Chapter 12:
Control strategies

This chapter discusses control strategies for hydronic radiant systems. Uponor offers a comprehensive line of controls from thermostats for local zone control to supply water temperature control as well as a network-based system that can control a wide range of HVAC functions. Understanding the available options and selecting the appropriate approach for a given project are key to a properly controlled radiant heating system.

Local zone control

Good control logic requires accurate information to respond with a logical control action. Control action should be based on information (e.g., a call for heat) that has a direct relationship to the item controlled (e.g., the application of heat). No logic is more appropriate for hydronic radiant panel systems than local zone control. Local control is defined as a thermostat in a room that determines when the room is not within an acceptable margin of the setpoint and sends a signal that heating or cooling is needed.

The local thermostat monitors the climate of the room. It recognizes a reduction in the heat requirement due to solar gain, high occupancy or internal gains, and responds by not calling for heat. The local zone thermostat also recognizes the need for additional heat when the outdoor temperature drops, curtains are opened or cold materials are introduced into an area. A local zone thermostat also provides the homeowner with the means to easily change the room setpoint temperature according to personal preference.

Two conditions must be met to achieve good local zone control.

- First, supply water temperature must be limited to no more than the maximum required for the highest heat load served. Using the highest required water temperature for a given area brings the system to within the "control authority" of the thermostat. Large projects with multiple heat plants and/or tempering devices very often use several supply water temperatures for different areas of the building. The correct supply water temperature should be maintained by using mixing devices, such as tempering valves, modulating valves, injection pumps or modulating-condensing boilers. All of these components have the ability to maintain a desired water temperature at a specific condition.
- Second, the control input and output logic must be equipped with appropriate and synchronized mechanisms for anticipating and distributing heat. These devices should be precisely engineered to work together. Because radiant panel systems can be either high mass or low mass, and because the resistance of potential floor coverings varies widely, anticipation is more critical with radiant floor than other forms of heating and cooling.

Refer to **Chapter 11** for information on determining zones.

Figure 12-1: Uponor Climate Control Zoning System II

Thermostats

Uponor offers several types of thermostats that vary in both operation and appearance. Regardless of the hardware set used, pay close attention to using the correct thermostats for properly sensing and accurately controlling a radiant heating system. This is because, due to the mass, radiant system dynamics are different than conventional air systems. All Uponor thermostats are designed for use in a radiant system to provide the highest level of comfort and efficiency.

Heat-only thermostats with touchscreen

Heat-only thermostats with touchscreen are designed specifically for radiant floor heating. They use fully automatic differential and pulse width modulation (PWM) to ensure each zone or area is comfortable and energy efficient. The touchscreen provides a simple, intuitive display with large, easy-to-read numbers. The thermostat can control room temperature through operative temperature sensing, an optional floor sensor or a combination of both. The floor sensor can be used to maintain warm floors throughout the heating season as well as provide temperature limit protection. The thermostat is designed to operate using two wires, making it simple to install and service.

Figure 12-2: Uponor Heat-only Thermostat with Touchscreen (A3100101)

SetPoint 521 programmable thermostats

SetPoint 521 programmable thermostats are designed to provide three different modes of operation: single-stage heating, two stages of heating with a fan, or one stage of heating and one stage of cooling with a fan. Auxiliary sensors may be added to measure floor, outdoor or room temperature. The thermostat includes an Uponor Floor Sensor (A3040079) to measure floor temperature for protecting the floor from overheating and enhancing comfort. Programmable schedules support either a 7-day or 24-hour schedule with two or four events per day.

Figure 12-3: SetPoint 521 Programmable Thermostat (A3040521)

Piping and control options

The following pages show piping and control arrangements for various radiant floor and radiant ceiling zoning options that support local zone control.

Option 1:

Multiple zones on a single manifold with actuators

- Single manifold with multiple zones, serviced by a single circulator (P1)
- Each circuit or group of circuits is an individual zone, controlled by an Uponor thermostat. Uponor Four-wire Actuator(s) and thermostats are wired into the Uponor Zone Control Module (ZCM).
- Uponor ZCM is wired into a hydronic relay (single or multiple).

Advantages:

- Allows for zoning flexibility within a single manifold
- Makes room-by-room zoning simple and cost effective

Refer to **pages 145-168** for the specific wiring schematic.

