Application 2300 Constant Volume with Hot Water Reheat and Humidity Control

Note: For the latest on Custom Solution Applications and Controllers, visit the Custom Solutions website.

Overview

In Application 2300, the controller provides a constant volume of air to the room during occupied periods, and a lower constant volume of air to the room during unoccupied periods. Reheat is provided by modulating a hot water valve heating, and a humidity valve is modulated for humidification. In order for the application to work properly, the central air handling unit must provide pre-conditioned air to the terminal box. Refer to Figures 2300-1 and 2300-2.

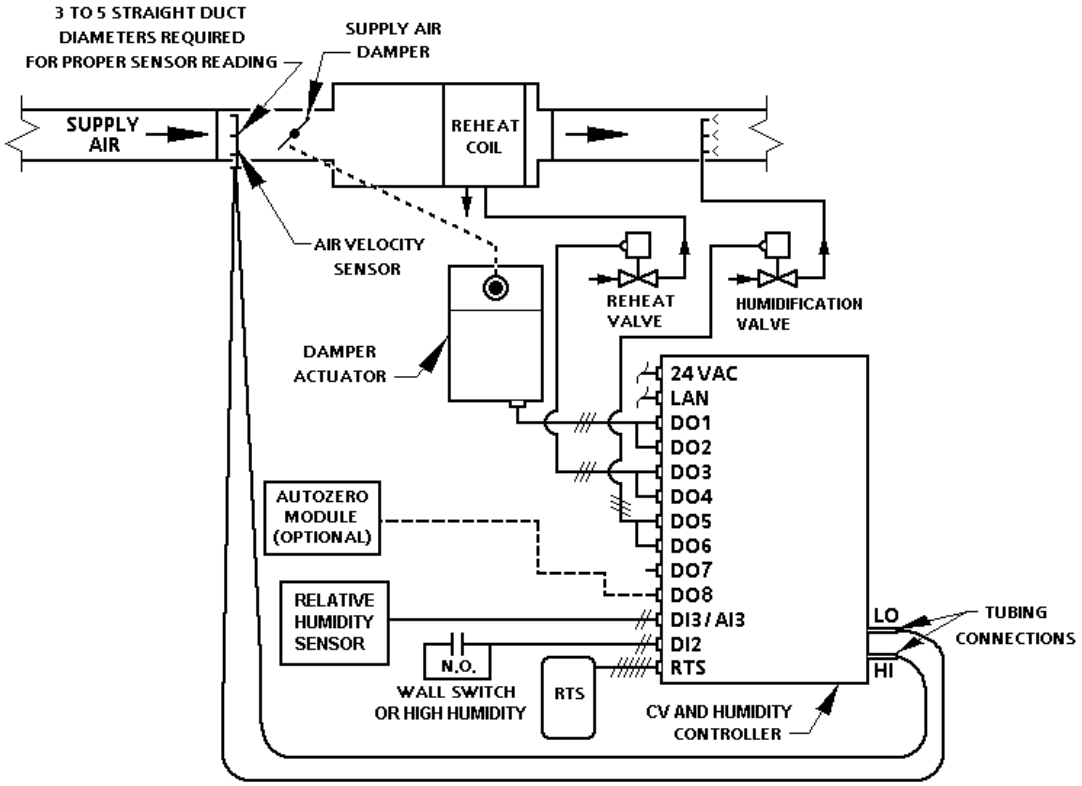
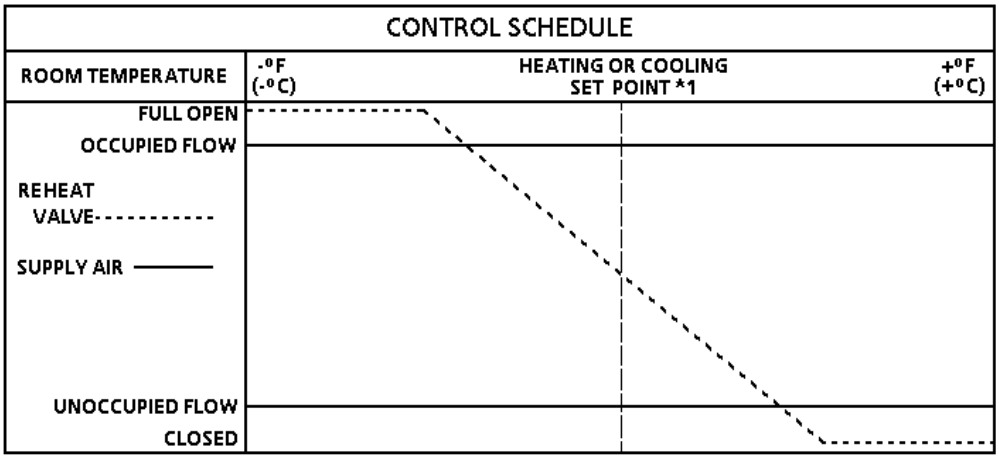


