Water Temperature Control Options

Achieving smooth and accurate heating from any hydronic heat emitter requires good water temperature control. This section discusses several options for water temperature control that can be used with DiaNorm panel radiators.

Setpoint Water Temperature Control

The "standard" method for regulating the water temperature supplied to a hydronic distribution system is called setpoint control. This is usually done using a high limit aquastat on the boiler.

Upon a demand for heat from a room thermostat, the distribution circulator is turned on. If the water temperature inside the boiler is less than the setpoint temperature minus a differential 5 to 10 ºF, then the burner is also turned on.

If boiler heat output exceeds the rate of heat dissipation by the distribution system, which is often the case, the boiler water temperature steadily increases.

If the boiler water temperature reaches the temperature to which the high limit aquastat is set, the boiler's burner is turned off. However, flow through the distribution system continues as long as there is a demand for heat from a room thermostat.

When this flow has removed enough heat from the boiler to lower its temperature by the differential setting the burner is restarted.

For example, if the high limit aquastat is set for 180 ºF and has a 10 ºF differential setting, the burner is turned off if the water temperature leaving the boiler reaches 180 ºF, and turned back on when this temperature drops to 170 ºF. Circulation through the boiler and distribution system continue as long as a room thermostat demands heat.

Although this method of control is simple, it does have several limitations including:

1. The water temperature supplied by the boiler is always hot enough to provide the "design" rate of heat output from the panel radiators. This rate of heat output is only needed on the coldest day of the year. At all other times the rate of heat output from the panel radiators can be less, and could be attained with lower boiler water temperture. Unfortunately, with setpoint control this will not take place. Operating the boiler at the highest required water temperature regardless of the heating load reduces its efficiency and increases fuel usage.

2. Because boiler water temperature remains high at all times, the system controls tend to "short cycle" at low load conditions. Heat is delivered to the rooms in "pulses" rather than a smooth continuous process. Occupants are notice this cycling operation, and generally not be pleased with it.

3. Since the water temperature is higher than necessary most of the time, heat output must be restricted by turning the flow through the panel radiators on and off. This can create rapid temperature changes in piping that may cause expansion sounds. This is especially true if the distribution piping system has not been detailed to properly accommodate expansion movement. Such noise, although generally harmless to system components, is annoying and of concern to building occupants.

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4. High water temperatures also decrease the control capability of thermostatic radiator valves (TRVs) because the valves are forced to operate with very limited stem travel during partial load conditions. Under such conditions, the TRVs tend to act more like on/off devices.

Variable Water Temperature Systems

Setpoint control systems do not provide an ideal match between the heat output of the panel radiators and the room heating load. One of the ways to improve this match is through variable water temperature control. As the outdoor temperature decreases and the building's heating load increases, the water temperature supplied to the radiators increases and so does their heat output. When such a control system is properly set, heat output from the panel radiators accurately matches the heat loss of the rooms they serve. Flow through the distribution system will be almost continuous under such conditions.

The most common way of varying the water temperature supplied to the panel radiators is based on outdoor temperature and called outdoor reset control. When properly executed, outdoor reset control is like cruise control for the heating system. It allows just the right amount of heat to be released from the panel radiators to match the current heating load.

There are several benefits associated with outdoor reset control including:

• Stable indoor temperature: When outdoor reset control is properly applied, the water temperature supplied to the panel radiators is just warm enough to satisfy the prevailing load conditions. Rooms don't undergo noticeable changes in temperature, as is the case when heat input is cycled on and off using setpoint control.

• Near-continuous circulation: Because the water supplied to the panel radiators is just warm enough to meet the prevailing load, the distribution circulator remains on most of the time. This reduces the perception of on/off cycles and uses the thermal mass of the distribution system to smoothen heat delivery.

• Reduced Expansion Noise: The combination of near-continuous circulation and very gradual changes in water temperature minimizes expansion noises from the distribution piping. During a heating season, the piping and panel radiators still experience thermal expansion movement similar to that in systems not using outdoor reset control. However, with outdoor reset control the movement takes place over days rather than a few seconds (as is often the case when setpoint control is used). Piping expansion noise is much more noticeable in systems where rapid changes in temperature occur.