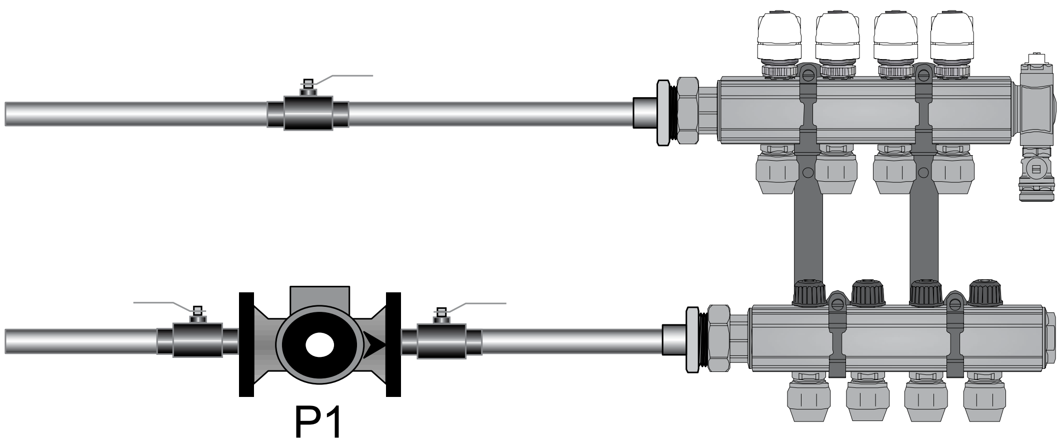

Figure 12-4: Multiple zones on a single manifold with actuators

Option 2:

Multiple zones on multiple manifolds with zone valves

- Each manifold is a single zone, all serviced by one circulator (P1).
- Each manifold (zone) is controlled by an Uponor thermostat and an Uponor four-wire zone valve.
- Thermostats and zone valves are wired into the Uponor Zone Control Module (ZCM).
- Uponor ZCM is wired into a hydronic relay (single or multiple).

Refer to **pages 145-168** for the specific wiring schematic.

Advantages:

- Simplified zoning — single-zone valve instead of multiple actuators
- Possible reduced costs
- Easiest way to zone a manifold with a single zone

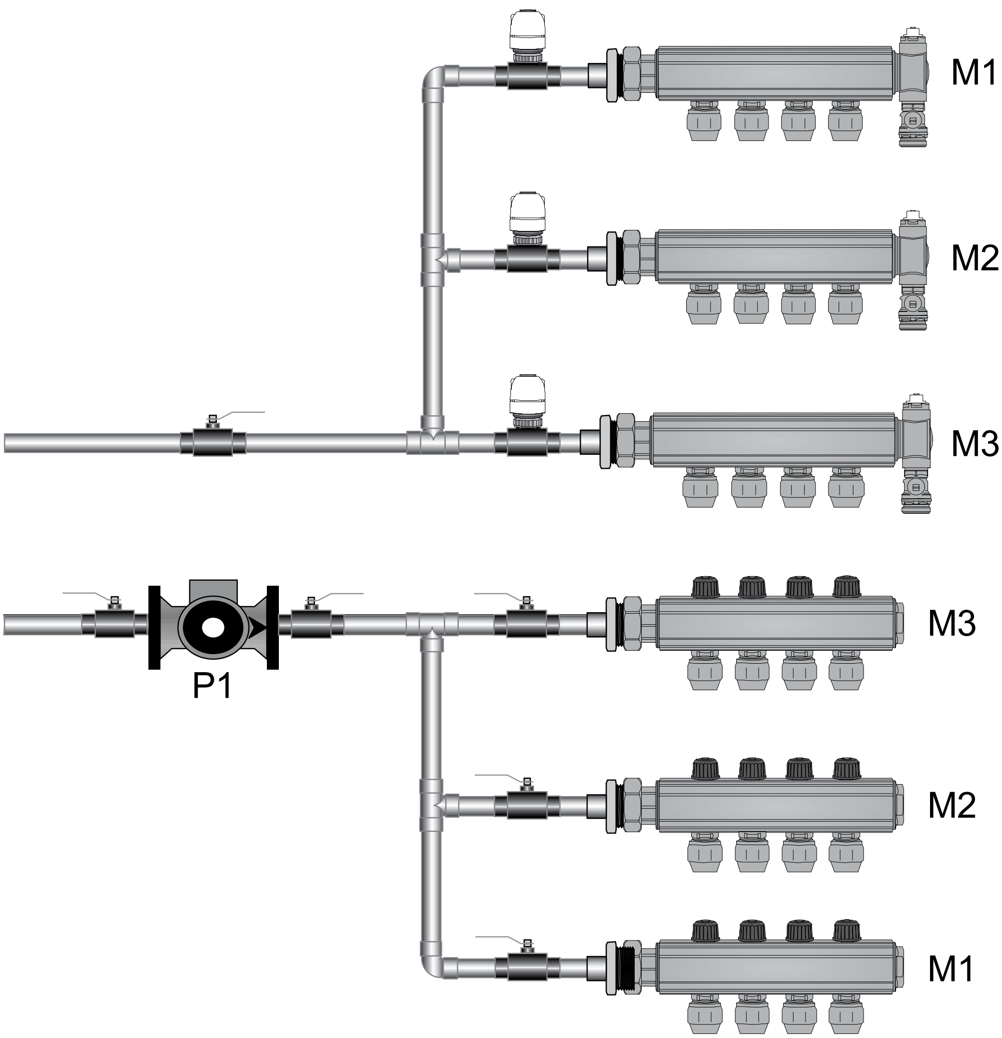

Figure 12-5: Multiple zones on multiple manifolds with zone valves

Option 3:

Multiple zones on multiple manifolds with actuators and zone valves

- Mixture of options 1 and 2
- Some manifolds are single zones, controlled by Uponor thermostats and Uponor Four-wire Zones Valves.
- Other manifolds are multiple zones, controlled by Uponor thermostats and Uponor four-wire actuators.
- Thermostats, actuators and zone valves are wired into the Uponor Zone Control Module (ZCM).
- Uponor ZCM is wired into a hydronic relay (single or multiple).

