

Application 2326 Single Compressor Heat Pump with Reversing Valve Control and Dehumidification Sequence

Overview

In Application 2326, the controller controls a one compressor heat pump with a reversing valve. In addition to a compressor, this heat pump must be equipped with electric heat for auxiliary heat. A dehumidification sequence is included where on a call for dehumidification the compressor is turned ON in cooling mode and the electric heat is used to control temperature. Refer to Figures 2326-1 and 2326-2.

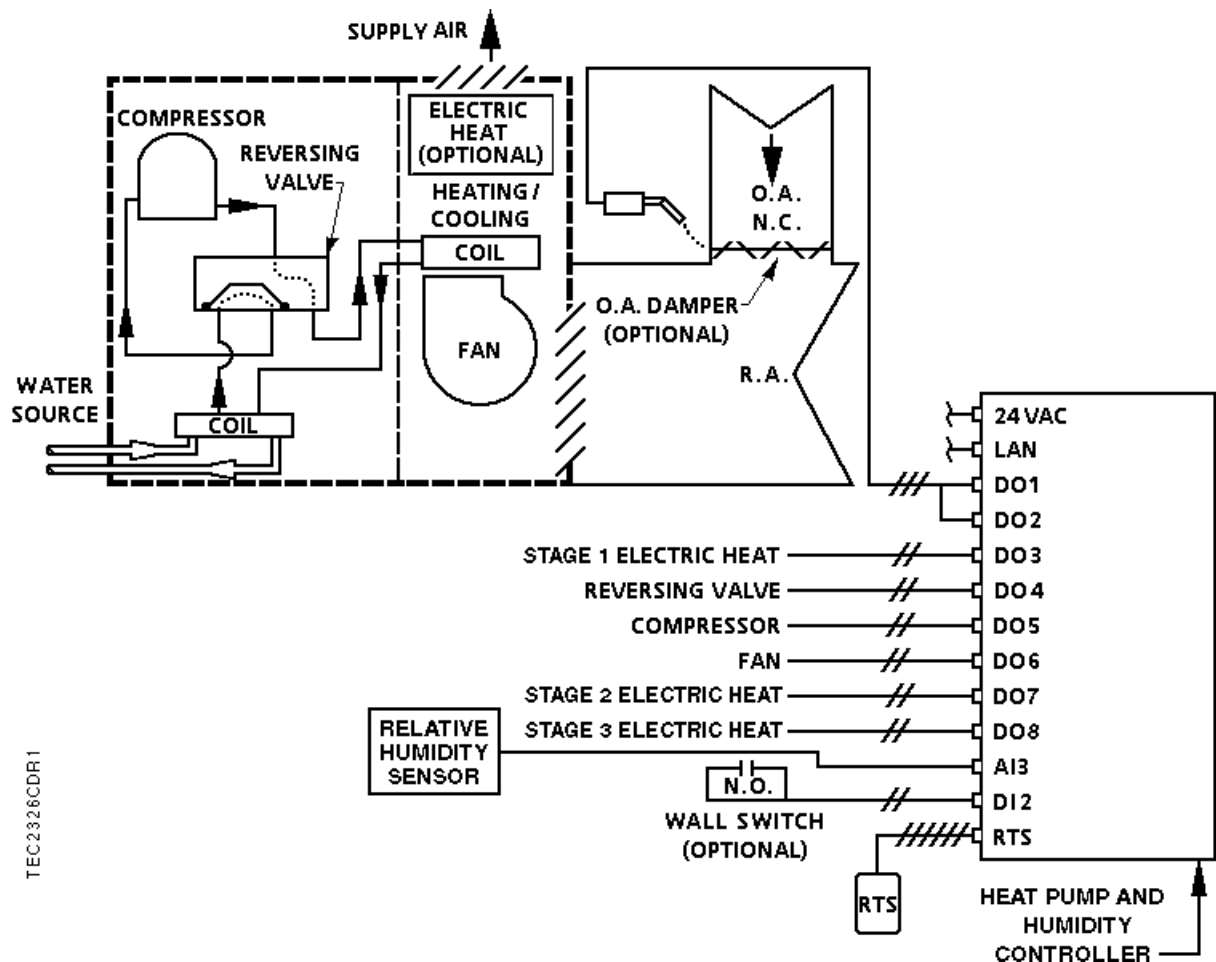
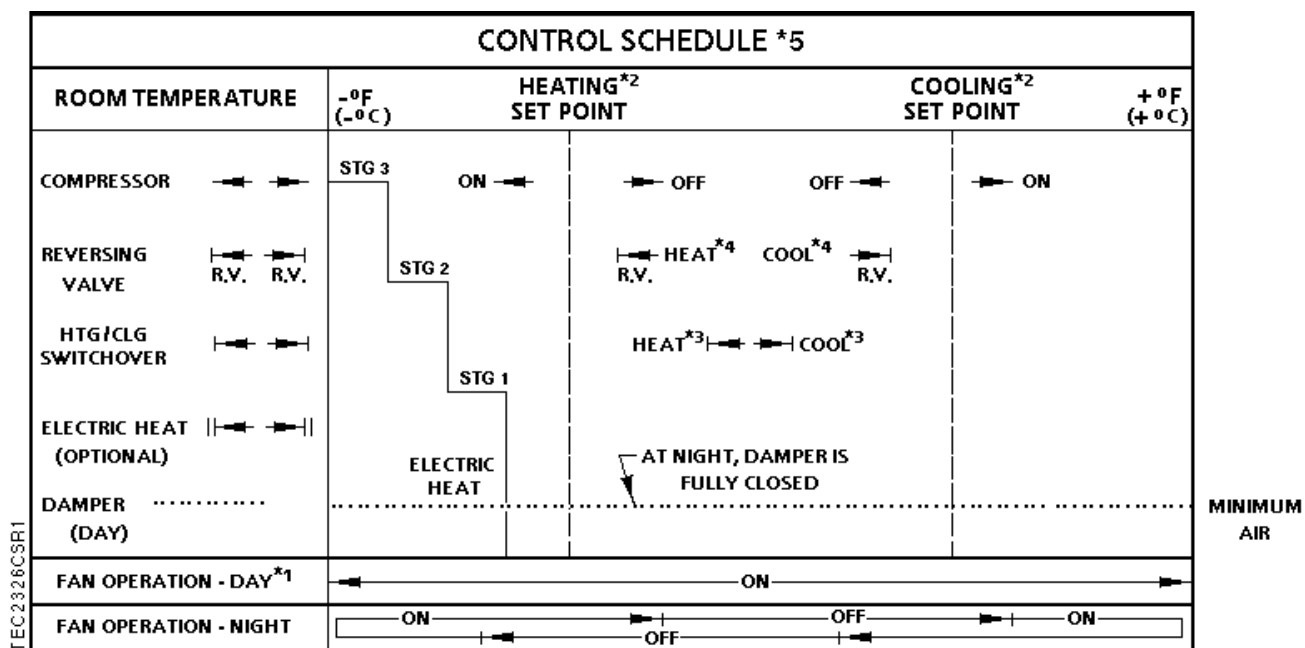