Figure 2300-1. Application 2300 Control Drawing.



NOTES:
1. Refer to Sequence of Operation, “Control Temperature Set Points”.

Figure 2300-2. Application 2300 Control Schedule.

Hardware inputs

analog

- air velocity sensor
- humidity sensor (0-10v or 4-20mA)*
- room temperature sensor
- room temperature set point dial (optional)

digital

- night mode override (optional)
- wall switch or high humidity cut-off (optional)

*Hardware output*s

analog

- none

digital

- Autozero Module (optional)
- damper actuator
- humidity valve actuator (or PTS-4 from ACT for controlling pneumatic valve)
- valve actuator

Ordering notes

Constant Volume and Humidity Controller – Electronic Output
Part Number 540-501 Custom Solution #205

Autozero modules should be used in applications if:

- it is not possible, due to operational restrictions, to calibrate the air velocity transducer by fully closing the damper (e.g., clean rooms, laboratories),
- a minimum position damper stop is used.

Refer to *APOGEE Automation Configuration and Sizing Guidelines* on InfoLink for product numbers.

Autozero Module (optional)
damper actuator
Humidity Sensor
Humidity Valve Actuator
Terminal Equipment Controller room temperature sensor
valve actuator

Point database

Table 2300-1 presents the point database information for Application 2300. Each point number is represented on a line in the point database table.

* A 24 Vdc Power Supply is required to drive the input circuit if a 4-20 mA sensor is used. Refer to the Installation Instructions for this controller.

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2300, “Constant Volume with Hot Water Reheat and Humidity Control”.

Control temperature set points

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

NOTE: Application 2300 will not automatically switch between heating and cooling. If a seasonal switchover (e.g., summer to winter) is to occur, then the field panel must command HEAT.COOL (number 5). This allows the controller to use the appropriate set points for the season.

Occupied Mode – In occupied mode, CTL STPT holds the value of the point OCC CLG STPT (number 6) in cooling mode and the point OCC HTG STPT (number 7) in heating mode. If the room temperature sensor has a set point dial and the point STPT DIAL (number 14) is set to YES, then CTL STPT holds the value of the point RM STPT DIAL (number 13).

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

Unoccupied Mode – In unoccupied mode, CTL STPT holds the value of the point UOC CLG STPT (number 8) in cooling mode and the point UOC HTG STPT (number 9) in heating mode. The set point dial is not used in unoccupied mode.

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

Occupied and unoccupied modes

The occupied/unoccupied status of the space is determined by the status of the point OCC.UNOCC (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 2300-1 and 2300-3), and the point WALL SWITCH (number 18) equals YES, the controller monitors the status of DI 2. When the status of the point DI 2 (number 24) is ON (the switch is closed), then OCC.UNOCC will be set to OCC indicating that the controller is in occupied mode. When the status of DI 2 is OFF (the switch is open), then OCC.UNOCC will be set to UNOCC indicating that the controller is in unoccupied mode.