Advantages:

- Simplified zoning where applicable
- Room-by-room zoning where applicable
- Can add actuators later to single-zone manifolds for multiple zoning

Refer to **pages 145-168** for the specific wiring schematic.

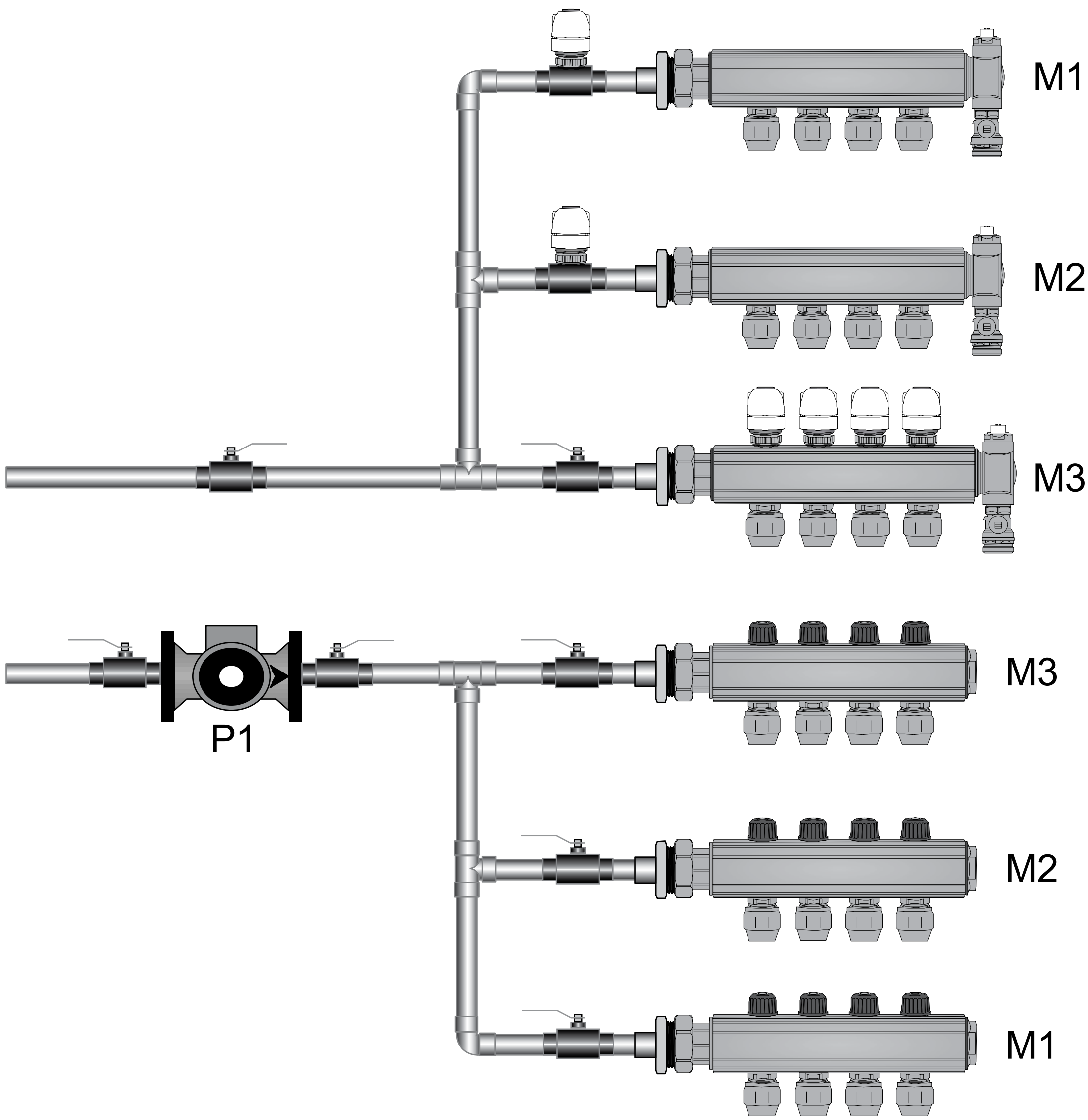

Figure 12-6: Multiple zones on multiple manifolds with actuators and zone valves

Option 4:

Single zones on multiple manifolds with circulators

- Each manifold is a single zone, each serviced by its own circulator.
- Each manifold (zone) is controlled by an Uponor thermostat and a hydronic relay (single or multiple).

Note: Add flow control valves as needed if circulators do not come with internal check valves to prevent flow when zone is not calling.

Refer to **pages 145-168** for the specific wiring schematic.