Figure 2326-1. Application 2326 Control Drawing.

**NOTES:**

1. Refer to Sequence of Operation, "Fan Operation".
2. Refer to Sequence of Operation, "Control Temperature Set Points".
3. Refer to Sequence of Operation, "Heating/Cooling Switchover".
4. Refer to Sequence of Operation, "Compressor Operation".
5. This control schedule applies when dehumidification mode is not active. Refer to "Dehumidification Mode" for the sequence when dehumidifying.

Figure 2326-2. Application 2326 Control Schedule.

*Hardware inputs***analog**

- relative humidity (0-10 V or 4-20 mA)
- room temperature sensor
- room temperature set point dial (optional)

digital

- night mode override (optional)
- wall switch (optional)

*Hardware outputs***analog**

- none

digital

- compressor
- damper actuator (floating control) (optional)
- fan
- reversing valve
- stage 1 electric heat
- stage 2 electric heat
- stage 3 electric heat

Point database

Table 2326-1 presents the point database information for Application 2326.

Sequence of Operation

Control temperature set points

The following paragraphs present the sequence of operation for Application 2326, "Single Compressor Heat Pump with Reversing Valve Control and Dehumidification Sequence".

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

Day Mode – In day mode, CTL STPT holds the value of the point DAY CLG STPT (number 6) or the point DAY HTG STPT (number 7). 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.

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

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.

