HYDRONICS WORKSHOP

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Drawn to professionalism: Part 2

Using schematics and narration to describe system operation helps ensure system longevity.

In last month's Hydronics Workshop column, I described the benefits of documentation for hydronic systems. They included improved odds of proper installation and commissioning, a lasting "road map" for future service technicians to follow, added value for the owner, and a sales tool that demonstrates professionalism to potential clients.

Good documentation also increases the possibility that local HVAC companies want to (and will be able to) service the system if the original installer is no longer available. The latter is not a rare occurrence. I've seen it happen numerous times. When thousands (or sometimes tens of thousands) of dollars have been invested and something breaks, and then service is not available, the situation usually ends up with lawyers involved.

BASIC SYSTEM DOCUMENTATION

In this column, we'll look at examples of basic documentation for a specific system. They include a piping schematic, electrical schematic, description of operation, and possible controller settings. The latter are labeled "possible" because they could change depending on the specific controllers used and the application.

Figure 1 on page 24 shows the piping schematic for a system that uses an air-to-water heat pump for heating (and cooling) a building. The system is shown in heating-mode operation; portions of the system that operate in cooling mode have been grayed out.

This system provides heating and cooling to two independently controlled zones. Heating is provided by low-temperature radiant panels. Cooling and dehumidification are provided by circulating chilled water through two air handlers, both equipped with condensate drip pans.

The entire system operates with a 35% solution of propylene glycol antifreeze. This eliminates the need for a heat exchanger between the exterior heat pump and the interior portion of the system. It also protects the entire system against a potential hard freeze.

The system includes an 80-gallon buffer tank, which has been set up in a three-pipe configuration. The latter allows fluid from the heat pump to go directly to the load when both are operating simultaneously. The difference between the heat source flow rate and the load flow rate passes through the buffer tank. For example, if the heat pump were operating with a flow rate of 10 gpm, and the load was operating at 6 gpm, then the difference, 4 gpm, would pass into the upper connection on the buffer tank.

By pulling the load flow off upstream of the tank, the flow velocity entering the tank is reduced. This reduces internal mixing and helps preserve temperature stratification in the tank (put another way, the hottest fluid remains at the top of the tank and the coolest fluid at the bottom).

This is especially important in heat pump applications since the coefficient of performance (COP)