Advantages:

- Each zone controlled with its own circulator
- Circulator only needs sizing for its particular zone

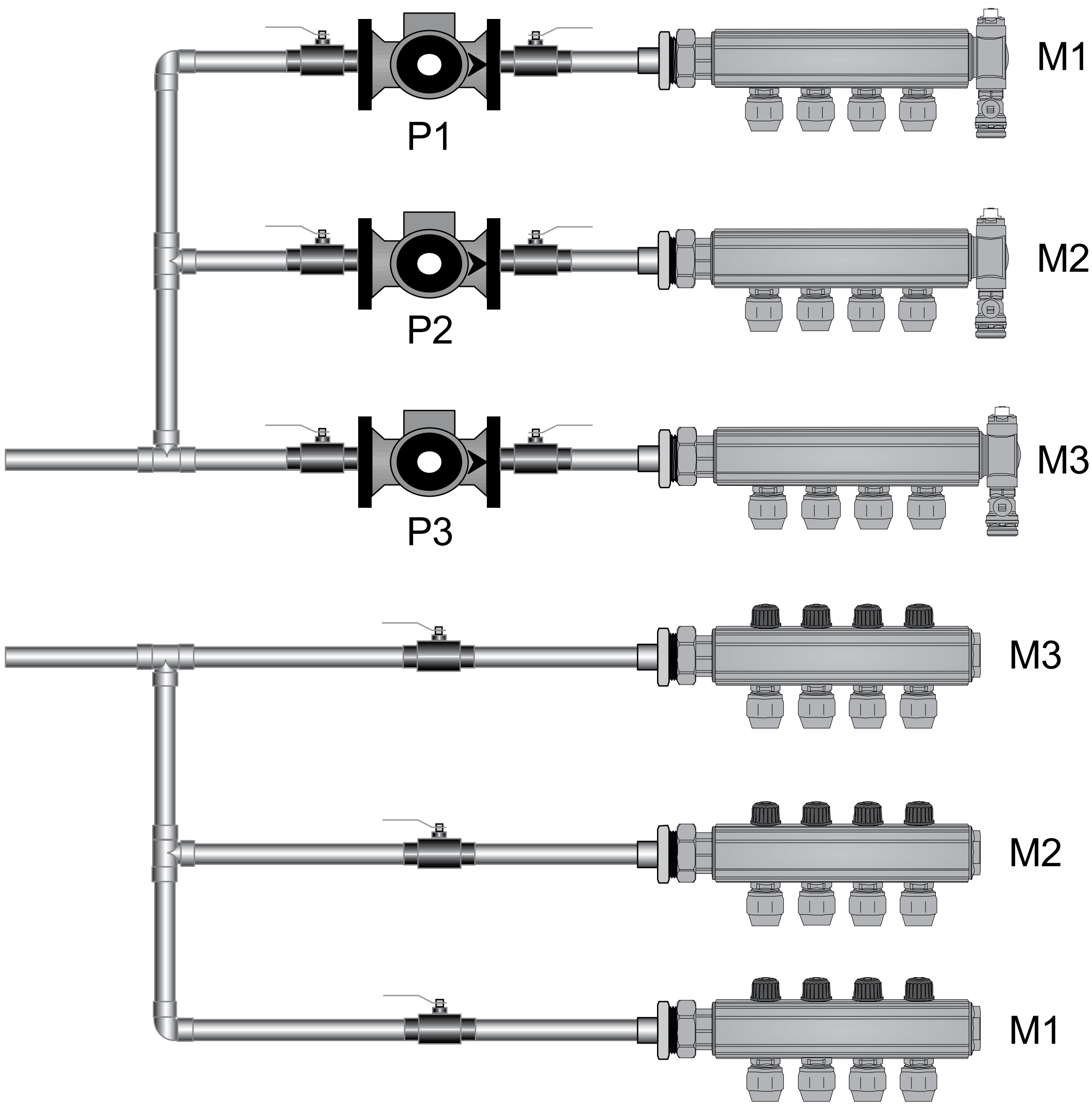

Figure 12-7: Single zones on multiple manifolds with circulators

Option 5:

Combination zoning with circulators

- Some manifolds are single zones, serviced by their own circulators and controlled by Uponor thermostats and a hydronic relay (single or multiple).
- Other manifolds are multiple zones, serviced by their own circulators, and controlled by Uponor thermostats and Uponor Four-wire Actuators.
- Actuators and thermostats are wired into the Uponor Zone Control Module (ZCM).
- Uponor ZCM, plus the other thermostats and circulators, are wired into hydronic relays (single or multiple).

Note: Add flow control valves as needed if circulators do not come with internal check valves to prevent flow when zone is not calling.

Refer to **pages 145-168** for the specific wiring schematic.