• Reduced Thermal Shock: The use of outdoor reset control reduces the possibility of thermal shock to both the heat source and the distribution system. Hot boilers are less likely to receive "slugs" of cold water from zone circuits that have been inactive for several hours.

• Indoor Temperature Limiting: If water is supplied to the panel radiators at design temperature regardless of the load, occupants can set the thermostat to a high setting, and simply open a window or door to control overheating. Although this sounds like an odd approach to comfort control, it is often

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done in rental properties where tenants don't pay for their heat. When the water temperature is controlled by outdoor reset control, the water is just hot enough to meet the prevailing load with the windows and doors closed, and thus discourages this practice.

• Reduced Energy Consumption: Outdoor reset control has demonstrated its ability to reduce fuel consumption in both residential and commercial buildings. The exact savings will vary from one project to another. Conservative estimates of 10 to 15% are often cited.

Implementing Outdoor Reset Control

There are two ways of implementing outdoor reset control in hydronic systems.

1. **Boiler Reset Control**
2. **Mixing Reset Control**

Boiler Reset Control

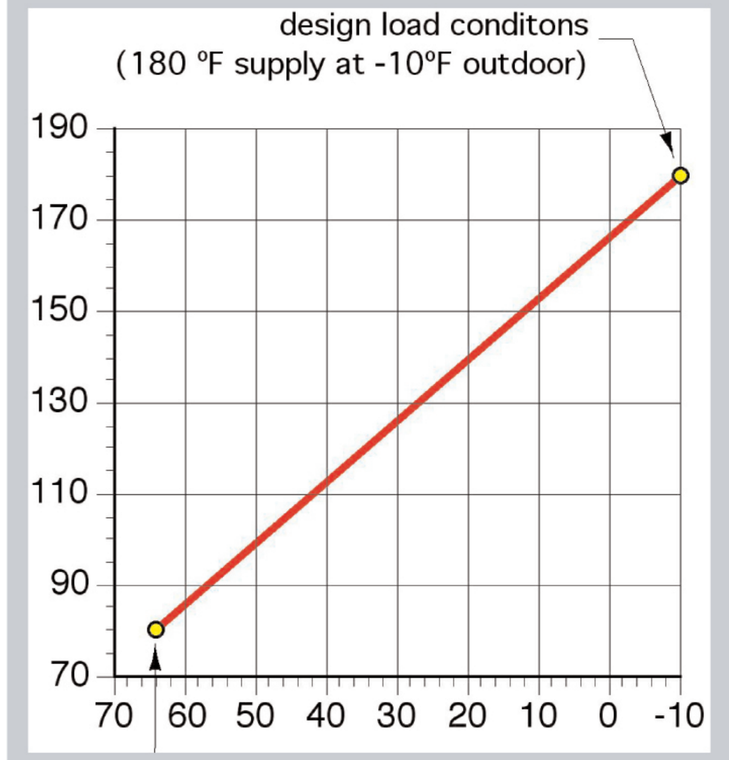
Boiler reset control regulates the temperature supplied by the boiler. The warmer it gets outside, the lower the water temperature supplied by the boiler (and vice versa). Boiler reset controllers are set up to follow a specific relationship between outdoor temperature and boiler supply temperature. This relationship is usually given in the form of a graph as shown at right.

The line shown on the graph is called a reset line. It shows the relationship between outdoor temperature and the corresponding water supply temperature from the boiler.

The heating designer can specify the slope of the reset line. The line shown puts the boiler supply temperature at 180 ºF when the outdoor temperature is -10 ºF. This is the design load condition, and is represented by the upper point on the line. The other end of the line shows a heat initiation condition with a water supply temperature of 80 ºF when the outdoor temperature is 65 ºF.

To find the water temperature supplied by the boiler at other conditions first find the outdoor temperature along the horizontal line, go straight up to the reset line, and then left to the vertical axis to read the water temperature.

Boiler reset control is largely responsible for the energy savings mentioned as one of the benefits of outdoor reset control. These saving are mostly the result of lower heat losses from the boiler. If boiler reset is used as the sole means of water temperature control to the panel radiators it also improves comfort, especially during partial load conditions.



