

## BACnet Heat Pump

### Application Notes

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## Application 2894 — Multiple Heating and Cooling with Mixed Air Control and Internal Reversing Valve

### Table of Contents

<b>Overview .....</b>	<b>3</b>
BACnet .....	5
Hardware Inputs .....	6
Analog .....	6
Digital .....	6
Hardware Outputs .....	6
Analog .....	6
Digital .....	6
Ordering Notes.....	6
Point Database .....	7
<b>Sequence of Operation .....</b>	<b>8</b>
Control Temperature Setpoints.....	8
Relative Setpoint Adjustment (optional) .....	10
Stat Supervision .....	10
Room Temperature Offset .....	11
AI5 / AI4 OFFSET (optional) .....	11
Day and Night Modes .....	11
Night Mode Override Switch.....	11
Heating/Cooling Switchover .....	12
Control Loops .....	12
Mixed Air Control .....	14
Compressor Operation.....	16
Electric Heat (optional).....	18

Fan Operation..... 18

Damper Status Operation (optional)..... 19

Power Failure Recovery ..... 19

Centralized Alarm Monitoring ..... 19

Overriding Critical Heat Pump DOs ..... 19

Fail-safe Operation ..... 20

Application Notes ..... 20

Wiring Diagram ..... 20

## Overview

In Application 2894, the controller controls one or two heating compressors for heating and one or two cooling compressors for cooling. The reversing valve is controlled internally by the heat pump. In addition to compressors, this heat pump may also be equipped with electric heat for auxiliary heat and mixed air control for free cooling. This application also controls small air handling units with two position heating and cooling control. The mixed air control can use either a spring return or a floating control damper motor.

Application 2894 is based on Application 2574 of the preceding revision of Siemens BACnet Heat Pump Controller. Application 2894 is identical to 2574 except for any differences listed in Table 1.

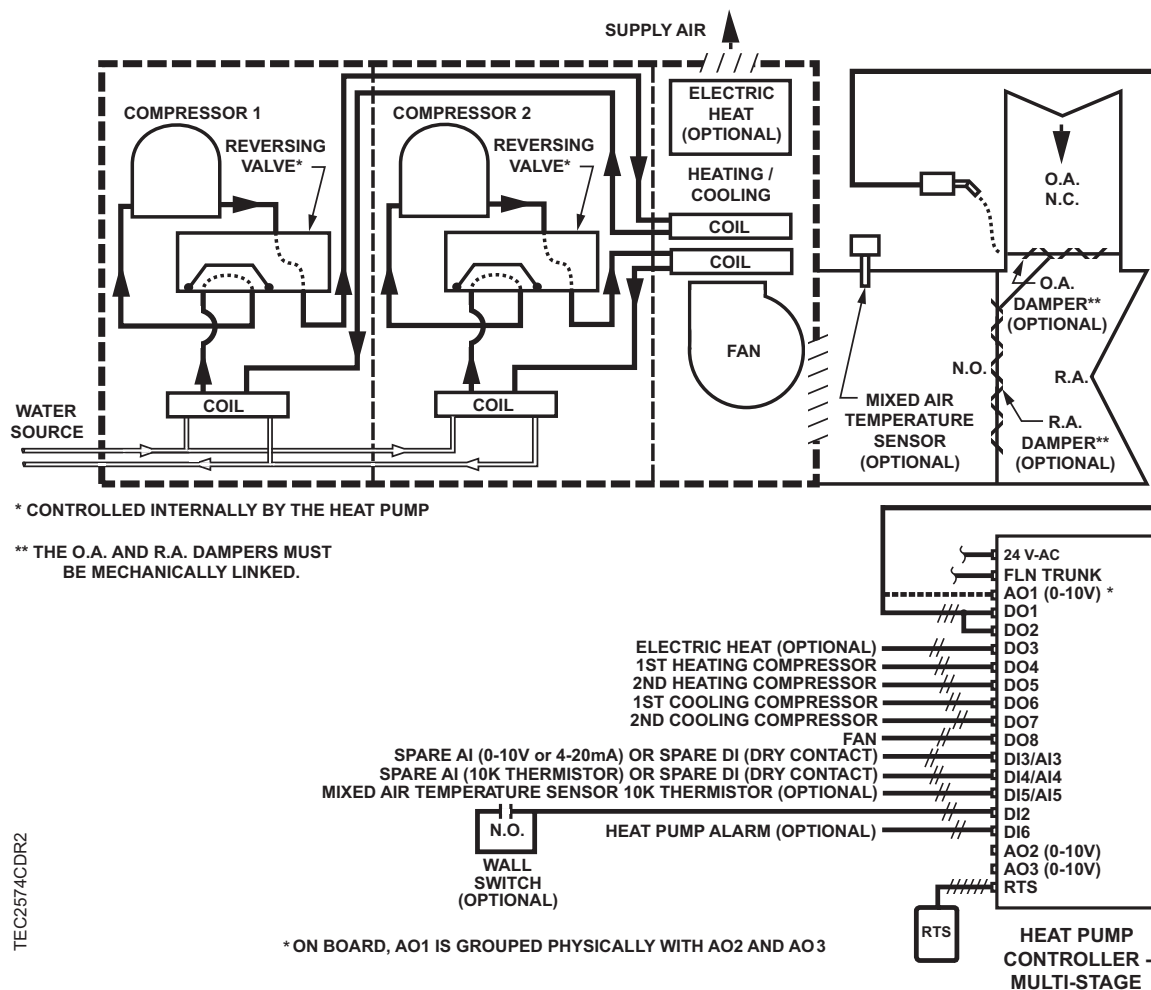
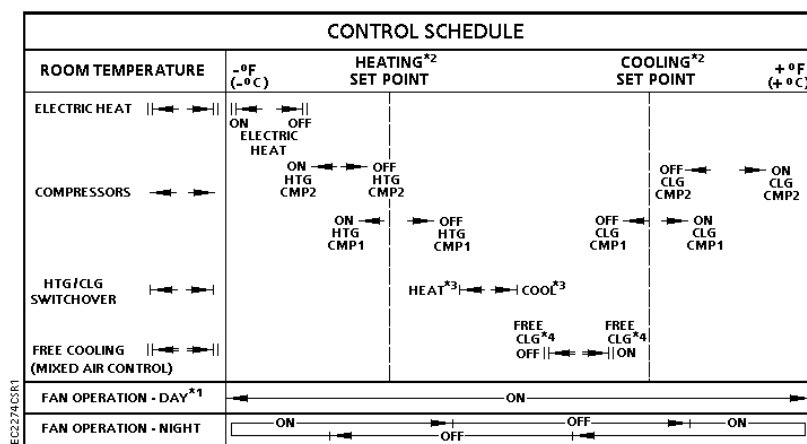


Figure 1. Application 2894 Control Drawing.