Advantages:

- Simplified zoning where applicable
- Room-by-room zoning where applicable
- Can add actuators later to single-zone manifolds for multiple zoning

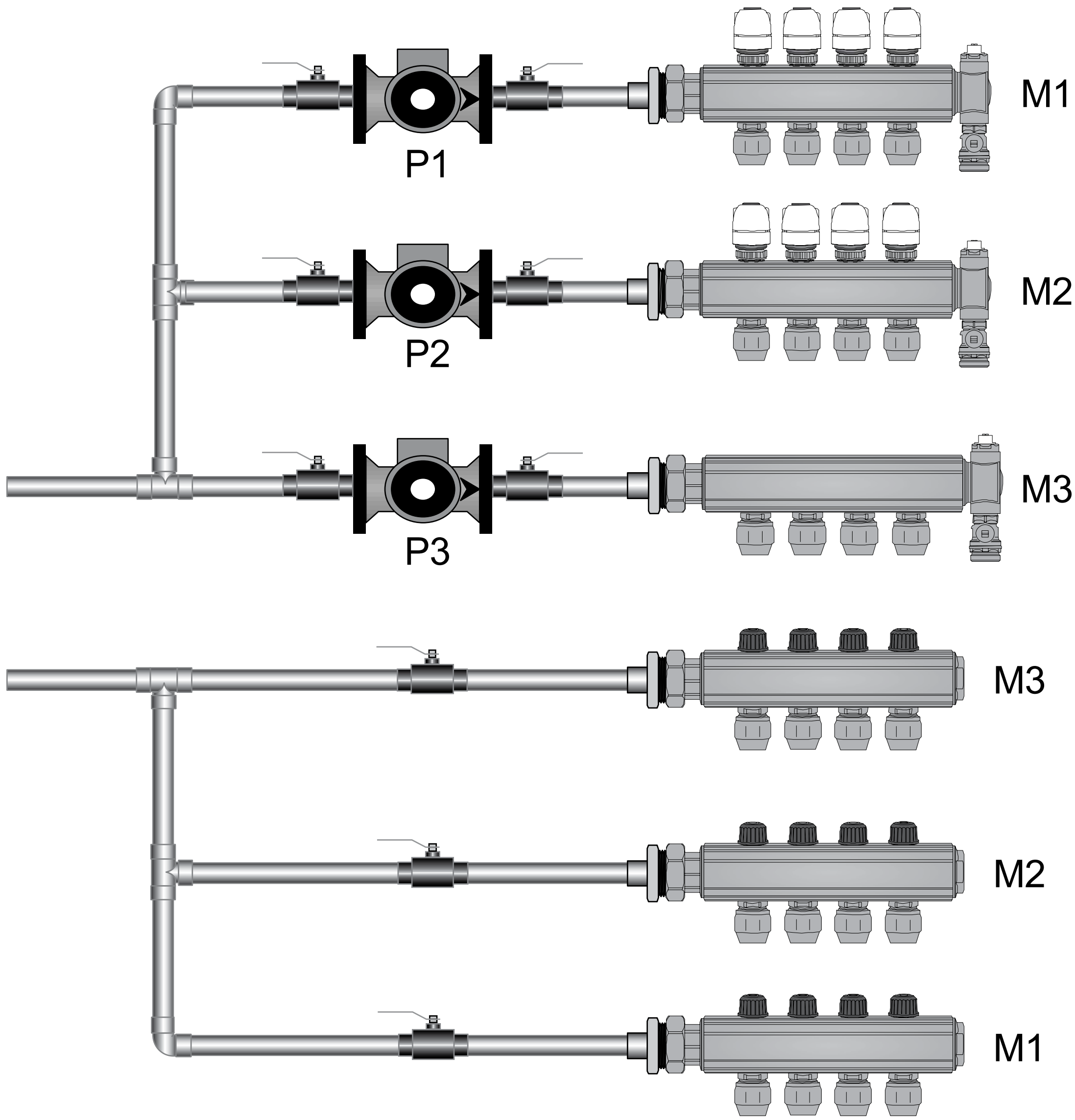

Figure 12-8: Combination zoning with circulators

Water temperature control

When considering radiant floor heating control, it is important to distinguish between zone control and water temperature control. For the most part, zone control may be achieved through the use of thermostats plus actuators, zone valves or circulators. This section discusses water temperature control for radiant floor heating.

Radiant floor heating is, in general, a relatively low water temperature system. There is no ideal or preferred water temperature for radiant. As discussed in **Chapter 8**, a variety of factors determine system water temperature. These factors include installation method, tube spacing, finished floor material and heat load. Once the system water temperature is determined, the question becomes how best to achieve and control that water temperature.

Radiant system water temperature control is categorized into three levels:

Level 1 — No additional temperature control

Level 2 — Single-temperature tempering

Level 3 — Weather-responsive reset control

Level 1 control is by far the simplest in terms of installation and operation.

Level 1 — No Additional Temperature

“No additional control” means using the water temperature control that comes with the heat source to control the radiant system water temperature. For example, if a simple gas-fired or electric water heater is used as a heat source, the desired system water temperature can be dialed into the water heater’s control. If 110°F water is needed, simply set the water heater to provide 110°F water.