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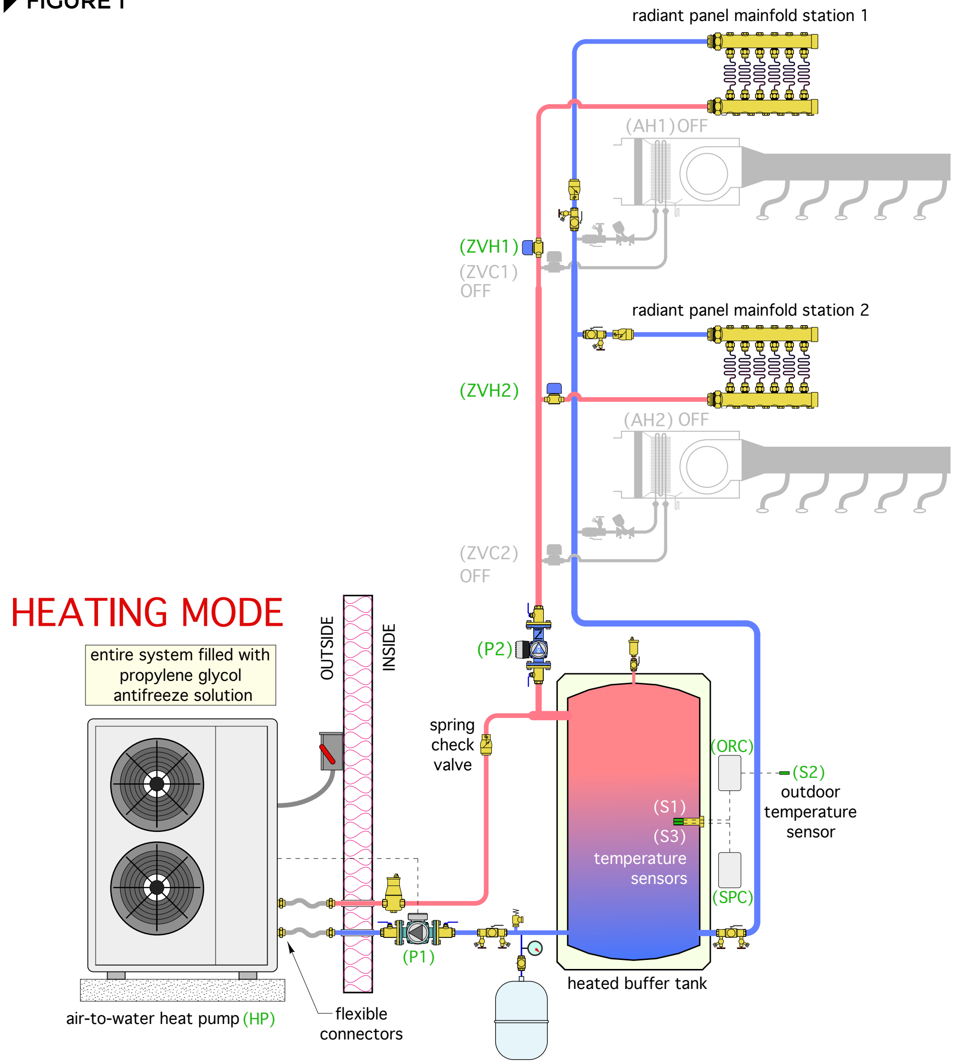
▶ FIGURE 1



increases as the temperature of the fluid entering the heat pump decreases. Highly mixed tanks increase the temperature of fluid entering the heat pump reduce COP.

Flow to the distribution system is handled by a single variable-speed pressure-regulated circulator. That circulator has been set to the differential pressure required when both heating zones, or both cooling zones, are operating. The circulator automatically reduces speed when one of the zone valves closes.

The distribution system contains check valves to prevent flow through the manifold stations during cooling mode as well as through the air handlers during heating mode. Balancing and purging valves are also provided.