**Table 1. Siemens BACnet Heat Pump Controller — New Features 2009.**

	Previous	New (2009)
Application Numbers	2573 and 2574 2590 (slave)	2893 and 2894 2849 (slave)
Rev string	BM20	BK22 (September 2009)
New Feature(s)	- -	<ul style="list-style-type: none"> <li>New Points: 65, 66, 69, 70, 124, 125, 126, 127 (original points numbered 65, 66, 69, 70 are re-numbered to 102, 103, 104, 105)</li> <li>Ability to Enable/Disable the commanding of critical DOs</li> <li>Relative Setpoint Adjustment option</li> <li>RH &amp; T support for Series 3000 room stats</li> <li>Flash/upgrade pass through using Series 1000, 2000, or 3000 stats (no need to connect directly to controller)</li> <li>AI 5 OFFSET (Point 125) – calibrate aux temp at AI5 if necessary for fine tuning sensor/temp accuracy (Note: AI 4 OFFSET (Point 124) is also available)</li> </ul>

**Figure 2. Application 2894 Control Schedule.**

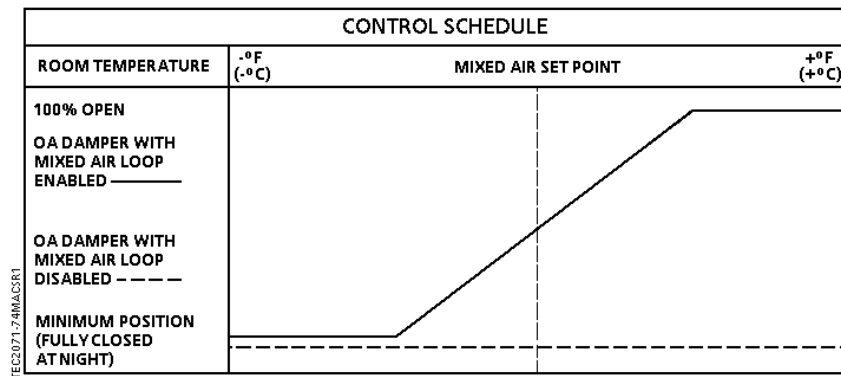


Figure 3. Application 2894 Control Schedule for Mixed Air Control.

## BACnet

The Siemens BACnet Heat Pump Controller - Multi-Stage communicates using BACnet MS/TP protocol for open communications on BACnet MS/TP networks.

Table 2. Supported BIBBS.

Product	Supported BIBBs	BIBB Name
BTEC	DS-RP-B	Data Sharing-ReadProperty-B
	DS-RPM-B	Data Sharing-ReadPropertyMultiple-B
	DS-WP-B	Data Sharing-WriteProperty-B
	DM-DDB-B	Device Management-Dynamic Device Binding-B
	DM-DOB-B	Device Management-Dynamic Object Binding-B
	DM-DDC-B	Device Management-Device Communication Control-B

## Hardware Inputs

### Analog

- Mixed air temperature sensor (optional)
- Room temperature sensor
- Room temperature setpoint dial (optional)

### Digital

- Heat pump alarm (optional)
- Night mode override (optional)
- Wall switch (optional)

## Hardware Outputs

### Analog

- Spring return damper actuator (optional)

### Digital

- Floating Control Damper actuator (optional)
- Fan
- Stage 1 cooling compressor (optional)
- Stage 2 cooling compressor (optional)
- Stage 1 heating compressor (optional)
- Stage 2 heating compressor (optional)
- Stage 1 electric heat (optional)

## Ordering Notes

Siemens BACnet Heat Pump Controller: 550-490

**Related Equipment:**

Damper Actuator (spring return or floating)  
Mixed Air Temperature Sensor  
Terminal Equipment Controller Room Temperature Sensor

**Point Database**

Table 3 presents the point database information for Application 2894.

## Sequence of Operation

The following paragraphs present the sequence of operation for the *Siemens BACnet Heat Pump Controller - Multi-Stage Application 2894, Multiple Heating and Cooling with Mixed Air Control and Internal Reversing Valve*.

### Control Temperature Setpoints

Application 2894 has a number of different room temperature setpoints (DAY HTG 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, the time of day, whether or not a temperature deadband (zero energy band) has been configured, and the type of RTS used.

#### Selection of RTS type:

The point STAT TYPE can be set to NORMAL (default) or OFFSET. When STAT TYPE = OFFSET, an optional Relative Setpoint Adjustment feature can be used. For more information see the *Relative Setpoint Adjustment (optional)* section.

#### CTL STPT in Day Mode:

If the controller is in day mode and STPT DIAL = YES (and a setpoint dial is present), RM STPT DIAL will be used to determine the value of CTL STPT.

If RM STPT DIAL is Failed but has been overridden, CTL STPT will be Normal and the current value of RM STPT DIAL will be used to determine the value of CTL STPT. If RM STPT DIAL is Failed and **not** overridden, CTL STPT will be Failed and the last known good value of RM STPT DIAL will be used to determine the value of CTL STPT.

If the controller is in day mode and STPT DIAL = NO, CTL STPT will hold the value of DAY CLG STPT or DAY HTG STPT. Also, CTL STPT will have a status of Normal even if RM STPT DIAL is Failed.

#### CTL STPT in Night Mode:

In night mode, CTL STPT holds the value of NGT CLG STPT or NGT HTG STPT regardless of whether a setpoint dial is used. Also, CTL STPT will always have a status of Normal, even if RM STPT DIAL is Failed.

#### CTL STPT is Overridden:

When CTL STPT is overridden, CTL STPT will equal its overridden value and the application will have no effect on the value of CTL STPT. Also, CTL STPT will always have a status of Normal, even if RM STPT DIAL is Failed.

#### Setpoint Dial and Deadband:

When a setpoint dial is being used during day mode, the value of CTL STPT depends in part on whether a deadband is being used.