Day and night modes

The day/night status of the space is determined by the status of the point DAY.NGT (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 2326-1 and 2326-4), 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 DAY.NGT will be set to DAY indicating that the controller is in day mode. When the status of DI 2 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 equals 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 the point DAY.NGT. Refer to *Powers Process Control Language (PPCL) User's Manual* (125-1896) and *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 the point OVRD TIME (number 20), then by pressing the override switch a room occupant can reset the controller to day operational mode for the amount of time that is set in OVRD TIME. The status of the point NGT OVRD (number 21) changes to DAY. After the override time elapses, the controller returns to night mode and the status of NGT OVRD changes back to NIGHT.

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

Heating/cooling switchover

The heating/cooling switchover determines whether the controller is in heating or cooling mode by monitoring the room temperature and the demand for heating and cooling (as determined by the temperature control loops).

If the following conditions are met for the length of time set in the point SWITCH TIME (number 86), then the controller switches from heating to cooling mode by setting the point HEAT.COOL (number 5) to COOL:

- The point HTG LOOPOUT (number 80) is less than the point SWITCH LIMIT (number 85).
- The point CTL TEMP (number 78) is above the point CTL STPT (number 92) by at least the value set in the point SWITCH DBAND (number 90).
- CTL TEMP is greater than the appropriate cooling set point minus SWITCH DBAND.

If the following conditions are met for the length of time set in SWITCH TIME, then the controller switches from cooling to heating mode by setting HEAT.COOL to HEAT:

- The point CLG LOOPOUT (number 79) is less than SWITCH LIMIT.
- CTL TEMP is below CTL STPT by at least the value set in SWITCH DBAND.
- CTL TEMP is less than the appropriate heating set point plus SWITCH DBAND.

Control loops

The heat pump is controlled by two Proportional, Integral, and Derivative (PID) control loops: a cooling loop and a heating loop.

Temperature Loops – The two temperature loops are a cooling loop and a heating loop and the value of the point HEAT.COOL (number 5) determines which is active. The active temperature loop maintains room temperature at the value in the point CTL STPT (number 92). Refer to “Control Temperature Set Points”. The inputs to the temperature loops are the points CTL TEMP (number 78) and CTL STPT. The outputs are the points CLG LOOPOUT (number 79) and HTG LOOPOUT (number 80).

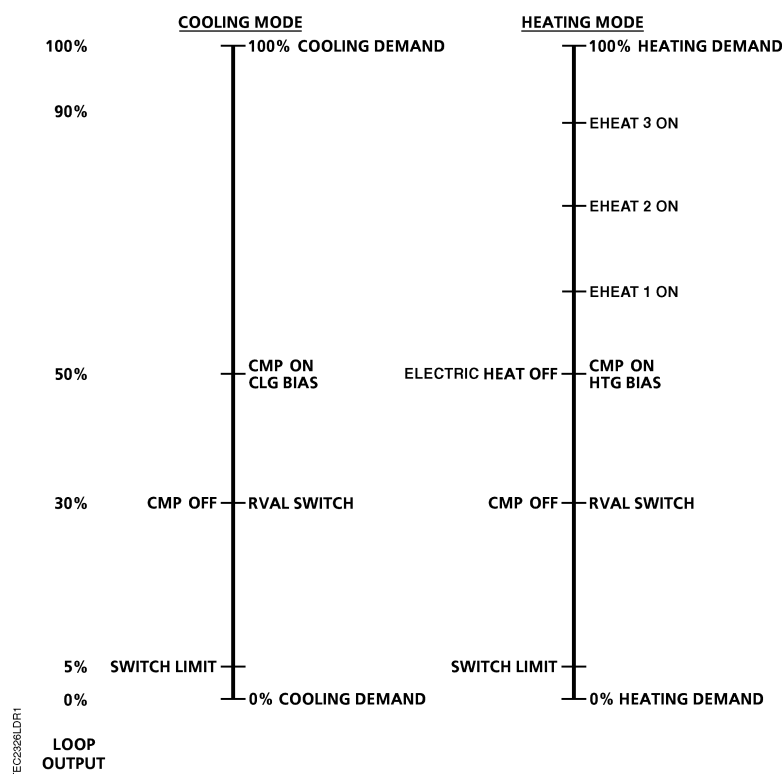


Figure 2326-3. Heating and Cooling Loops.

These two loops perform the overall sequencing of the heat pump equipment; they determine when to turn the compressor, fan, and electric heat ON and OFF.

NOTE: The values used in this diagram are for example purposes only. They may be set to different values to suit your specific needs.