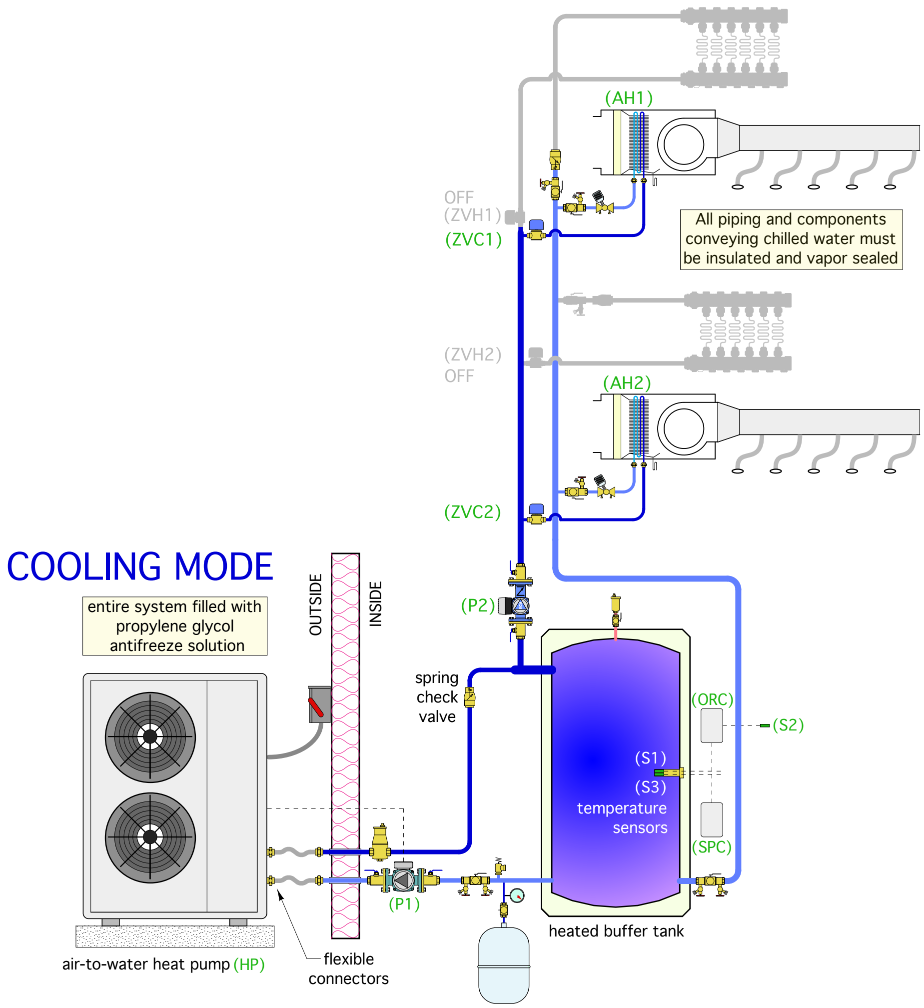
ADD SOME NAMES

Notice the green abbreviations next to several components in the piping schematic. These designations allow each component to be unambiguously identified. Instead of "primary pump," "system circulator," or "tank pump," which are nondescript, each circulator has a mutually exclusive name: (P1), (P2), etc.

The piping schematic for a complex system might have the same circulator symbol showing in several locations. Without mutually exclusive component designations, it's easy to confuse one circulator for another.

The component designations used in the piping schematic will also show up in the electrical schematic and description of

FIGURE 2



operation. A given component must have the same designation in all documentation produced for the system. This is critical for cross referencing.

Figure 2 above shows the same system in cooling mode. Portions of the system used in heating mode are grayed to help focus attention on the components used for cooling mode. The component designations for components used in cooling remain in green. Those that are not used in cooling mode are grayed out.