When DAY HTG STPT equals DAY CLG STPT, a deadband is **not** being used and the value of CTL STPT is limited to the range RM STPT MIN to RM STPT MAX, regardless of the value/position of the setpoint dial. For instance,



- CTL STPT will equal RM STPT MAX if  $\text{RM STPT DIAL} > \text{RM STPT MAX}$ .
- CTL STPT will equal RM STPT MIN if  $\text{RM STPT DIAL} < \text{RM STPT MIN}$ .

..otherwise, CTL STPT will equal RM STPT DIAL.

When DAY HTG STPT **does not** equal DAY CLG STPT, a deadband (or zero energy band) is being used. In this case, the controller operates as follows:

**When HEAT.COOL equals HEAT**

1. If RM STPT DIAL > than RM STPT MAX, then:

- If  $[\text{RM STPT MAX} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})] > \text{RM STPT MAX}$ , then CTL STPT will equal RM STPT MAX.
- If  $[\text{RM STPT MAX} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})] < \text{RM STPT MIN}$ , then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal  $\text{RM STPT MAX} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})$ .

2. If RM STPT DIAL < than RM STPT MIN, then:

- If  $[\text{RM STPT MIN} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})] > \text{RM STPT MAX}$ , then CTL STPT will equal RM STPT MAX.
- If  $[\text{RM STPT MIN} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})] < \text{RM STPT MIN}$ , then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal  $\text{RM STPT MIN} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})$ .

3. If RM STPT MAX > RM STPT DIAL > RM STPT MIN, then:

- If  $[\text{RM STPT DIAL} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})] > \text{RM STPT MAX}$ , then CTL STPT will equal RM STPT MAX.
- If  $[\text{RM STPT DIAL} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})] < \text{RM STPT MIN}$ , then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal  $\text{RM STPT DIAL} - 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})$ .

**When HEAT.COOL equals COOL**

1. If RM STPT DIAL > than RM STPT MAX, then:

- If  $[\text{RM STPT MAX} + 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})] > \text{RM STPT MAX}$ , then CTL STPT will equal RM STPT MAX.
- If  $[\text{RM STPT MAX} + 0.5 * (\text{DAY CLG STPT} - \text{DAY HTG STPT})] < \text{RM STPT MIN}$ , then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal  $RM\ STPT\ MAX + 0.5 * (DAY\ CLG\ STPT - DAY\ HTG\ STPT)$ .

2. If  $RM\ STPT\ DIAL < RM\ STPT\ MIN$ , then:

- If  $[RM\ STPT\ MIN + 0.5 * (DAY\ CLG\ STPT - DAY\ HTG\ STPT)] > RM\ STPT\ MAX$ , then CTL STPT will equal RM STPT MAX.
- If  $[RM\ STPT\ MIN + 0.5 * (DAY\ CLG\ STPT - DAY\ HTG\ STPT)] < RM\ STPT\ MIN$ , then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal  $RM\ STPT\ MIN + 0.5 * (DAY\ CLG\ STPT - DAY\ HTG\ STPT)$ .

3. If  $RM\ STPT\ MAX > RM\ STPT\ DIAL > RM\ STPT\ MIN$ , then:

- If  $[RM\ STPT\ DIAL + 0.5 * (DAY\ CLG\ STPT - DAY\ HTG\ STPT)] > RM\ STPT\ MAX$ , then CTL STPT will equal RM STPT MAX.
- If  $[RM\ STPT\ DIAL + 0.5 * (DAY\ CLG\ STPT - DAY\ HTG\ STPT)] < RM\ STPT\ MIN$ , then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal  $RM\ STPT\ DIAL + 0.5 * (DAY\ CLG\ STPT - DAY\ HTG\ STPT)$ .

## Relative Setpoint Adjustment (optional)

When  $STAT\ TYPE = OFFSET$ , the point STPT SPAN can be used to keep the temperature range that is available to the user of a setpoint dial constrained to a narrow range. Room sensor part number SB1-0916 or SB1-1072 should be used for this option (SB1-1072 has a display; SB1-0916 does not). These room sensors have a slider with red and blue colored bands indicating warmer/cooler, instead of a preprinted 55 to 95 degree temperature scale. When  $STAT\ TYPE = OFFSET$ , moving the slider up/down adjusts the room temperature a few degrees above/below the day heating or cooling setpoint. The maximum amount of adjustment is configured in STPT SPAN. For example, if STPT SPAN is set to 2.0, then moving the slider all the way up would add only 2 degrees to the day heating (or cooling) setpoint. Similarly, 2 degrees would be subtracted if the slider were moved all the way down. Between these extremes the offset is proportionately scaled.

## Stat Supervision

Point 126, STAT SUPV is an enumerated point that can be configured to tell the controller how to respond to a loss of communication between a Series 3000 room stat and the controller. The default value for STAT SUPV is zero, no response (good 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 Fail. A value of 2 means that if communication is lost for at least one minute, Point 127, RM RH (humidity monitoring) will be Fail. A value of 3 means that both CTL TEMP and RM RH will be Fail after a loss of communications of at least one minute.

## Room Temperature Offset



The Room Temperature Offset feature is optional.

RMTMP 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.

**CTL TEMP = ROOM TMP + RMTMP OFFSET.**

**EXAMPLE:** If the actual room temperature is 72°F, and the value of ROOM TEMP is 73.0°F, then the value entered into RMTMP 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.

## AI5 / AI4 OFFSET (optional)

AI 5 OFFSET (Point 125) works like RMTMP OFFSET. It can be used to calibrate AI5 aux temp sensor input if necessary. The *actual* temperature plus AI 5 OFFSET will equal AI5 display temperature.

AI 4 OFFSET (Point 124) works exactly like AI 5 OFFSET.

## 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 DI 2 and WALL SWITCH = YES, the controller monitors the status of DI 2. When DI 2 is ON (the switch is closed), DAY.NGT will be set to DAY indicating that the controller is in day mode. When DI 2 is OFF (the switch is open), 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, the controller is operating stand-alone, it stays in day mode all the time. If the controller is operating with centralized control, connected to a field panel, the field panel can send an operator or PPCL command to override the status of DAY.NGT.

## 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 mode for the time period set in OVRD TIME. The status of NGT OVRD changes to DAY. After the override time elapses, the controller returns to night mode and NGT OVRD changes back to NIGHT.