When WALL SWITCH equals NO, the controller uses DI 2 as a humidity safety cutoff. Refer to *Fail-safe operation.*

Unoccupied 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 the point OVRD TIME (number 20), then by pressing the override switch a room occupant can reset the controller to occupied operational mode for the amount of time that is set in OVRD TIME. The status of the point UNOCC OVRD (number 21) changes to OCC. After the override time elapses, the controller returns to unoccupied mode and the status of UNOCC OVRD changes back to UNOCC.

It is only when the controller is in unoccupied mode that the override switch on the room temperature sensor will have any effect on the controller.

Control loops

Flow Loop – The flow loop maintains FLOW STPT (number 93) by modulating the supply air damper point, DMPR COMD (number 48). The flow loop maintains the air flow at either OCC FLOW (number 32) or UNOCC FLOW (number 31) depending on the value of OCC.UNOCC.

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 (LPS) and OCC FLOW In the following text, this percentage will be referred to as % flow.

- If AIR VOLUME equals 0 CFM (LPS), then FLOW is 0% flow.
- If AIR VOLUME equals OCC FLOW, then FLOW is 100% flow.

The FLOW STPT percentage that corresponds to UNOCC FLOW is calculated as: (UNOCC FLOW ÷ OCC FLOW) × 100% flow.

For example: If,

UNOCC FLOW equals 250 CFM, and if OCC FLOW equals 1000 CFM

then, in unoccupied mode the FLOW STPT

= (250 CFM ÷ 1000 CFM) × 100% flow
= 0.25 × 100% flow
= 25% flow

Since 25% of 1000 CFM equals 250 CFM, the flow set point in unoccupied mode will be 25%.
UNOCC FLOW can be set less than or equal to, but not greater than OCC FLOW.

Temperature Loop – The temperature loop will modulate the point HTG LOOPOUT (number 80) and control the hot water valve in order to maintain the room temperature in both heating and cooling modes.

Humidity Loop – The humidity loop and its associated control algorithm maintain the relative humidity, ROOM RH (number 15), at its setpoint, ROOM RH STPT (number 16). The humidity loop itself controls the specific humidity using the points SPEC HUM (number 26) and SPH CTL SET (number 28) by modulating the humidity valve. The specific humidity setpoint is reset to control relative humidity.

Relative humidity is affected by both the quantity of moisture in the air (specific humidity) and the temperature of the air. When the room temperature changes (rises), the relative humidity changes (decreases), even though the amount of moisture in the air stays the same. This is because relative humidity is the percentage ratio between the amount of moisture is in the air and the amount of moisture the air can hold at a particular temperature. When the temperature rises, it is capable of holding more moisture, so the percentage ratio drops.

By controlling specific humidity, some of this interaction between temperature and relative humidity is eliminated. When the temperature setpoint is raised, the specific humidity setpoint is automatically recalculated to a higher level. This new level corresponds to the amount of moisture necessary to keep the relative humidity at its setpoint when the temperature reaches its new setpoint. The result is that both the temperature and the specific humidity will rise at the same time, while the relative humidity will stay constant.

The specific humidity and the specific humidity setpoint are constantly recalculated using the relative humidity and temperature readings and the relative humidity and temperature setpoints.

Hot water reheat

The temperature loop modulates the heating valve in order to maintain the room temperature set point. The reheat valve will be modulated whenever necessary to maintain the room temperature regardless of the status of HEAT.COOL (number 5).

Calibration

Calibration of the controller's internal air velocity transducer 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 air flow reading during calibration.
- For a controller used with an Autozero Module (CAL MODULE = YES), calibration occurs without closing the damper.

NOTE: The first time after start-up or initialization, the controller will calibrate the damper as if not using an Autozero Module, although the Autozero Module will be activated. All subsequent calibrations will use the Autozero Module only.

Hot Water and Humidity Valves – Calibration of the valves is done by commanding the valves to closed.

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.

The Autozero Module is enabled when it is wired to DO 8 and the point CAL MODULE (number 87) is set to YES.