*Equipment sequencing
with dehumidification
mode inactive*

In heating mode, as the room temperature drops below the heating set point, the heating loop calls for more heating (the heating loop output rises). In cooling mode, if the room temperature rises above the cooling set point, the cooling loop calls for more cooling (the cooling loop output rises). The output of the inactive loop will remain at zero. Refer to Figure 2326-3.

The ladder diagrams in Figure 2326-3 show the heating and cooling loop sequencing of one compressor with three stages of electric heat. The diagrams show the outputs of the heating and cooling loops as vertical bars from 0 to 100%. The right side of each ladder diagram reflects a rising loop output. The left side of each ladder diagram reflects a falling loop output.

No action occurs when the loop outputs rise above or drop below the values of the points CLG BIAS (number 66) and HTG BIAS (number 70). The purpose of these points is to provide a starting place for the loops at startup.

CLG LOOPOUT – The value of CLG LOOPOUT must be greater than the value stored in the point RVAL SWITCH (number 84) before the reversing valve will switch from heating to cooling. When the reversing valve is in cooling mode, the compressor operates as a cooling compressor.

The value of the point COMPRESSOR (number 45) will not be allowed to turn ON until CLG LOOPOUT becomes greater than the value of the point CMP ON (number 82). COMPRESSOR will not be allowed to turn OFF until CLG LOOPOUT drops below the value of the point CMP OFF (number 83).

When CLG LOOPOUT drops below the value of the point SWITCH LIMIT (number 85), the controller will be allowed to change to heating mode if all other criteria for the change have been met.

HTG LOOPOUT – The value of HTG LOOPOUT must be greater than the value stored in RVAL SWITCH before the reversing valve will switch from cooling to heating. When the reversing valve is in heating mode, the compressor operates as a heating compressor. COMPRESSOR will not be allowed to turn ON until HTG LOOPOUT becomes greater than CMP ON.

COMPRESSOR will not be allowed to turn OFF until HTG LOOPOUT drops below CMP OFF.

When HTG LOOPOUT drops below the value of SWITCH LIMIT, the controller will be allowed to change to cooling mode if all other criteria for the change have been met.

*Equipment sequencing
in dehumidification
mode*

Dehumidification mode is active when the point DEHUM MODE (number 22) equals ON.

In cooling mode, the reversing valve is kept in the cooling position and the compressor is turned ON, obeying the minimum off-time. The compressor is kept ON throughout dehumidification mode. Although the heating loop is not run in cooling mode, the point HTG LOOPOUT (number 80) is set equal to 100% - the point CLG LOOPOUT (number 79), allowing the electric heat to be controlled by the cooling loop.

In heating mode, the compressor is turned OFF (obeying the minimum on-time), the reversing valve is switched to the cooling position (obeying the point RVAL SW TIME (number 89)), and the compressor is turned back on again (obeying the minimum off-time). The electric heat is controlled by HTG LOOPOUT as described in "Electric Heat".

*Dehumidification
mode control*

When the point ROOM RH (number 15) rises above the point RH STPT (number 34), the point DEHUM MODE (number 22) is set to YES and the dehumidification sequence is initiated. When ROOM RH drops more than RH DBAND (number 35) percent below RH STPT, DEHUM MODE is set to NO, and normal control resumes.

*Reversing valve
operation*

NOTE: To prevent damage to the heat pump, the point REV VALVE (number 44) is not operator commandable at the portable operator's terminal or the field panel.

The status of REV VALVE determines the operation of the heat pump's compressors (heating or cooling).

The reversing valve changes from heating to cooling when all of the following conditions have been met:

- The point HEAT.COOL (number 5) equals COOL.
- The compressor has been OFF longer than the time stored in the point RVAL SW TIME (number 89).
- The point CLG LOOPOUT (number 79) is greater than the value set in the point RVAL SWITCH (number 84).

- or -

- The point DEHUM MODE (number 22) equals YES.
- The compressor has been off longer than the time stored in the point RVAL SW TIME (number 89).

The reversing valve changes from cooling to heating when all of the following conditions have been met:

- DEHUM MODE equals NO.
- HEAT.COOL equals HEAT.
- The compressor has been OFF longer than the time stored in RVAL SW TIME.
- The point HTG LOOPOUT (number 80) is greater than the value set in RVAL SWITCH.

Compressor operation

NOTE: To prevent damage to the heat pump, the point COMPRESSOR (number 45) is not operator commandable at the portable operator's terminal or the field panel.