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

## 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 SWITCH TIME, the controller switches from heating to cooling mode by setting HEAT.COOL to COOL:

- $HTG\ LOOPOUT < SWITCH\ LIMIT$ .
- $CTL\ TEMP > CTL\ STPT$  by at least the value set in SWITCH DBAND.
- $CTL\ TEMP > \text{the appropriate cooling setpoint minus SWITCH DBAND}$ .

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

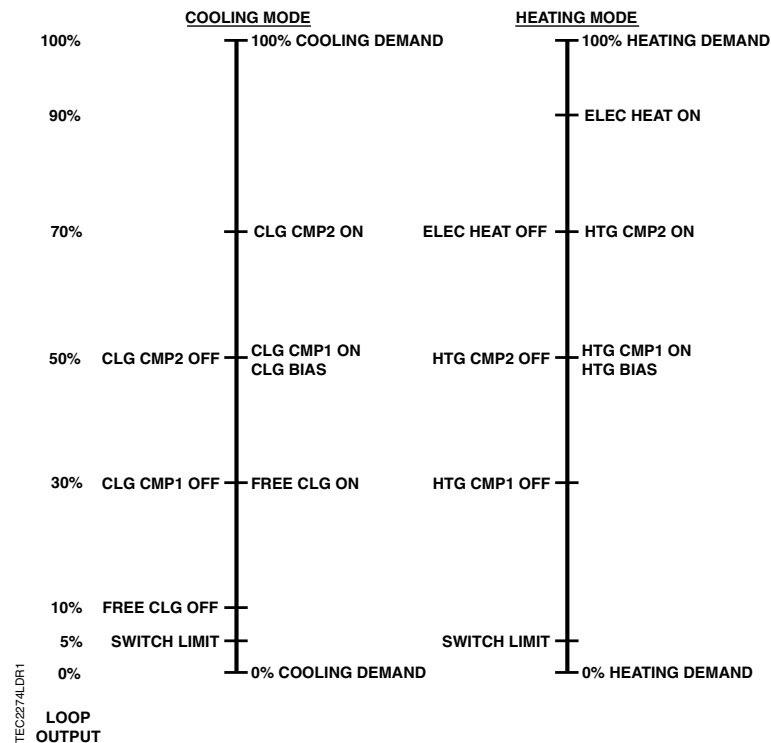
- $CLG\ LOOPOUT < SWITCH\ LIMIT$ .
- $CTL\ TEMP < CTL\ STPT$  by at least the value set SWITCH DBAND.
- $CTL\ TEMP < \text{the appropriate heating setpoint plus SWITCH DBAND}$ .

## Control Loops

The heat pump is controlled by three Proportional, Integral, and Derivative (PID) control loops; two temperature loops and a mixed air loop.

The two temperature loops are a cooling loop and a heating loop and the value of HEAT.COOL determines which is active. The active temperature loop maintains room temperature at the value in CTL STPT. The inputs to the temperature loops are CTL TEMP and CTL STPT. The outputs are CLG LOOPOUT and HTG LOOPOUT.

The two temperature loops perform the overall sequencing of the heat pump equipment; they determine when to turn the compressors, fan, and stages of electric heat ON and OFF and when to enable or disable mixed air control.



**Figure 4. Heating and Cooling Control Loops.**



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

In heating mode, as the room temperature drops below the heating setpoint, the heating loop calls for more heating (the heating loop output rises). In cooling mode, if the room temperature rises above the cooling setpoint, the cooling loop calls for more cooling (the cooling loop output rises). The output of the inactive loop will remain at zero (Figure 4).

The ladder diagrams (Figure 4) show the heating and cooling loop sequencing of multiple compressors with one stage 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 CLG BIAS and HTG BIAS. The purpose of these points is to provide a starting place for the loops at startup.

**Cooling Loop** – CLG LOOPOUT must be greater than FREE CLG ON before free cooling will be used. The controller accomplishes free cooling by enabling the mixed air loop to modulate the mixed air damper.

CLG CMP 1 will not be allowed to turn ON until CLG LOOPOUT becomes greater than the value of CLG CMP1 ON. CLG CMP 1 will not be allowed to turn OFF until CLG LOOPOUT drops below the value of CLG CMP1 OFF.

CLG CMP 2 will not be allowed to turn ON until CLG LOOPOUT becomes greater than the value of CLG CMP2 ON. CLG CMP 2 will not be allowed to turn OFF until CLG LOOPOUT drops below the value of CLG CMP2 OFF.

CLG LOOPOUT must be less than the value of FREE CLG OFF before free cooling will be turned OFF. The controller turns OFF free cooling by disabling the mixed air loop. When the loop is disabled, the mixed air damper will be sent to either minimum position for day mode or to 0% open for night mode.

When CLG LOOPOUT becomes less than SWITCH LIMIT, the controller will be allowed to change to heating mode if all other criteria for the change have been met.

**Heating Loop** – HTG LOOPOUT must be greater than ELEC HEAT ON before ELEC HEAT is turned ON. When HTG LOOPOUT drops below HTG CMP2 ON, ELEC HEAT will shut OFF.

HTG CMP 1 will not be allowed to turn ON until HTG LOOPOUT becomes greater than the value of HTG CMP1 ON. HTG CMP 1 will not be allowed to turn OFF until HTG LOOPOUT drops below the value of HTG CMP1 OFF.

HTG CMP 2 will not be allowed to turn ON until HTG LOOPOUT becomes greater than the value of HTG CMP2 ON. HTG CMP 2 will not be allowed to turn OFF until HTG LOOPOUT drops below the value of HTG CMP2 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.

**Mixed Air Loop** – The heat pump is controlled by two Proportional, Integral, and Derivative (PID) control loops: a cooling loop and a heating loop. This section describes the mixed air control loop.

The mixed air loop controls only the mixed air portion of the application. The inputs to the mixed air loop are MA TEMP and MA STPT. The output is DMPR COMD.

## Mixed Air Control

**Day Mode** – If the fan is ON, the mixed air damper, DMPR COMD, will be set to minimum position (as stored in DMPR MIN POS) when at least one of the following conditions occurs:

- HEAT.COOL = HEAT. Free cooling is not needed in the heating season.
- MA TEMP is failed. When this point is failed, mixed air control is not possible.
- FREE CLG = DISABL. The outside air temperature is too warm to be used for free cooling. During day mode, the damper is at its minimum position. During night mode, the damper is at its closed position.
- CLG LOOPOUT < FREE CLG OFF. The cooling load is so small that no cooling is required.