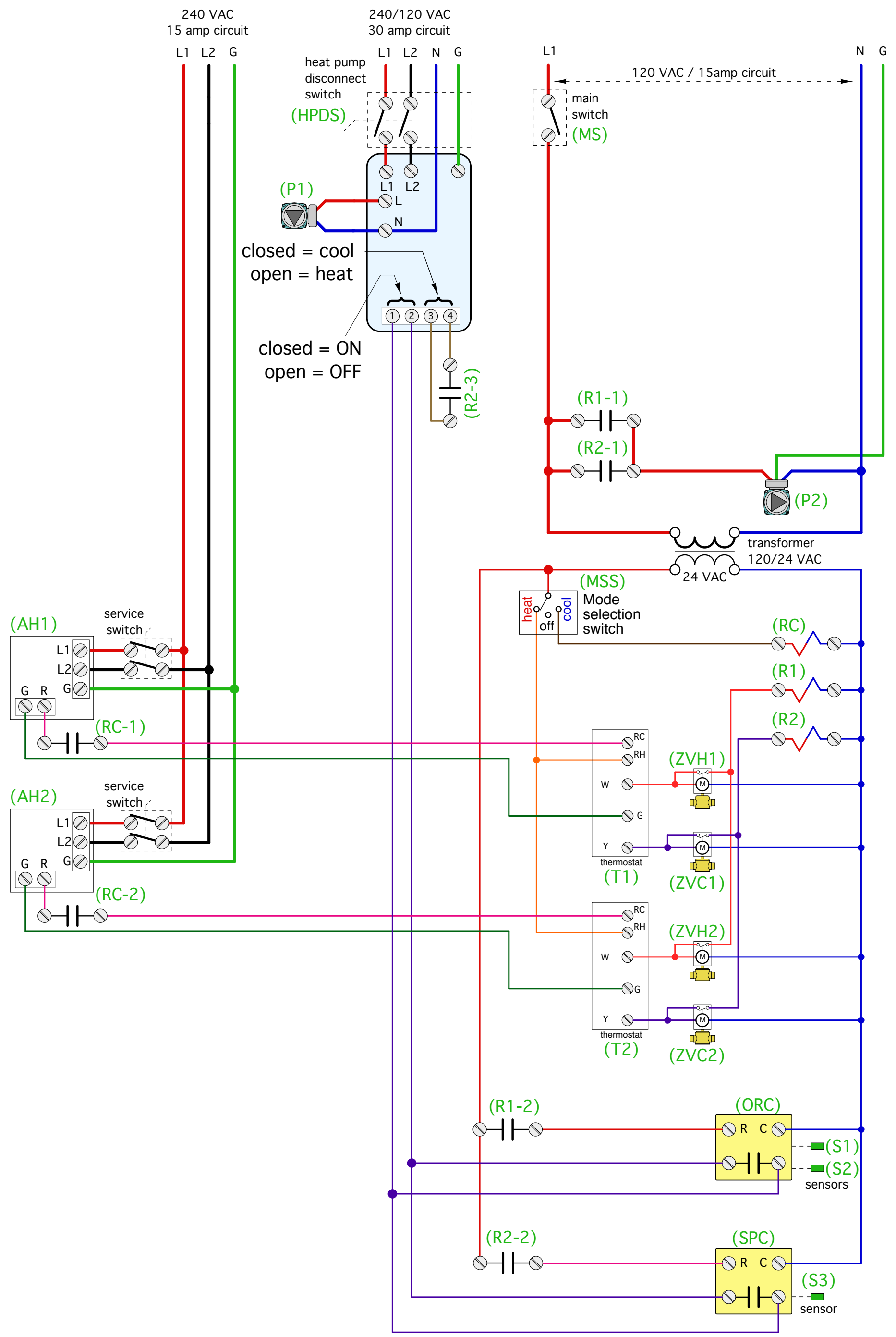
Figure 3 on page 28 shows an electrical schematic for the system. Electrical interconnections are shown based on a modified ladder diagram.

All power supplies to the system are shown at the top. In this case, there are three independent circuits. One supplies the heat pump, another supplies the two air handlers, and the third supplies the remainder of the electrically operated hardware (thermostats, controllers and relays) and the distribution circulator.

A 120/24 VAC transformer lowers the line voltage to the controllers, thermostats and relays.

There are three standard industrial control relays in the system designated as R1, R2 and RC. These relays operate normally open as well as normally closed contacts. In this system, only the normally open contacts are used. A label, such as R1-1 seen next to a contact, means pole number 1 on relay R1. A pole on a relay or switch is an isolated path through the switch. When

FIGURE 3



relays have more than one pole, those poles can be labelled as R1-1, R1-2, R1-3, etc. Each of these poles is associated with the same relay (R1). Each pole switches at the exact same time but they are electrically isolated from each other. Thus R1-1 could be switching a 120 VAC circuit while R1-2 switches a 24 VAC circuit.

The word "normally" as associated with a "normally open" or "normally closed" contact gives the status of that contact when the coil of the relay is off. A normally open contact is open until the relay coil is powered on, at which time it closes. A normally closed contact is closed when the coil is off to allow an electrical current to pass through it. These contacts are sometimes designated at N.O. for normally open and N.C. for normally closed. Both types of contacts are used in many HVAC electrical schematics.

WHAT IS THAT THING?

It's good practice to include a legend of both piping and electrical symbols with schematic drawings.

Figure 4 on page 30 shows a legend of symbols for piping as well as electrical symbols.

There is no "standard" legend of piping and electrical component symbols used in the industry. Although one design firm may standardize on the symbols used in all its schematic drawings, another may use a significantly different set of symbols. Because of this, it's good practice to include a legend of both piping and electrical symbols with schematic drawings.