The following holds true when the point DEHUM MODE (number 22) equals NO:

When the points HEAT.COOL (number 5) and REV VALVE (number 44) are both in cooling mode, the output of the cooling loop controls the staging of the compressor.

When HEAT.COOL and REV VALVE are both in heating mode, the output of the heating loop controls the staging of the compressor.

When HEAT.COOL and REV VALVE are in opposite states, the compressor is turned OFF. If a compressor has been ON it will not shut OFF until its minimum ON timer has expired. The following paragraphs explain the compressor staging.

If the loop that is currently active (either the point CLG LOOPOUT (number 79) or the point HTG LOOPOUT (number 80)), is greater than the point CMP ON (number 82) and the compressor has been OFF for at least the time set in the point CMP MIN OFF (number 87), then COMPRESSOR is turned ON.

COMPRESSOR is turned OFF when the loop currently under control is less than the point CMP OFF (number 83) provided the following conditions have been met:

- The compressor has been ON for at least the time set in the point CMP MIN ON (number 88).
- All stages of electric heat are OFF for more than 30 seconds.

The following holds true when DEHUM MODE equals YES:

If HEAT.COOL equals COOL, then the compressor is turned ON (obeying the minimum off-time requirement).

If HEAT.COOL equals HEAT, then the compressor, if ON, is turned OFF (obeying the minimum on-time requirement).

After the reversing valve changes to COOL, the compressor is turned back ON again (obeying the minimum off-time requirement).

Electric heat

NOTE: To prevent damage to the heat pump, the points EHEAT 1 DO 3 (number 43), EHEAT 2 DO 7 (number 47), and EHEAT 3 DO 8 (number 50) are not operator commandable at the portable operator's terminal or the field panel.

If the reversing valve is in cooling mode and the point DEHUM MODE (number 22) equals NO, then the electric heat is OFF.

If the reversing valve is in heating mode or if DEHUM MODE equals YES, then EHEAT 1 DO 3 turns ON when the point HTG LOOPOUT (number 80) is greater than the value of the point EHEAT 1 ON (number 81). EHEAT 1 DO 3 turns OFF when HTG LOOPOUT is less than the point CMP ON (number 82).

If the reversing valve is in heating mode or if DEHUM MODE equals YES, EHEAT 2 DO 7 turns ON when HTG LOOPOUT is greater than the value of the point EHEAT 2 ON (number 94). EHEAT 2 DO 7 turns OFF when HTG LOOPOUT is less than EHEAT 1 ON.

If the reversing valve is in heating mode or if DEHUM MODE equals YES, EHEAT 3 DO 8 turns ON when HTG LOOPOUT is greater than the value of the point EHEAT 3 ON (number 95). EHEAT 3 DO 8 turns OFF when HTG LOOPOUT is less than EHEAT 2 ON.

Fan operation

NOTE: To prevent damage to the heat pump, the point FAN (number 46) is not operator commandable at the portable operator's terminal or the field panel.

In day mode, FAN is ON when the point CYCLE FAN (number 60) equals NO. If CYCLE FAN equals YES, then the fan control in day mode is the same as it is in night mode.

In night mode, FAN cycles ON with the compressor. The fan does not shut OFF until the compressor and the electric heat have been OFF for 30 seconds.

Damper operation (optional)

If the heat pump has a damper, it is set at the value of the point DMPR MIN POS (number 10) during day mode and is fully closed during night mode.

Power failure recovery

Upon return from a power failure, the heating and cooling compressors are kept OFF, the optional electric heat (if used), is kept OFF and the fan is kept OFF. In addition to the equipment being OFF, both points, CLG LOOPOUT (number 79) and HTG LOOPOUT (number 80) are set to 0. This situation will remain in effect until the power failure recovery period is over for this controller.

The controller returns to normal control when its power failure recovery period is over. The power failure recovery time for a heat pump is based on the following formula:

$$\text{RETURN DELAY} + (\text{CTLR ADDRESS} \times 10 \text{ seconds})$$

The point RETURN DELAY (number 3) is useful for water to air heat pumps because it allows the central equipment to be running before the heat pumps start coming back on-line. This gives the water loop a chance to stabilize its temperature before the compressors start using it and therefore minimizes the chance that the heat pumps will trip the high temperature/pressure alarms.

The point CTLR ADDRESS (number 1) is used so the power failure recovery time of the controllers will be different from each other even if they all have the same value for RETURN DELAY. This lessens the demand penalty of having all the electrical equipment starting at once.