If the fan is OFF, DMPR COMD will be set to 0%.

DMPR COMD will be modulated by the mixed air temperature control loop when all of the following conditions have been met:

- HEAT.COOL = COOL.
- MA TEMP is normal. (Not failed.)
- FREE CLG = ENABLE. The outside air is cool enough to be used for free cooling.
- CLG LOOPOUT > FREE CLG ON. The cooling load is large enough to require cooling.
- DMPR COMD > DMPR MIN POS.

DMPR COMD will not be set below minimum position (DMPR COMD = DMPR MIN POS). This is done to make sure that the ventilation requirements are being met.

**Night Mode** – DMPR COMD = 0% OPEN if at least one of the following conditions occurs:

- HEAT.COOL = HEAT. Free cooling is not needed in the heating season.
- MA TEMP is failed. When this point is failed, mixed air control is not possible.
- NGT MA CTL = NO. Mixed air control is not being used during the night mode.
- FREE CLG = DISABL. The outside air is too warm to be used for free cooling.
- CLG LOOPOUT < FREE CLG OFF. The cooling load is so small that no cooling is required.

DMPR COMD will be modulated by the mixed air temperature control loop when all of the following conditions have been met:

- HEAT.COOL = COOL.
- MA TEMP is normal. (Not failed)
- NGT MA CTL = YES. (See *Application Notes*)
- FREE CLG = ENABLE. The outside air is cool enough to be used for free cooling.
- CLG LOOPOUT > FREE CLG ON. The cooling load is large enough to require cooling.

If CLG LOOPOUT is between FREE CLG ON and FREE CLG OFF and all other conditions have been met for enabling the mixed air loop, the action taken will depend on the following:

- If CLG LOOPOUT was previously above FREE CLG ON, the mixed air loop will remain enabled.
- If CLG LOOPOUT was previously below FREE CLG OFF, the mixed air loop will remain disabled.



This will happen whether or not the heat pump is in day or night mode.

The mixed air damper motor can be either a spring return damper motor or a floating control damper motor.

- For a spring return damper, set DAMPER TYPE = SPRING. The mixed air loop will control the damper through its 0 – 10 volt analog output, AOV1, and DO 1 and DO 2 will be spare DOs.
- For a floating control damper, set DAMPER TYPE = FLOAT. The mixed air loop will control the damper through DO 1 and DO 2, and AOV1 will be a spare analog output.



**CAUTION:**

This application does not have built in low temperature detection for the mixed air dampers. The low temperature detection is handled differently depending on the type of damper used (spring return or floating control).

**Spring Return Damper** – Stand-alone low temperature detection can be accomplished with an external low limit thermostat. In order to do this, the damper should be set up to be normally closed and the external low temperature thermostat should cut power to the damper actuator upon reaching a low limit condition. When this happens, the spring will drive the damper shut.

**Floating Control Damper** – Stand-alone low temperature detection is not possible. A PPCL program can be written to close the damper when a low temperature situation occurs. In order to do this, an outside air temperature sensor needs to be connected to the field panel and DMPR COMD needs to be unbundled. Even though this is possible, make sure that the customer will allow it before attempting it.

## Compressor Operation



To prevent damage to the heat pump, the default setting of HP DO OVRD does not allow operator command of compressors. See *Overriding Critical Heat Pump DOs* for more information.

This application can support from 0 to 2 cooling compressors (as defined by the value of CLG CMP TOTL) and from 0 to 2 heating compressors (as defined by the value of HTG CMP TOTL).

When HEAT.COOL = COOL, HTG LOOPOUT will be set to 0. CLG LOOPOUT will also equal 0 until all of the heating compressors have been OFF for at least their minimum OFF time. This is a safety feature that prevents the simultaneous operation of the heating and cooling compressor DOs.

When the heating compressors have been OFF for the MIN OFF time, CLG LOOPOUT is placed under normal control.

As cooling demand increases, the cooling compressors are controlled as follows:



- CLG CMP 1 will turn ON when CLG LOOPOUT > CLG CMP1 ON provided that the first cooling compressor has been OFF for at least the time set in CLG1 MIN OFF.
- If CLG CMP TOTL = 2, CLG CMP 2 will turn ON when CLG LOOPOUT > CLG CMP2 ON provided that the following conditions are met:
  - The second cooling compressor has been OFF for at least the time set in CLG2 MIN OFF.
  - The first cooling compressor has been ON for at least 30 seconds. (This creates less demand than having more than one compressor start at once).

As cooling demand decreases, the cooling compressors are controlled as follows:

- CLG CMP 2 will turn OFF when CLG LOOPOUT < CLG CMP2 OFF provided that the second cooling compressor has been ON for at least the time set in CLG2 MIN ON.
- CLG CMP 1 will turn OFF when CLG LOOPOUT < CLG CMP1 OFF provided that the following conditions are met:
  - The first cooling compressor has been ON for at least the time set in CLG1 MIN ON.
  - The second cooling compressor has been OFF for at least 30 seconds. This will prevent the first cooling compressor from turning OFF before the second cooling compressor is OFF.

When HEAT.COOL = HEAT, CLG LOOPOUT will be set to 0. HTG LOOPOUT will also equal 0 until all of the cooling compressors have been OFF for at least their minimum OFF time. This is a safety feature that prevents the simultaneous operation of the heating and cooling compressor DOs.

When the cooling compressors have been OFF for the MIN OFF time, HTG LOOPOUT is placed under normal control.

As heating demand increases, the heating compressors are controlled as follows:

- HTG CMP 1 will turn ON when HTG LOOPOUT > HTG CMP1 ON provided that the first heating compressor has been OFF for at least the time set in HTG1 MIN OFF.
- If HTG CMP TOTL is 2, HTG CMP 2 will turn ON when HTG LOOPOUT > HTG CMP2 ON provided that the following conditions are met:
  - The second heating compressor has been OFF for at least the time set in HTG2 MIN OFF.
  - The first heating compressor has been ON for at least 30 seconds. (This creates less demand than having more than one compressor start at once.)

As heating demand decreases, the heating compressors are controlled as follows:

- HTG CMP 2 will turn OFF when HTG LOOPOUT < HTG CMP2 OFF provided that the second heating compressor has been ON for at least the time set in HTG2 MIN ON.