Condensing boilers are ideal for Level 1 control. These boilers are designed to operate at extremely low return water temperatures. In fact, the lower the return water temperature to a condensing boiler, the more efficiently it operates. Condensing boilers use low return water temperatures to condense the flue gasses. The boiler then uses the latent heat in the condensed flue gasses to help heat the system water. This extra energy can increase the overall efficiency of a condensing boiler by 10% when compared to a non-condensing boiler.

Other heat sources are also suitable for Level 1 control. Electric boilers, like water heaters, may be controlled to provide a specific water temperature. Since there is no flue and no combustion gasses, electric boilers can operate at very low water temperatures with no fear of condensation.

Since a radiant system often requires relatively low water temperatures, a traditional cast iron non-condensing boiler (oil or gas fired), is not usually advisable for Level 1 control. Non-condensing boilers typically require return water temperatures of 125°F to 145°F to prevent flue gas condensation. If a system with return water temperatures lower than 125°F to 145°F is connected to such a boiler, the flue gasses within the boiler will condense. This condensation is highly acidic, and it can damage the flue pipe and the boiler itself. Only use non-condensing boilers for Level 1 control if return water temperatures are above the manufacturer’s minimum return limit. Refer to boiler manufacturer’s installation guidelines for model-specific information.

Level 2 — Simple mixing control

In its most basic form, single-temperature tempering mixes hot boiler supply water with cooler radiant system return water to achieve the desired radiant supply water temperature. Single-temperature tempering is used in cases where a standard non-condensing boiler is the heat source. Since these boilers are limited to no less than 125°F to 145°F return water temperatures, a tempering device is needed between the boiler and the radiant system for two reasons:

1. To achieve the desired radiant supply water temperature
2. To protect the boiler against return water temperatures below 125°F to 145°F, thereby preventing flue gas condensation

Three-way mixing valves — Uponor three-way mixing valves are microprocessor-controlled valves designed to regulate the supply water temperature to a radiant heating system by modulating the position of the valve. Configure mixed supply setpoint to reset from the outdoor air temperature or a fixed setpoint. Use an optional boiler sensor to provide boiler protection in non-condensing boiler applications.

Thermal mixing valves — A thermal mixing valve is the simplest and most effective way to achieve Level 2 control. The Uponor thermal mixing valves (A5402112) provide a constant, fixed water temperature for radiant floor heating, without affecting boiler operation.

The valve has three ports, labeled + (plus), - (minus) and MIX. Hot boiler water is supplied to the + port. Inside, the valve contains an element that expands and contracts to control the temperature of the radiant system supply water coming out of the MIX

Figure 12-9: Uponor three-way mixing valve (A3040075)

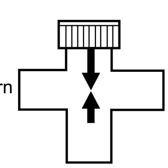

Figure 12-10: Thermal mixing valve (A5402112)

port. The port is for radiant system return water, piped into the – (minus) port as part of a bypass that also goes back to the boiler.

The valve has a dial for setting a fixed system water temperature. The internal element then expands and contracts as it senses the water temperature leaving the MIX port. If the MIX temperature is too hot, the element expands, pushing a shuttle valve to restrict the flow of hot boiler water from the + (plus) port. If the water temperature in the MIX port is too low, the element contracts, relaxing tension on the shuttle valve and allowing more flow of hot boiler water into the system through the + (plus) port. In effect, the valve will temper the hot boiler water with cooler radiant return water that is recirculated through the bypass and into the - (minus) port.

The valve is considered a reactive valve in that it supplies a constant water temperature to the radiant heating system, despite potential drops in boiler supply water temperature. A reactive valve works well with intermittent, or on-off, zone control.

There are several advantages to this valve, including:

- Low cost
- Non-electric — no additional wiring required
- Reactive — automatically adjusts to maintain proper supply water temperature
- Easy installation — only three piping connections
- Operating temperature range from 80ºF to 160°F

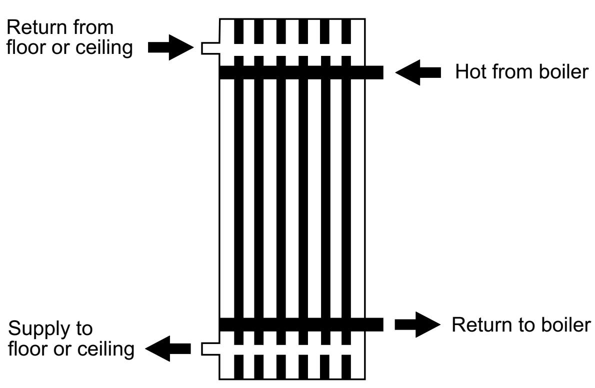

Figure 12-11: Heat exchanger

The valve can be installed in any position. The valve must have a circulator installed on the radiant side to insure proper flow through the radiant system. The best location for this circulator is between the MIX port and the supply manifold. In addition, a temperature gauge should be installed downstream of the MIX port to monitor supply water temperature. Refer to **Chapter 13** for a piping schematic.