Damper status operation

Under normal operation the point DMPR STATUS (number 84) reads “CAL”. However, when 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 velocity (AIR VOLUME (number 35) ÷ DUCT AREA (number 97)) > 200 FPM
FLOW (number 75) < FLOW STPT (number 93)

- or -

DMPR POS = 0%
Air velocity (AIR VOLUME ÷ DUCT AREA) > 200 FPM
FLOW > FLOW STPT

If DMPR STATUS has been changed to “RECAL” in response to one of the conditions described above, then do one of the following:

1. If flow is now being properly controlled, then set DMPR STATUS to “CAL” and release it.

2. If flow is still not being properly controlled (i.e., one of the conditions described above is still present) or if it is important that the damper position be accurate, then initialize the controller.

If these steps do not fix the problem of maintaining flow, then a mechanical problem might exist.

Temperature and Humidity Interaction Protection

Under most conditions the interaction between temperature and relative humidity is prevented because specific humidity is used as the loop input instead of relative humidity (refer to *Control loops*). Occasionally, additional protections are needed to prevent potentially hazardous conditions.

In some circumstances, the temperature loop is held constant while the humidity loop operates. In other circumstances, the humidity loop is held constant while the temperature loop operates. This protection only takes place when allowing both loops to operate simultaneously may lead to dangerously high or low relative humidity levels.

The temperature loop is held still under the following conditions:

1. Both temperature and humidity are low, and both temperature and humidity setpoints are raised, or the temperature setpoint is raised while the relative humidity is more than RH LIMIT (number 83) below its setpoint.

If both loops are allowed to operate, the temperature loop may move faster than the humidity loop, which would cause the relative humidity to dip to unacceptably low levels.

2. Both temperature and humidity are high, and both temperature and humidity setpoints are lowered, or the temperature setpoint is lowered while the relative humidity is more than RH LIMIT above its setpoint.

   If both loops are allowed to operate, the temperature loop may move faster than the humidity loop, which would cause the relative humidity to rise to unacceptably high levels.

The humidity loop is held constant under the following conditions (these are more rare):

1. Temperature is low and humidity is high, both temperature and humidity setpoints are raised, and the relative humidity setpoint, although it has been raised, is still far below the relative humidity.

   It is possible that the specific humidity needs to increase to meet the new setpoint requirements, although the relative humidity needs to decrease. The humidity loop is held constant until the relative humidity is within RH LIMIT of the relaive humidity setpoint to prevent the relative humidity from going even higher. This condition might occur in the winter on a night-to-day changeover.

2. Temperature is high and humidity is low, both temperature and humidity setpoints are lowered, and the relative humidity setpoint, although it has been lowered, is still far above the relative humidity.

   It is possible that the specific humidity needs to decrease to meet the new setpoint requirements, although the relative humidity needs to increase. The humidity loop is held constant until either the temperature reaches its setpoint, or the relative humidity is within RH LIMIT of the relative humidity setpoint to prevent the relative humidity from dropping any further.

Fail-safe operation

If the air velocity sensor fails, then the controller determines the status of the point FAIL MODE (number 40) and positions the damper accordingly. If FAIL MODE equals OPEN and the velocity sensor fails, then the damper will open. If FAIL MODE equals CLOSED (the default) and the velocity sensor fails, then the damper will close.

If the room temperature sensor fails, then the controller holds the last known temperature value.

If the point WALL SWITCH (number 18) is set to NO, then if DI2 is closed the humidity valve will be closed and the humidity loop suspended to prevent wind-up. DI 2 is used to indicate a high duct humidity or a low duct flow.

If the point AIR VOLUME (number 35) falls below the value held in LOW FLOW (number 30), the humidity valve will be closed to prevent condensation in the duct. The air volume must then rise above the value held in UNOCC FLOW (number 31) for the humidity control to be re-enabled.