Overriding DOs

This application is designed to prevent you from directly commanding critical DOs ON or OFF. Specifically, the fan, reversing valve, stages of electric heat, and compressor cannot be directly commanded ON or OFF. Commanding these DOs can only be done indirectly by overriding the output of the loop currently under control (either the point CLG LOOPOUT (number 79) or the point HTG LOOPOUT (number 80)). This is done to protect the equipment.

You will be able to directly turn any spare DOs ON or OFF. Also, you will always be able to command the damper via the point DMPR COMD (number 48).

Fail-safe operation

If the room temperature sensor or the set point dial fails, then the controller operates using the last known temperature value.

Application notes

1. If the heat pump cycles excessively, 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. Refer to *System 600 Maintenance and Troubleshooting Manual* (125-1855) for more information.
2. The Heat Pump and Humidity Controller, as shipped from the factory, keeps all associated equipment OFF. Refer to the "Equipment Controllers" tab in *System 600 Start-up Manual* (125-1851) for information on how to release the controller and its equipment to application control.

Wiring diagram

The point wiring for Application 2326 is shown in Figure 2326-4.

**CAUTION:**

The Heat Pump and Humidity Controller controls 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 220 V 4-relay module (P/N 540-147).

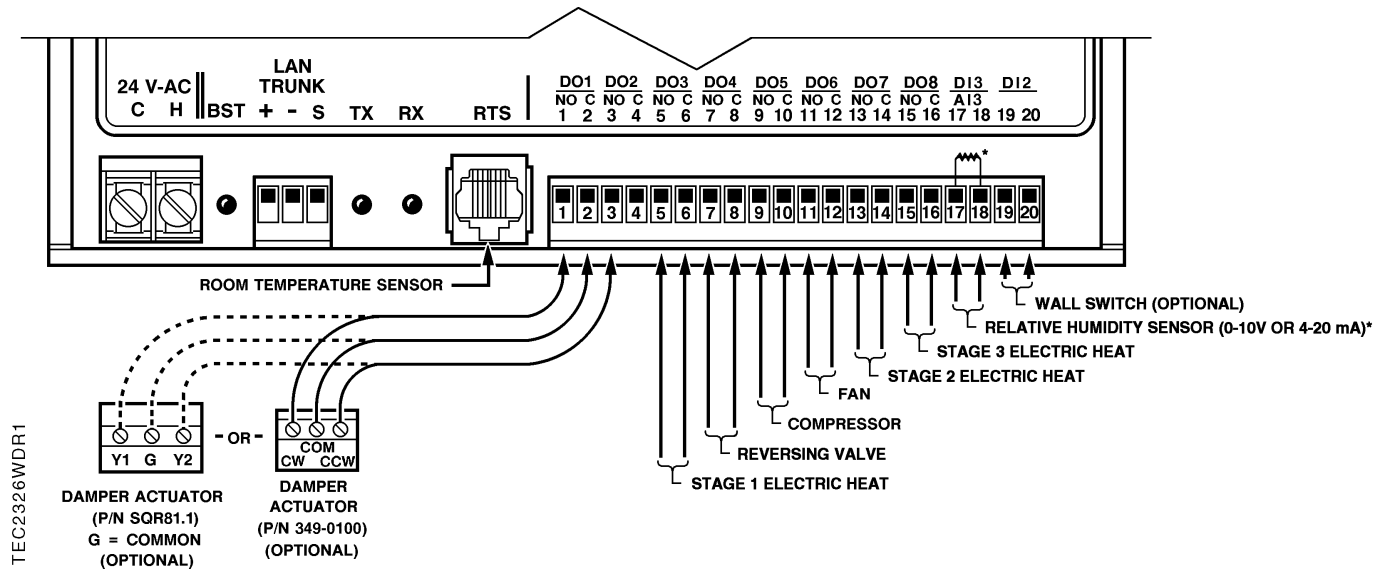


Figure 2326-4. Application 2326 Wiring Diagram.

Table 2326-1. Point Database for Application 2326.