Other level 2 options — There are several other methods of achieving Level 2 control, including mixing tanks, heat exchangers, four-way motorized mixing valves and injection mixing. Motorized mixing valves and injection mixing controls can also be made weather responsive; see the Level 3 section on **page 123** for more information.

Heat exchangers —Stainless steel brazed-plate heat exchangers provide fixed water temperatures for radiant floor heating and, more commonly, snow melting. Heat exchangers have two separate chambers, or sides. One side contains boiler water, and the other contains radiant heating system water. The hot boiler water is pumped through the heat exchanger, warming the walls of the exchanger itself. Radiant system water is pumped through the other side of the exchanger, and the water is warmed as it comes in contact with the hot wall of the exchanger. The boiler water and the radiant system water never mix.

Heat exchangers are most commonly used to deal with the issue of oxygen-diffusion corrosion when non-barrier Uponor AquaPEX® piping is used for radiant heating or snow melting. Non-ferrous components are used with the non-barrier piping on the radiant or snow-melting side of the heat exchanger. This means using a bronze or stainless steel circulator with non-ferrous flanges, a potable water-type expansion tank, a brass or bronze air separator, and all non-ferrous hard piping. No steel or cast iron piping or other ferrous materials may be used with non-barrier piping.

On the boiler side of the heat exchanger, traditional piping materials may be used. The heat exchanger prevents oxygen-diffusion corrosion by separating the "open" system (using the non-barrier piping on non-ferrous components) from the boiler system.

Heat exchangers are also used in conjunction with domestic water heaters for small heating or floor conditioning jobs. The heat exchanger keeps the radiant system water separate from the potable water system. In all cases in which a heat exchanger is used for radiant heating, a circulator and expansion tank are required on the radiant side of the exchanger.

Water temperature on the radiant side of the heat exchanger is controlled by an aquastat, which is set to maintain a fixed supply temperature. When the aquastat remote sensor detects the supply water temperature dropping below that fixed temperature, the aquastat will fire a circulator on the boiler side of the heat exchanger (and the boiler, if necessary). Hot boiler water will pass through the heat exchanger, heating the radiant system water on the radiant side of the exchanger.

Advantages of heat exchangers include:

- Universally acceptable
- Provides protection from oxygen-diffusion corrosion when using non-barrier piping
- Perfect for snow-melt applications — protects heat plant from cold return temperatures
- Allows for isolation of systems using high glycol mixes

Heat exchangers can add expense to some systems, since an additional circulator, expansion tank, air separator and hard piping will be necessary. However, in snow-melting applications and installations using a domestic water heater, heat exchangers can be the ideal solution. Refer to **Chapter 13** for a piping schematic.

Mixing tanks — Mixing tanks are often referred to as buffer tanks. Water from the heat plant is mixed with return water from the radiant panel. A boiler loop circulator and a radiant panel loop circulator are required. A fixed water temperature is maintained in the mixing tank with an aquastat (either immersion or strap-on) that senses supply water temperature for the radiant panel. When that water temperature drops below the desired temperature, the aquastat fires the boiler loop circulator (and the boiler, if necessary), to pump more hot water into the mixing tank.

A mixing tank is often used with extremely low mass, or “flash” type, boilers. The mixing tank adds water to the system and can prevent the boiler from short cycling. Any insulated tank is suitable for use as a mixing tank.

Mixing tank advantages include:

- Medium to low cost
- Provides water mass to reduce potential boiler short-cycling
- Provides energy storage
- Excellent for wood boilers
- Simple piping

Refer to **Chapter 13** for a piping schematic.

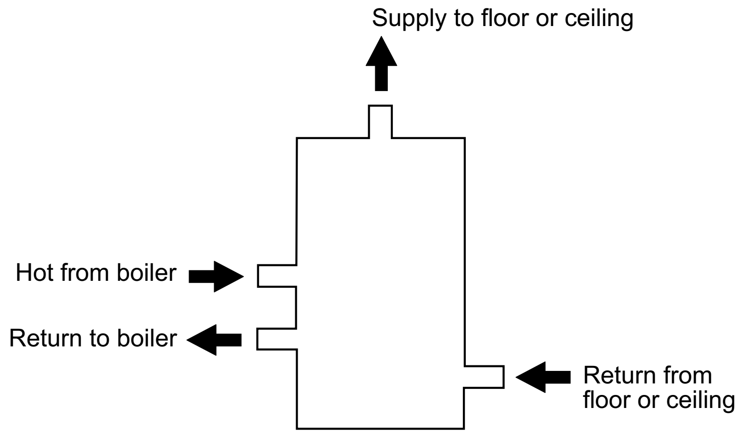

Figure 12-12: Mixing tank

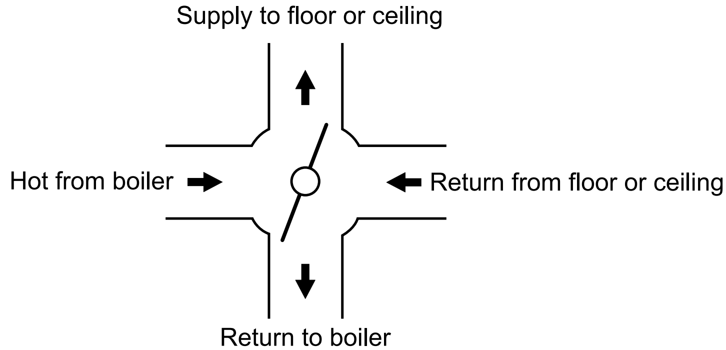

Figure 12-13: Four-way motorized mixing valve

Four-way motorized mixing valves — Four-way motorized valves are automatic and respond to control input from electronic sensors to maintain a fixed water temperature within a radiant system. They perform essentially the same function as a three-way tempering valve, performing those functions electronically and mechanically.