Application notes

1. If the temperature swings in the room are excessive, or if there is trouble in maintaining the room temperature set point, then the temperature loop needs to be tuned. If the point FLOW (number 73) is oscillating while the point FLOW STPT (number 93) is constant, then the flow loop requires tuning. Refer to *APOGEE Automation Maintenance and Troubleshooting Manual* on InfoLink for more information.

2. The Constant Volume and Humidity Controller – Electronic Output, as shipped from the factory, keeps all associated equipment OFF. Refer to *Start-up* document for this application 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. If not using a heating valve, then the combination of DO 3 and DO 4 may be used as auxiliary motor points. If using this pair of spare DOs to control a motor, you must unbundle the point VLV COMD (number 52) and set the point MTR SETUP (number 58) as described in the *Start-up* document for this application.

Wiring diagram The point wiring for Application 2300 is shown in Figure 2300-3.

CAUTION:
The Controller' 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 220V relay module.

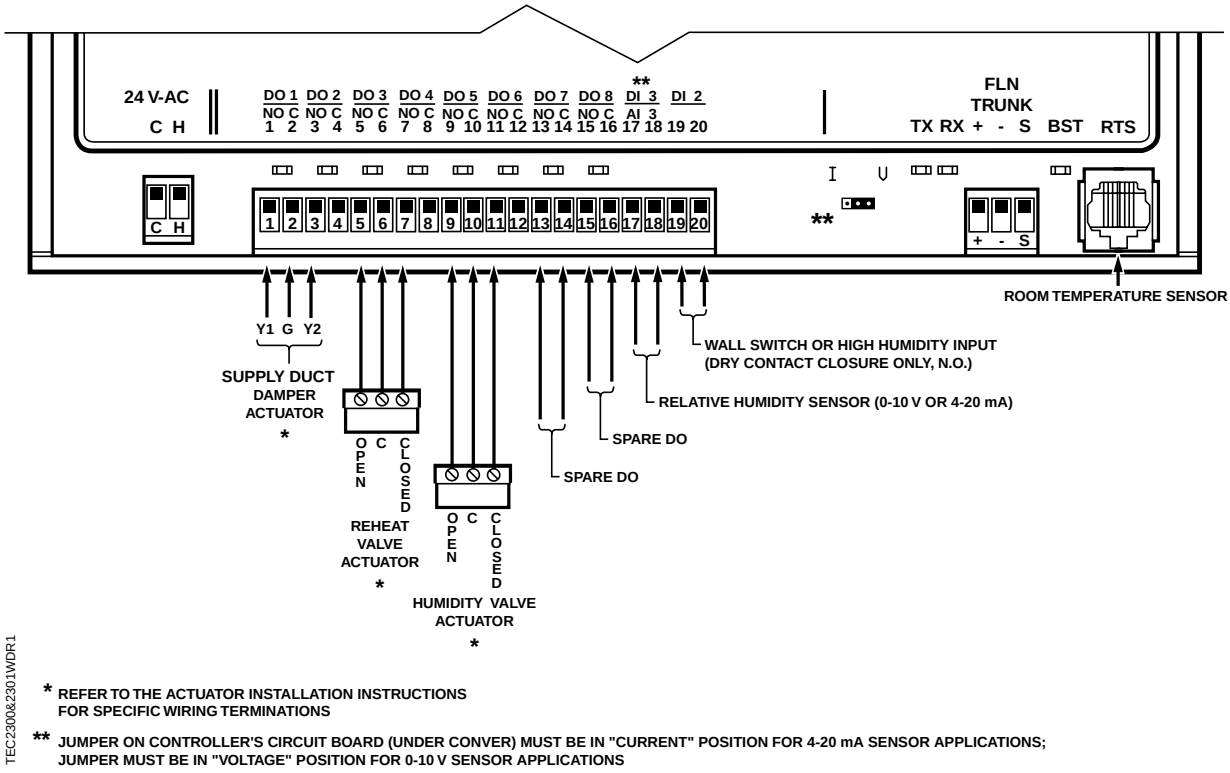


Figure 2300-3. Application 2300 Wiring Diagram.