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	2399	--	1	0	--	--
03	RETURN DELAY	10	MIN	1	0	--	--
{04}	ROOM TEMP	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
{05}	HEAT.COOL	COOL	--	--	--	HEAT	COOL
06	DAY CLG STPT	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
07	DAY HTG STPT	70.00 (21.21)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
08	NGT CLG STPT	82.00 (27.93)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
09	NGT HTG STPT	65.00 (18.41)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
10	DMPR MIN POS	14.8	PCT	0.4	0.0	--	--
11	RM STPT MIN	55.00 (12.81)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
12	RM STPT MAX	90.00 (32.41)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
{13}	RM STPT DIAL	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
14	STPT DIAL	NO	--	--	--	YES	NO
{15}	ROOM RH	50.0	PCT	0.4	0.0	--	--
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
{22}	DEHUM MODE	NO	--	--	--	YES	NO
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
{26}	DI 4	OFF	--	--	--	ON	OFF
{29}	DAY.NGT	DAY	--	--	--	NIGHT	DAY
34	RH STPT	50.0	PCT	0.4	0.0	--	--
35	RH DBAND	2.0	PCT	0.4	0.0	--	--
{41}	DO 1	OFF	--	--	--	ON	OFF
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	EHEAT 1 DO 3	OFF	--	--	--	ON	OFF
{44}	REV VALVE	COOL	--	--	--	HEAT	COOL
{45}	COMPRESSOR	OFF	--	--	--	ON	OFF
{46}	FAN	OFF	--	--	--	ON	OFF
{47}	EHEAT 2 DO 7	OFF	--	--	--	ON	OFF
{48}	DMPR COMD	0.0	PCT	0.4	0.0	--	--
{49}	DMPR POS	0.0	PCT	0.4	0.0	--	--
{50}	EHEAT 3 DO 8	OFF	--	--	--	ON	OFF

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 2326-1. Point Database for Application 2326.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
51	MTR TIMING	130	SEC	1	0	--	--
54	AI3 VOLT.CUR	VOLTS	--	--	--	CURRENT	VOLTS
56	DMPR ROT ANG	90	--	1	0	--	--
58	MTR SETUP	0	--	1	0	--	--
59	DO DIR.REV	0	--	1	0	--	--
60	CYCLE FAN	NO	--	--	--	YES	NO
63	CLG P GAIN	10.00 (18.00)	--	0.25 (0.45)	0.00 (0.00)	--	--
64	CLG I GAIN	0.010 (0.0180)	--	0.001 (0.0018)	0.000 (0.0000)	--	--
65	CLG D GAIN	24 (43.2)	--	2 (3.6)	0 (0.0)	--	--
66	CLG BIAS	50.0	PCT	0.4	0.0	--	--
67	HTG P GAIN	10.00 (18.00)	--	0.25 (0.45)	0.00 (0.00)	--	--
68	HTG I GAIN	0.010 (0.0180)	--	0.001 (0.0018)	0.000 (0.0000)	--	--
69	HTG D GAIN	24 (43.2)	--	2 (3.6)	0 (0.0)	--	--
70	HTG BIAS	50.0	PCT	0.4	0.0	--	--
76	EHTG STG CNT	1	--	1	0	--	--
{78}	CTL TEMP	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
{79}	CLG LOOPOUT	0.0	PCT	0.4	0.0	--	--
{80}	HTG LOOPOUT	0.0	PCT	0.4	0.0	--	--
81	EHEAT 1 ON	90.0	PCT	0.4	0.0	--	--
82	CMP ON	50.0	PCT	0.4	0.0	--	--
83	CMP OFF	30.0	PCT	0.4	0.0	--	--
84	RVAL SWITCH	30.0	PCT	0.4	0.0	--	--
85	SWITCH LIMIT	4.8	PCT	0.4	0.0	--	--
86	SWITCH TIME	10	MIN	1	0	--	--
87	CMP MIN OFF	3	MIN	1	0	--	--
88	CMP MIN ON	3	MIN	1	0	--	--
89	RVAL SW TIME	30	SEC	1	0	--	--
90	SWITCH DBAND	2.00 (1.12)	DEG F (DEG C)	0.25 (0.14)	0.00 (0.00)	--	--
{92}	CTL STPT	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
94	EHEAT 2 ON	80.0	PCT	0.4	0.0	--	--
95	EHEAT 3 ON	90.0	PCT	0.4	0.0	--	--
96	CAL TIMER	12	HRS	1	0	--	--
98	LOOP TIME	5	SEC	1	0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--

NOTES:

- Points not listed are not used in this application.
- A single value in a column means that the value is the same in English units and in SI units.
- Point numbers that appear in brackets {} may be unbundled at the field panel.