- HTG CMP 1 will turn OFF when HTG LOOPOUT < HTG CMP1 OFF provided that the following conditions are met:
  - The first heating compressor has been ON for at least the time set in HTG1 MIN ON.
  - The second heating compressor has been OFF for at least 30 seconds. This will prevent the first heating compressor from turning OFF before the second heating compressor is OFF.

## Electric Heat (optional)

If no stages of electric heat are being used (EHTG STG CNT = 0), this control is omitted.

If the stage of electric heat is being used (EHTG STG CNT = 1) and HEAT.COOL = COOL, the stage of electric heat is OFF.

When the stage of electric heat is being used and HEAT.COOL = HEAT, the electric heat is controlled as follows:

- If HTG LOOPOUT > ELEC HEAT ON, the electric heat point, ELEC HEAT, is turned ON.
- ELEC HEAT will turn OFF differently depending on the number of heating compressors being used (as determined by HTG CMP TOTL).
  - If HTG CMP TOTL = 0 or 1 and HTG LOOPOUT < HTG CMP1 ON, ELEC HEAT is turned OFF.
  - If HTG CMP TOTL = 2 and HTG LOOPOUT < HTG CMP2 ON, ELEC HEAT is turned OFF.

## Fan Operation



To prevent damage to the heat pump, the default setting of HP DO OVRD does not allow operator command of the fan. See *Overriding Critical Heat Pump DOs* for more information.

**Day Mode** – FAN is ON when CYCLE FAN = NO. If CYCLE FAN = YES, the fan control in day mode is the same as it is in night mode.

**Night Mode** – The fan is controlled as follows:

The fan will turn ON when at least one of the following two conditions has been met:

1. Free cooling is being provided by the mixed air control loop.
2. At least one compressor or stage of electric heat is ON.

The fan will turn OFF only after the following two conditions have been met:

1. Free cooling is not being provided by the mixed air control loop.

2. All compressors and stages of electric heat have been OFF for at least 30 seconds.

## Damper Status Operation (optional)

If the heat pump has a damper, it is set at the value of DMPR MIN POS 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 CLG LOOPOUT and HTG LOOPOUT 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:

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

RETURN DELAY 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.

CTLR ADDRESS 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 of having all the electrical equipment starting at once.

## Centralized Alarm Monitoring

DI 6 can be used to monitor an input that changes state when the heat pump is in alarm. DI 6 can be unbundled to send alarm information to the field panel for centralized alarm monitoring.

## Overriding Critical Heat Pump DOs

This application includes a setup point that enables or disables ON and OFF commands to critical DOs. Specifically, the fan and compressor(s) cannot be directly commanded ON or OFF unless the point HP DO OVRD is set to ENABLE. When HP DO OVRD is set to DISABL, commands to the fan or compressor DO points are ignored regardless of BACnet command priority. Commands to electric heat DOs and any spare DOs are always allowed. Physical points DO1 and DO2 can never be overridden when configured for motor control. However, the position of the attached motor is always commandable via the DMPR COMD point.



**CAUTION:**

HP DO OVRD should be set to ENABLE only when there is a complete understanding of the consequences. Since the direct control will override the applications minimum on and off time safeties, improper use of the DO commands can cause permanent equipment damage. Also, during normal daily operation, the override of critical DOs should only be done via a BACnet command. If a digital output is overridden via the MMI port, the point may be left in an incorrect internal state upon release. If during commissioning an override command must be issued via the MMI port, it is critical that the point be manually commanded off before the point is released.

## Fail-safe Operation

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

## Application Notes

1. If the heat pump cycles excessively, temperature swings in the room are excessive, or there is trouble maintaining the setpoint, the cooling loop, the heating loop or both need to be tuned.
2. Running the mixed air loop during night mode can increase energy savings by taking advantage of free cooling at night to pre-cool the building in time for day mode. This can lessen the need to use mechanical cooling during day mode. Pre-cooling the building this way can also improve the indoor air quality because this type of cooling is accomplished with fresh air.

Some field panel involvement is necessary to pre-cool the building with this application. For instance, the field panel needs to adjust the night cooling setpoint downward whenever the outside can be used for free cooling at night. This would require unbundling FREE CLG and CTL STPT.

3. In this application the maximum configurations are as follows:

- The maximum of HTG CMP TOTL = 2.
- The maximum of CLG CMP TOTL = 2.
- The maximum of EHTG STG CNT = 1.

If these limits are exceeded, HTG CMP TOTL, CLG CMP TOTL, and EHTG STG CNT will be set to 0. These points will remain at 0 until they are set correctly. (This prevents the application from trying to control equipment that it does not have.)

4. Rev string BK22 makes it possible to upgrade/flash the controller using Series 1000, 2000, or 3000 stats as a pass through to the controller. In other words you do not have to connect to the controller directly.

## Wiring Diagram

The point wiring for Application 2894 is shown in Figure 5.



**CAUTION:**

The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. Use an interposing 220V 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.