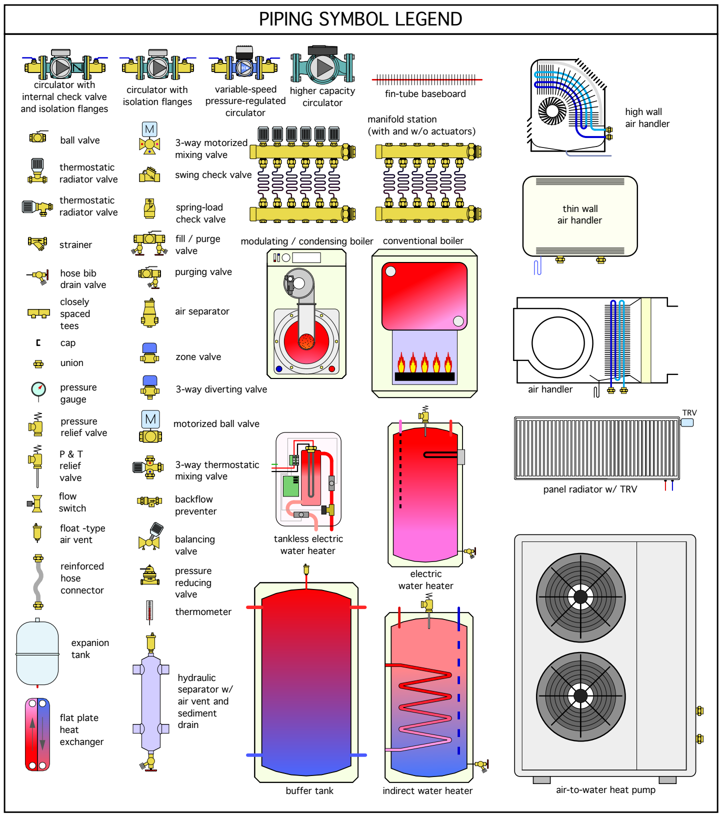
As the designer, you may know exactly what a given symbol represents, but the person using the drawing for installation or troubleshooting may not. With modern CAD systems, it's easy to cut and paste a symbol legend onto a large drawing sheet such as 18 inches by 24 inches or larger. When the printed drawings will be on standard 8.5-by-11-inch piece of paper, just print the legend on a separate sheet and include it with the schematics, each printed on their own sheets.