CAUTION:

IMPORTANT! If a 4-20mA sensor is used at AI 3, special wiring precautions must be followed. See Figure 2300-4.

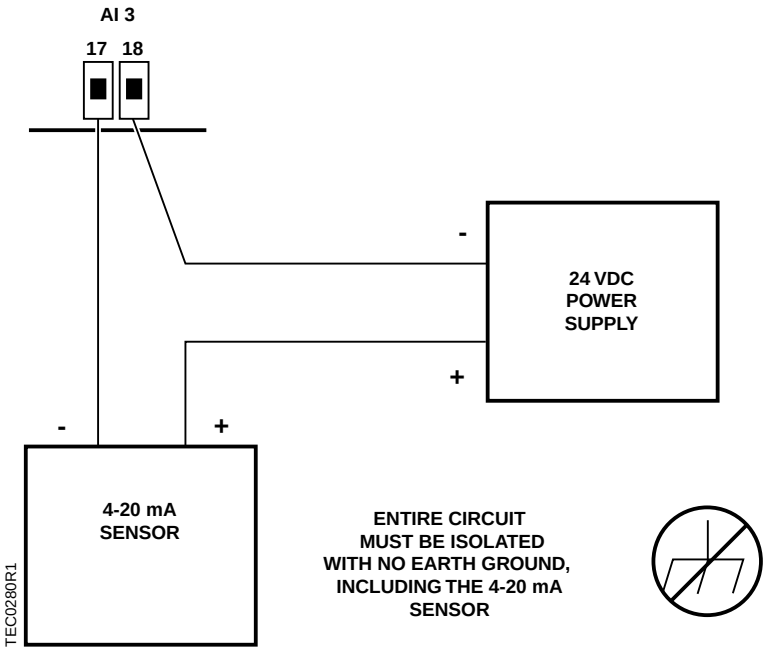


Figure 2300-4. Special Wiring Requirements if 4-20mA sensor used at AI 3.

CAUTION:

You can NOT use the same transformer to power the TEC and the 4-20 mA sensor(s). A **SEPARATE** power supply is required for the 4-20 mA sensor(s).

Table 2300-1. Point Database for Application 2300.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
01	CTLR ADDRESS	99.000	--	1.000	0.000	--	--
02	APPLICATION	2092	--	1.000	0.000	--	--
{04}	ROOM TEMP	74.000 (23.449)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
{05}	HEAT.COOL	COOL	--	--	--	HEAT	COOL
06	OCC CLG STPT	70.000 (21.109)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
07	OCC HTG STPT	70.000 (21.109)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
08	UOC CLG STPT	65.000 (18.409)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
09	UOC HTG STPT	65.000 (18.409)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
11	RM STPT MIN	55.000 (12.809)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
12	RM STPT MAX	90.000 (32.409)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
{13}	RM STPT DIAL	74.000 (23.449)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
14	STPT DIAL	NO	--	--	--	YES	NO
{15}	ROOM RH	29.2	PCT	0.400	0.000	--	--
{16}	ROOM RH STPT	50.0	PCT	0.400	0.000	--	--
18	WALL SWITCH	NO	--	--	--	YES	NO
{19}	DI OVRD SW	OFF	--	--	--	ON	OFF
20	OVRD TIME	0.000	HRS	1.000	0.000	--	--
{21}	UNOCC OVRD	UNOCC	--	--	--	UNOCC	OCC
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
{26}	SPEC HUM	0.0		0.100	0.000	--	--
{27}	SPEC HUM STPT	0.0		0.100	0.000	--	--
{28}	SPH CTL SET	50.0		0.100	0.000	--	--
{29}	OCC.UNOCC	OCC	--	--	--	UNOCC	OCC
30	LOW FLOW	220.000 (103.818)	CFM (LPS)	4.000 (1.888)	0.000	--	--
{31}	UNOCC FLOW	220.000 (103.818)	CFM (LPS)	4.000 (1.888)	0.000	--	--
{32}	OCC FLOW	2200.000 (1038.180)	CFM (LPS)	4.000 (1.888)	0.000	--	--
{35}	AIR VOLUME	0.000	CFM (LPS)	4.000 (1.888)	0.000	--	--
36	FLOW COEFF	1.000	--	0.010	0.000	--	--
{37}	HMD VLV CMD	0.0	PCT	0.400	0.000	--	--
{38}	HMD VLV POS	0.0	PCT	0.400	0.000	--	--
39	MTR3 TIMING	90.000	SEC	1.000	0.000	--	--