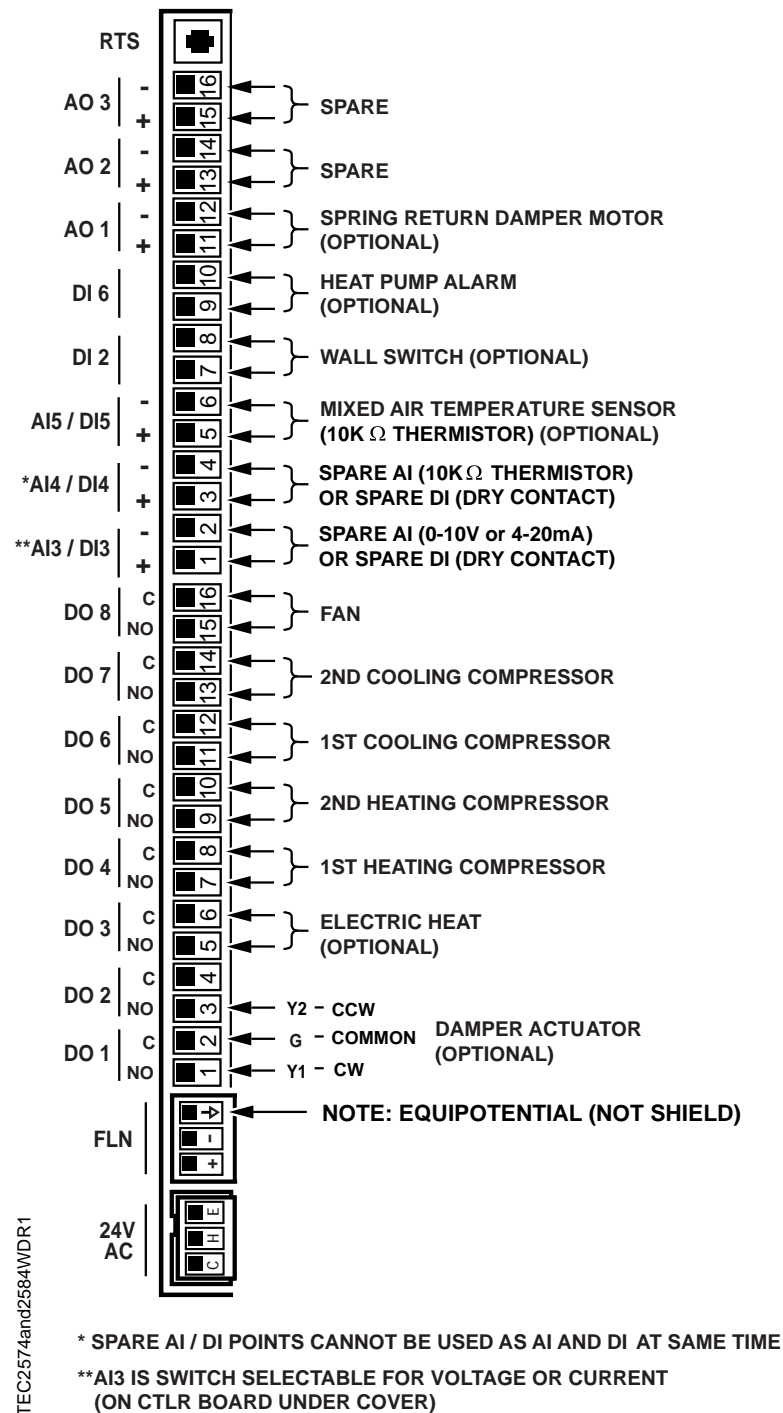


Figure 5. Application 2894.

Table 3. Point Database for Application 2894.

Object Type <sup>a</sup>	Object Instance (Point Number) <sup>b</sup>	Object Name and Description	Factory Default (SI Units) <sup>c</sup>	Eng Units (SI Units) <sup>c</sup>	Range	Active Text	Inactive Text
AO	1	CTLR ADDRESS	99	–	0 to 254	–	–
AO	2	APPLICATION	2849	–	2849, 2893 and 2894	–	–
AO	3	RETURN DELAY	10	MIN	0 to 255	–	–
AI	{04} <sup>d</sup>	ROOM TEMP	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
BO	{05}	HEAT.COOL	COOL	–	Binary	HEAT	COOL
AO	6	DAY CLG STPT	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	7	DAY HTG STPT	70.0 (21.21)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	8	NGT CLG STPT	82.0 (27.93)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	9	NGT HTG STPT	65.0 (18.41)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	10	DMPR MIN POS	14.8	PCT	0.0 to 102.0	–	–
AO	11	RM STPT MIN	55.0 (12.81)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	12	RM STPT MAX	90.0 (32.41)	DEG F (DEG C)	48.0 to 111.75	–	–
AI	{13}	RM STPT DIAL	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
BO	14	STPT DIAL	NO	–	Binary	YES	NO
AI	{15}	MA TEMP	74.0 (23.496)	DEG F (DEG C)	37.5 to 165.0	–	–
AO	16	HTG CMP2 ON	70	PCT	0.0 to 102.0	–	–
AO	17	HTG CMP2 OFF	50	PCT	0.0 to 102.0	–	–
BO	18	WALL SWITCH	NO	–	Binary	YES	NO
BI	{19}	DI OVRD SW	OFF	–	Binary	ON	OFF
AO	20	OVRD TIME	0	HRS	0 to 255	–	–
BO	{21}	NGT OVRD	NIGHT	–	Binary	NIGHT	DAY
AO	22	RMTMP OFFSET	0.0 (0.0)	DEG F (DEG C)	-31.75 to 32.0	–	–

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Table 3. Point Database for Application 2894. (continued)

Object Type <sup>a</sup>	Object Instance (Point Number) <sup>b</sup>	Object Name and Description	Factory Default (SI Units) <sup>c</sup>	Eng Units (SI Units) <sup>c</sup>	Range	Active Text	Inactive Text
BO	{23}	FREE CLG	DISABL	–	Binary	ENABLE	DISABL
BI	{24}	DI 2	OFF	–	Binary	ON	OFF
BI	{25}	DI 5	OFF	–	Binary	ON	OFF
BI	{26}	DI 6	OFF	–	Binary	ON	OFF
AO	27	HTG2 MIN OFF	3	MIN	0 to 255	–	–
AO	28	HTG2 MIN ON	3	MIN	0 to 255	–	–
BO	{29}	DAY.NGT	DAY	–	Binary	NIGHT	DAY
AO	30	CLG CMP1 ON	50	PCT	0.0 to 102.0	–	–
AO	31	CLG CMP1 OFF	30	PCT	0.0 to 102.0	–	–
AO	32	CLG1 MIN OFF	3	MIN	0 to 255	–	–
AO	33	CLG1 MIN ON	3	MIN	0 to 255	–	–
AO	34	CLG CMP2 ON	90	PCT	0.0 to 102.0	–	–
AO	35	CLG CMP2 OFF	70	PCT	0.0 to 102.0	–	–
AO	36	CLG2 MIN OFF	3	MIN	0 to 255	–	–
AO	37	CLG2 MIN ON	3	MIN	0 to 255	–	–
BO	38	DAMPER TYPE	FLOAT	–	Binary	SPRING	FLOAT
AO	39	AO DIR.REV	0	–	0 to 255	–	–
AO	{40}	AOV1	0	VOLTS	0.0 to 10.23	–	–
BO	{41}	DO 1	OFF	–	Binary	ON	OFF
BO	{42}	DO 2	OFF	–	Binary	ON	OFF
BO	{43}	ELEC HEAT	OFF	–	Binary	ON	OFF
BO	{44}	HTG CMP 1	OFF	–	Binary	ON	OFF
BO	{45}	HTG CMP 2	OFF	–	Binary	ON	OFF
BO	{46}	CLG CMP 1	OFF	–	Binary	ON	OFF
BO	{47}	CLG CMP 2	OFF	–	Binary	ON	OFF
AO	{48}	DMPR COMD	0	PCT	0.0 to 102.0	–	–
AO	{49}	DMPR POS	0	PCT	0.0 to 102.0	–	–
BO	{50}	FAN	OFF	–	Binary	ON	OFF
AO	51	MTR TIMING	130	SEC	0 to 511	–	–