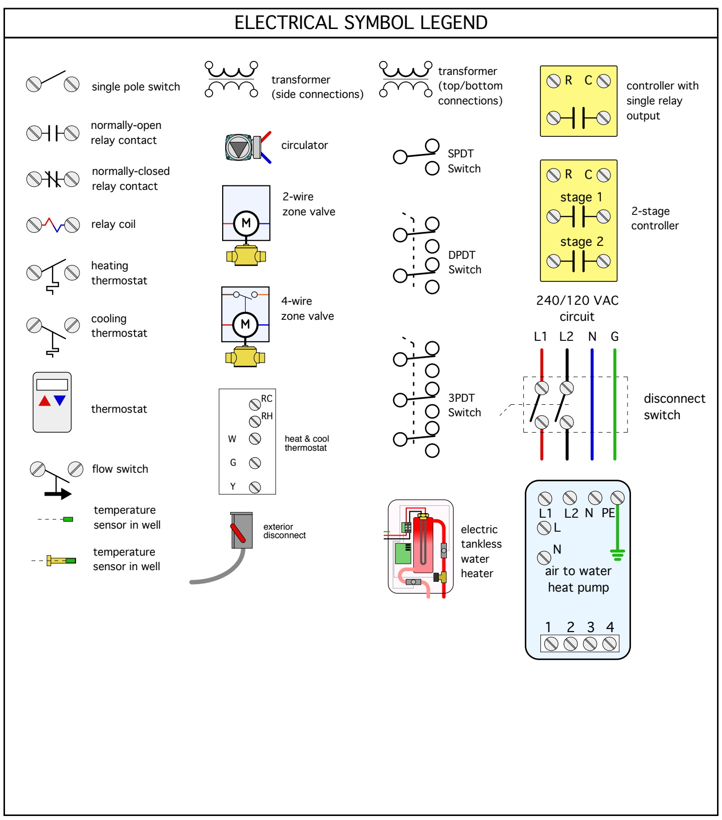
TELL THE STORY

While it may be possible for an experienced technician to understand how a system operates by looking at the piping and electrical schematics, that task is much easier when a description of operation accompanies the schematics.

A description of operation is simply

FIGURE 4





a narration describing how the system operates. It typically begins with describing what calls for heating or cooling and proceeds to describe the sequence of how controls and other electrically-operated devices respond to that call.

Descriptions of operation should be divided into "modes," which are sub-sections that describe what happens when the system is operating toward a specific objective. Examples would be space-heating mode, cooling mode, domestic water-heating mode, auxiliary heat-source mode, etc.

When writing a description of operation, it's helpful to make frequent reference to specific components that have been identified in the piping and electrical schematics. For example: "Upon a demand for heating from thermostat (T1), 24 VAC is passed from transformer (X1) to relay coil (R1). Relay contact (R1-1) closes supplying 120 VAC to circulator (P2)."

See the sidebar on page 32 for an example description of operation for the system shown in Figures 1, 2 and 3.

I think one of best ways to use this decimation is to print out the piping and electrical schematics along with the description of operation and lay it out on a table. Start reading the description of operation, perhaps a sentence or two, and then go to both schematics and find all the components mentioned in these sentences. Continue reading the description of operation and then cross referencing the components mentioned on the two schematics.

Another benefit of good system documentation is that it serves as a "check" on the design. For example, if there are five circulators on the piping schematic and only four circulators on the electrical schematic, something's wrong. Ditto for the description of operation. All the drawings should show all the components, and all the components should be contained within the description of operation.

POSSIBLE CONTROLLER SETTINGS

The following values give an indication of how some of the controllers in the system would be set. They assume generic controllers such as for temperature set points and outdoor reset control. Specific controls may use different settings.

Outdoor design temperature = 10° F

Outdoor temperature corresponding to no heating load = 70°

Target temperature at sensor (S1) at heating design conditions = 100°

Target temperature at sensor (S1) at no heating load = 70°

Minimum temperature to be maintained at sensor (S1) = 80°

Outdoor set controller contacts open when sensor (S1) = [target temperature + 5°]

Outdoor set controller contacts close when sensor (S1) = [target temperature - 5°]

Heat Pump internal controller turns OFF heat pump if leaving fluid temperature ≥ 130°

Heat Pump internal controller turns ON heat pump if leaving fluid temperature ≤ 125°

Temperature at sensor (S1) for heat pump on (cooling mode) = 60°

Temperature at sensor (S1) for heat pump off (cooling mode) = 45°

Solstice Heat Pump internal controller turns OFF heat pump

A SAMPLE DESCRIPTION OF OPERATION

The following is a description of operation for the system shown in Figures 1, 2 and 3. Specific makes and models of heat pumps may require slightly different wiring to enable their operation in heating or cooling modes. Always verify the specific wiring requirements for the heat pump being used and ensure it is coordinated with the balance of system wiring.

Power supply: The air-to-water heat pump and circulator (P1) are powered by a dedicated 240/120 VAC 30 amp circuit. The heat pump disconnect switch (HPDS) must be closed to provide power to the heat pump. The remainder of the control system is powered by 120 VAC/15 A circuit. The main switch (MS) must be closed to provide power to the control system. Both fan-coils are powered by a dedicated 240 VAC/15 A circuit. The service switch for each air handler must be closed for that air handler to operate.