NOTES:
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 2300-1. Point Database for Application 2300.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
40	FAIL MODE	CLOSED	--	--	--	CLOSED	OPEN
{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
{47}	DO 7	OFF	--	--	--	ON	OFF
{48}	DMPR COMD	0.000	PCT	0.400	0.000	--	--
{49}	DMPR POS	0.000	PCT	0.400	0.000	--	--
{50}	DO 8	OFF	--	--	--	ON	OFF
51	MTR1 TIMING	95.000	SEC	1.000	0.000	--	--
{52}	VLV COMD	0.000	PCT	0.400	0.000	--	--
{53}	VLV POS	0.000	PCT	0.400	0.000	--	--
54	AI3 VOLT.CUR	CURENT	--	--	--	VOLT	CURENT
55	MTR2 TIMING	90.000	SEC	1.000	0.000	--	--
56	DPR1 ROT ANG	90.000	--	1.000	0.000	--	--
58	MTR SETUP	0.000	--	1.000	0.000	--	--
59	DO DIR.REV	0.000	--	1.000	0.000	--	--
65	HTG P GAIN	10.000 (18.000)	--	0.250 (0.450)	0.000	--	--
66	HTG I GAIN	0.012 (0.022)	--	0.001 (0.002)	0.000	--	--
67	HTG D GAIN	0.000	--	2.000 (3.600)	0.000	--	--
68	HTG BIAS	0.000	PCT	0.400	0.000	--	--
69	FLOW P GAIN	0.250	--	0.050	0.000	--	--
70	FLOW I GAIN	0.018	--	0.001	0.000	--	--
71	FLOW D GAIN	0.000	--	2.000	0.000	--	--
72	FLOW BIAS	50.000	PCT	0.400	0.000	--	--
{73}	FLOW	0.000	PCT	0.250	0.0000	--	--
74	SPH P GAIN	5.000 (9.000)	--	0.250 (0.450)	0.000	--	--
75	SPH I GAIN	0.005 (0.009)	--	0.001 (0.0018)	0.000	--	--
76	SPH D GAIN	0.000	--	2.000 (3.600)	0.000	--	--
77	SPH BIAS	0.000	PCT	0.400	0.000	--	--
{78}	CTL TEMP	74.000 (23.449)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--

NOTES:
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 2300-1. Point Database for Application 2300.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{80}	HTG LOOPOUT	0.000	PCT	0.400	0.000	--	--
83	RH LIMIT	2.000	PCT	0.400	0.000	--	--
{84}	DMPR STATUS	CAL	--	--	--	RECAL	CAL
87	CAL MODULE	NO	--	--	--	YES	NO
{91}	TOTAL VOLUME	0.000	CF (L)	4.000 (113)	0.000	--	--
{92}	CTL STPT	74.000 (23.449)	DEG F (DEG C)	0.250 (0.140)	48.000 (8.889)	--	--
{93}	FLOW STPT	0.000	PCT	0.250	0.000	--	--
{94}	CAL AIR	NO	--	--	--	YES	NO
95	CAL SETUP	4.000	--	1.000	0.000	--	--
96	CAL TIMER	12.000	HRS	1.000	0.000	--	--
97	DUCT AREA	1.000 (0.093)	SQ. FT (SQ M)	0.025 (0.002)	0.000	--	--
98	LOOP TIME	5.000	SEC	1.000	0.000	--	--
99	ERROR STATUS	--	--	--	--	--	--

NOTES:

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.