEMP	80.0 (26.855556)	DEG F (DEG C)	37.5-165	--	--
AO	63	CLG P GAIN	20.0 (36.0)	--	0-63.75	--	--

Object Type ^{a)}	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units) ^{b)}	Eng Units (SI Units)	Range	Active Text	Inactive Text
AO	64	CLG I GAIN	0.01 (0.018)	--	0-1.023	--	--
AO	65	CLG D GAIN	0 (0.0)	--	0-510	--	--
AO	{66}	AOV 1	0	VOLTS	0-10.23	--	--
AO	67	HTG P GAIN	10.0 (18.0)	--	0-63.75	--	--
AO	68	HTG I GAIN	0.01 (0.018)	--	0-1.023	--	--
AO	69	HTG D GAIN	0 (0.0)	--	0-510	--	--
AO	{70}	AOV 2	0	VOLTS	0-10.23	--	--
AO	71	FLOW P GAIN	0	--	0-51.15	--	--
AO	72	FLOW I GAIN	0.01	--	0-1.023	--	--
AO	73	FLOW D GAIN	0	--	0-510	--	--
AO	74	FLOW BIAS	50	PCT	0-102	--	--
AO	{75}	FLOW	0	PCT	0-1023.75	--	--
AO	{76}	CTL FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	{77}	CTL FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AO	{78}	CTL TEMP	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	{79}	CLG LOOPOUT	0	PCT	0-102	--	--
AO	{80}	HTG LOOPOUT	0	PCT	0-102	--	--
BO	{84}	DMPR STATUS	CAL	--	Binary	RECAL	CAL
BO	87	CAL MODULE	NO	--	Binary	YES	NO
AO	{91}	AOV 3	0	VOLTS	0-10.23	--	--
AO	{92}	CTL STPT	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	{93}	FLOW STPT	0	PCT	0-255.75	--	--
BO	{94}	CAL AIR	NO	--	Binary	YES	NO
AO	95	CAL SETUP	4	--	0-255	--	--
AO	96	CAL TIMER	12	HRS	0-255	--	--
AO	97	DUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0-6.375	--	--
AO	98	LOOP TIME	5	SEC	0-255	--	--
AO	{99}	ERROR STATUS	0	--	0-255	--	--
BO	{102}	DO 7	OFF	--	Binary	ON	OFF
BO	{103}	DO 8	OFF	--	Binary	ON	OFF

Object Type ^{a)}	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units) ^{b)}	Eng Units (SI Units)	Range	Active Text	Inactive Text
AO	122	AI 4 OFFSET	0.0 (0.0)	DEG F (DEG C)	-63.75	--	--
AO	123	AI 5 OFFSET	0.0 (0.0)	DEG F (DEG C)	-63.75	--	--
AO	124	STAT SUPV	0	--	0-255	--	--
AI	{125}	RM CO2	1000	PPM	0-8191	--	--
AI	{126}	RM RH	50	PCT	0-102	--	--
BO	{127}	PPCL STATE	EMPTY	--	Binary	LOADED	EMPTY

a) Object Types are; Analog Input (AI), Analog Output (AO), Binary Input (BI) and Binary Output (BO).

b) A single value in a column means that the value is the same in English units and in SI units.

c) Point numbers that appear in brackets { } may be unbundled at the field panel.