Heating mode: The mode selection switch (MSS) must be set for heating. This passes 24 VAC to the RH terminal in each thermostat. Whenever either thermostat (T1, T2) demands heat, 24 VAC is passed from the thermostat's W terminal to the associated heating zone valve (ZVH1 or ZVH2). When the zone valve reaches its fully open position, its internal end switch closes, passing 24 VAC to relay coil (R1). Relay contact (R1-1) closes to pass 120 VAC to circulator (P2). Relay contact (R1-2) closes to pass 24 VAC to the outdoor reset controller (ODR).

The (ODR) measures outdoor temperature at sensor (S2), and uses this temperature, along with its settings, to calculate the target supply water temperature for the buffer tank. It then measures the temperature of the buffer tank at sensor (S1). If the temperature at (S1) is more than 3° below the target temperature, the (ODR) closes its relay contact. This completes a circuit between terminals 1 and 2 in the heat pump, enabling it in heating mode.

The heat pump (HP) turns on circulator (P1) and verifies adequate flow through the heat pump. After a short time delay, the heat pump turns on it compressor. The heat pump continues to operate until the temperature at sensor (S1) is 3° above the target temperature calculated by the (ODR), or until neither thermostat call for heat, or the heat pump reaches its internal high-limit setting. Note: Neither air handler operates in heating mode, regardless of the fan switch setting on the thermostats.

Cooling mode: The mode selection switch (MSS) must be set for cooling. This passes 24 VAC to relay coil (RC). Normally open contacts (RC-1) and (RC-2) close, allowing 24 VAC from the air handlers to pass to the RC terminal in each thermostat (T1, T2). Whenever either thermostat calls for cooling, 24 VAC is passed from the thermostat's Y terminal to the associated cooling zone valve (ZVC1 or ZVC2). When the zone valve reaches its fully open position, its internal end switch closes, passing 24 VAC to relay coil (R2).

Relay contact (R2-1) closes to pass 120 VAC to circulator (P2). Relay contact (R2-2) closes to pass 24 VAC to the cooling set point controller (SPC). The cooling set point controller measures the temperature of the buffer tank at sensor (S3). If this temperature is 60° or higher, the (SPC) relay contact closes, completing a circuit between terminals 15 and 16 on the Solstice Extreme heat pump (HP) enabling it to operate. Relay contact (R2-3) closes between terminals 3 and 4 in the heat pump (HP), switching it to cooling mode.

The heat pump (HP) turns on circulator (P1) and verifies adequate flow through the heat pump. The heat pump compressor turns on and operates in chiller mode. This continues until the temperature at sensor (S3) drops to 45°, or until neither zone thermostat calls for cooling, or until the heat pump reaches its internal low-limit setting. The blowers in the air handlers can be manually turned on at the thermostats when the mode selection switch (MSS) is set to cooling. The blowers will operate automatically whenever either cooling zone is active.

Distribution: Circulator (P2) is a variable speed pressure-regulated circulator that is set for the required differential pressure when both heating zones, or both cooling zones, are operating. It will automatically reduce speed to maintain a constant differential pressure when only one heating zone, or one cooling zone, is operating. Automatic flow-balancing valves with preset flow rates are installed on both heating zone circuits and both cooling zone circuits.

if leaving fluid temperature ≤ 41°

Solstice Heat Pump internal controller turns ON heat pump if leaving fluid temperature ≥ 43°

When you document a system containing specific controllers, you should indicate "initial" controller settings that match the intended operation of the system. The word "initial" means that the system should be turned on with these settings. Then, based on observations or measurements of system performance over time, the initial settings might be changed. All such changes should be written down on a log sheet that remains with the system. The log sheet should show the following for each setting:

1. The value of the setting as found;
2. The value the setting was changed to;
3. The date when setting was changed; and
4. The name of who made the change.

Now that you've seen some examples of schematics, you may be wondering how they are created. Computer-generated schematics are far more efficient than hand drawings. There are several software tools that lend themselves to the task, and they're available at very reasonable costs. We'll get into that in Part 3 next month.

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