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Table 3. Point Database for Application 2894. (continued)

Object Type <sup>a</sup>	Object Instance (Point Number) <sup>b</sup>	Object Name and Description	Factory Default (SI Units) <sup>c</sup>	Eng Units (SI Units) <sup>c</sup>	Range	Active Text	Inactive Text
AI	{52}	AI 3	0.0	PCT.	0.0 to 102.0	–	–
AI	{53}	AI 4	74.0 (23.496)	DEG F (DEG C)	37.5 to 165.0	–	–
AO	{54}	AOV2	0	VOLTS	0.0 to 10.23	–	–
BI	{55}	DI 3	OFF	–	Binary	ON	OFF
AO	56	DMPR ROT ANG	90	–	0 to 255	–	–
BI	{57}	DI 4	OFF	–	Binary	ON	OFF
AO	58	MTR SETUP	0	–	0 to 255	–	–
AO	59	DO DIR.REV	0	–	0 to 255	–	–
BO	60	CYCLE FAN	NO	–	Binary	YES	NO
AO	61	FREE CLG ON	30	PCT	0.0 to 102.0	–	–
AO	62	FREE CLG OFF	10	PCT	0.0 to 102.0	–	–
AO	63	CLG P GAIN	10.0 (18.0)	–	0.0 to 63.75	–	–
AO	64	CLG I GAIN	0.01 (0.018)	–	0.0 to 1.023	–	–
AO	65	STPT SPAN	4.0	DEG F	0 to 63.75	–	–
BO	66	STAT TYPE	NORMAL	–	Binary	OFFSET	NORMAL
AO	67	HTG P GAIN	10.0 (18.0)	–	0.0 to 63.75	–	–
AO	68	HTG I GAIN	0.01 (0.018)	–	0.0 to 1.023	–	–
BO	69	HP DO OVRD	DISABL	–	Binary	ENABLE	DISABL
AO	{70}	STPT OFFSET	0	DEG F	-31.75 to +32.0	–	–
AO	{71}	MA P GAIN	5.0 (9.0)	–	0.0 to 63.75	–	–
AO	{72}	MA I GAIN	0.024 (0.0432)	–	0.0 to 1.023	–	–
AO	{73}	MA D GAIN	0 (0.0)	–	0 to 510	–	–
AO	{74}	MA BIAS	0	PCT	0.0 to 102.0	–	–
AO	75	HTG CMP TOTL	1	–	0 to 255	–	–
AO	76	EHTG STG CNT	1	–	0 to 255	–	–
AO	77	CLG CMP TOTL	1	–	0 to 255	–	–
AI	{78}	CTL TEMP	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–

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Table 3. Point Database for Application 2894. (continued)

Object Type <sup>a</sup>	Object Instance (Point Number) <sup>b</sup>	Object Name and Description	Factory Default (SI Units) <sup>c</sup>	Eng Units (SI Units) <sup>c</sup>	Range	Active Text	Inactive Text
AO	{79}	CLG LOOPOUT	0	PCT	0.0 to 102.0	–	–
AO	{80}	HTG LOOPOUT	0	PCT	0.0 to 102.0	–	–
AO	81	ELEC HEAT ON	90	PCT	0.0 to 102.0	–	–
AO	82	HTG CMP1 ON	50	PCT	0.0 to 102.0	–	–
AO	83	HTG CMP1 OFF	30	PCT	0.0 to 102.0	–	–
AO	85	SWITCH LIMIT	4.8	PCT	0.0 to 102.0	–	–
AO	86	SWITCH TIME	10	MIN	0 to 255	–	–
AO	87	HTG1 MIN OFF	3	MIN	0 to 255	–	–
AO	88	HTG1 MIN ON	3	MIN	0 to 255	–	–
AO	90	SWITCH DBAND	2.0 (1.12)	DEG F (DEG C)	0.0 to 63.75	–	–
BO	{91}	NGT MA CTL	NO	–	Binary	YES	NO
AI	{92}	CTL STPT	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	{93}	MA SETPT	55.0 (12.856)	DEG F (DEG C)	37.5 to 165.0	–	–
AO	96	CAL TIMER	12	HRS	0 to 255	–	–
AO	{97}	AOV3	0	VOLTS	0.0 to 10.23	–	–
AO	98	LOOP TIME	5	SEC	0 to 255	–	–
AO	{99}	ERROR STATUS	0	–	0 to 255	–	–
AO	102	CLG D GAIN	24 (43.2)	–	0 to 510	–	–
AO	103	CLG BIAS	50	PCT	0.0 to 102.0	–	–
AO	104	HTG D GAIN	24 (43.2)	–	0 to 510	–	–
AO	105	HTG BIAS	50	PCT	0.0 to 102.0	–	–
AO	124	AI 4 OFFSET	0.0 (0.0)	DEG F (DEG C)	-31.75- 32	–	–

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Table 3. Point Database for Application 2894. (continued)

Object Type <sup>a</sup>	Object Instance (Point Number) <sup>b</sup>	Object Name and Description	Factory Default (SI Units) <sup>c</sup>	Eng Units (SI Units) <sup>c</sup>	Range	Active Text	Inactive Text
AO	125	AI 5 OFFSET	0.0 (0.0)	DEG F (DEG C)	-31.75- 32	—	—
AO	126	STAT SUPV	0	—	0- 255	—	—
AI	{127}	RM RH	50	PCT	0- 102	—	—
<sup>a</sup> Object Types are; Analog Input (AI), Analog Output (AO), Binary Input (BI) and Binary Output (BO). <sup>b</sup> Points not listed are not used in this application. <sup>c</sup> A single value in a column means that the value is the same in English units and in SI units. <sup>d</sup> Point numbers that appear in brackets {} may be unbundled at the field panel.							