A sensor (either strap-on or immersion-type) senses radiant supply water temperature. When that temperature falls below the desired temperature, a control fires a circulator on the boiler side of the valve and tells the motor on the mixing valve to adjust the valve setting. The control and valve will regulate the amount of hot boiler water and of radiant return water that mix together to produce the desired water temperature.

In order to be “reactive,” four-way mixing valves must be equipped with a motor. The motor adjusts the position of an internal diverting flapper, which regulates the amount of hot boiler water and cool radiant return water mixed together to create the desired radiant supply water temperature. This is important since the boiler supply water temperature and/or the radiant return water temperature may not be fixed. If either of those temperatures is not fixed, a non-motorized valve will not be able to maintain a constant supply water temperature.

A non-motorized mixing valve merely provides a “fixed ratio” mixture of hot boiler water with cooler radiant return water. A motor on the mixing valve will allow the valve to alter the mix to provide a constant radiant supply water temperature, regardless of changes in the other two water temperatures.

Advantages of motorized four-way mixing valves:

- Universally acceptable
- Can be made weather responsive with additional control

Four-way mixing valves can add expense to a system, since a valve, motor and separate control is required. Additional wiring may also be required.

Injection mixing with constant temperature — Injection mixing achieves Level 2 control in a manner very similar to the three-way tempering valve. A constant radiant supply water temperature is maintained by mixing short blasts of hot water boiler water with relatively cool radiant return water. Injection mixing is often piped in a primary/secondary configuration. Hot boiler water flows through the primary loop, with the relatively cooler radiant supply water flowing through the secondary loop. Supply and return injection legs connect the two loops, with a two-position zone valve on the supply injection leg.

A setpoint control or aquastat is used to measure the radiant supply water temperature. Whenever the sensor reads that radiant supply water temperature drops below the desired level, the zone valve on the injection leg opens and fires the primary circulator. Hot boiler water will then be injected into the radiant loop, bringing the radiant supply water temperature up to the desired level. A suitable balancing valve is required on the radiant loop, between the supply and return injection legs, to create the pressure drop required for injection to take place.

Advantages of injection mixing:

- Universally acceptable
- Can be made weather responsive with additional controls
- Protects boiler from low return water temperatures
- Relatively low cost

Level 3 control — weather-responsive reset

Weather-responsive reset is used to maximize both system efficiency and comfort. At its most basic level, weather-responsive reset control adjusts the radiant system supply water temperature to match the exact heat demand of a building on a given day. Heating systems are designed to maintain a certain indoor temperature under design conditions, or the coldest day of the year in that specific geographic region.

Figure 12-14: An appropriate analogy for weather responsive reset control is cruise control on a car.

The radiant system supply water temperature is the water temperature required to heat a room or building under design conditions. However, the heat load changes as weather conditions outside change. As the outdoor temperature increases, the heat load of a building decreases. By the same token, the radiant supply water temperature required to satisfy that heat load decreases. Weather-responsive reset control monitors outdoor temperatures and then adjusts, or modulates, the system supply water temperature to satisfy the specific heat load at that given time. As the outdoor temperature decreases, the radiant supply water temperature will increase, and vice versa.

An appropriate analogy for weather responsive reset control is cruise control on a car. Cruise control is set for maintaining a specific speed, and it will adjust the amount of gas going to the engine based on road conditions: more gas if the car is going uphill, ess gas if the car is going downhill. As cruise control maximizes the comfort of the ride and the fuel economy of the vehicle, weather responsive reset maximizes both the comfort and fuel economy of the heating system. Indoor comfort is maximized by closely matching system output to the heating load, while system efficiency is maximized by providing the lowest possible supply water temperature at a given load, while minimizing distribution losses.

Weather-responsive reset controls may be applied to the heat source or to the radiant distribution system. Condensing boilers are most often reset, given their capacity to 1) reduce the firing rate (which effectively lowers the heat output and water temperature) and 2) accept very low return water temperatures without causing flue gas condensation. This is known as “full reset.” Non-condensing boilers may also be reset, but they require a minimum return water temperature of 125°F to 145°F to prevent condensation. This is known as “partial reset.”

When full reset is applied to the radiant heat distribution system only, the boiler must be protected from low return water temperatures, flue gas condensation and possible thermal shock.

Notes