Boiler reset is limited when used with a conventional gas- or oil-fired boiler. If the water

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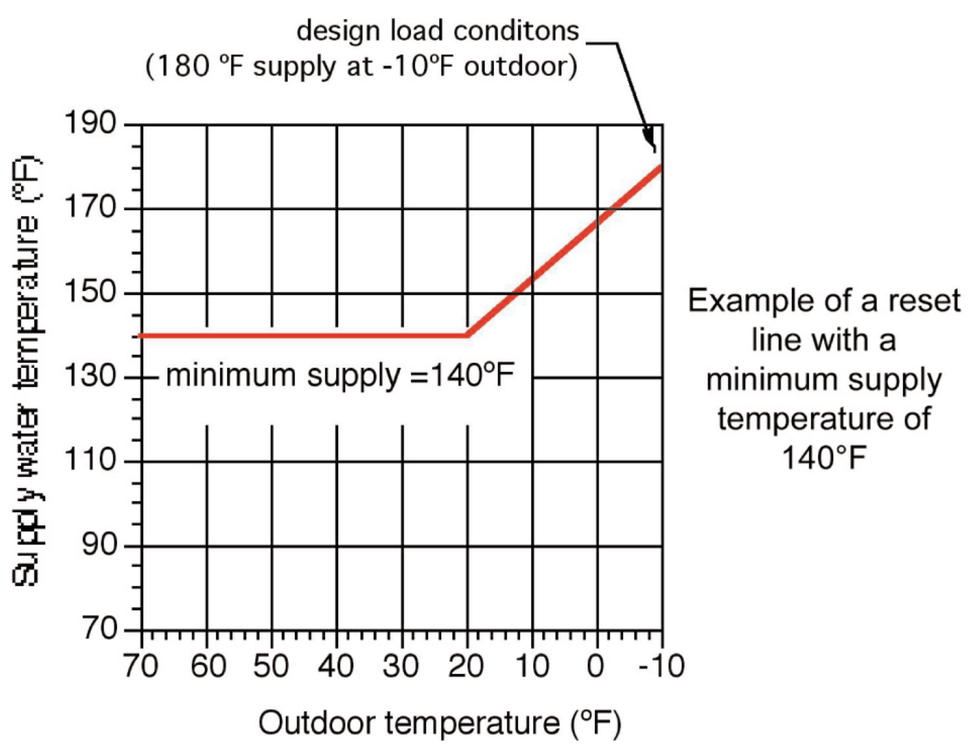
returning in the boiler is allowed to drop too low, flue gases will condense within the boiler and its venting system. Such condensation can severely scale and corrode both the boiler and vent connector. To prevent this, most boiler reset controllers have an adjustable minimum supply temperature setting. The controller does not allow the boiler to operate below a specified minimum temperature regardless of outdoor temperature. An example of a reset line with a minimum supply temperature setting of 140 ºF is shown below.



Notice how the lower portion of the sloping line has been "truncated" by the minimum supply temperature setting.

With the minimum water temperature setting, the water temperature supplied to the panel radiators is higher than necessary during low load conditions. Building overheating is prevented by slowing or stopping flow through the panel radiators.

In a system where each panel radiator is equipped with its own thermostatic valve operator flow is reduced as necessary to limit heat output. A differential pressure bypass valve would prevent the circulator from operating at excessively low flows and high differential pressure under such conditions. If the system used electrical thermostats instead of thermostatic valves, the circulator would cycle on and off to regulate heat output under low load conditions.

Mixing Reset Control

Mixing reset control requires a mixing device such as a 2-way, 3-way, or 4-way mixing valve, or a variable-speed injection pump. These options are shown in the diagram on the next page. A temperature sensor downstream of the mixing device provides continuous feedback to the mixing device allowing it to adjust the supply temperature very close to the target value calculated based on the reset line.

Mixing reset control allows the water temperature supplied to the panel radiators to range from a set maximum value at design load conditions, all the way down to the room air temperature. This is called "full reset" because the reset controller can operate the mixing device to produce a water temperature anywhere along the reset line.

Most mixing reset controllers also measure the temperature of the water returning to the boiler. If this temperature drops below a preset minimum, the mixing device decreases hot water flow into the mixing point allowing the boiler to quickly recover to a temperature where flue gas condensation will not occur.

SECTION SIX

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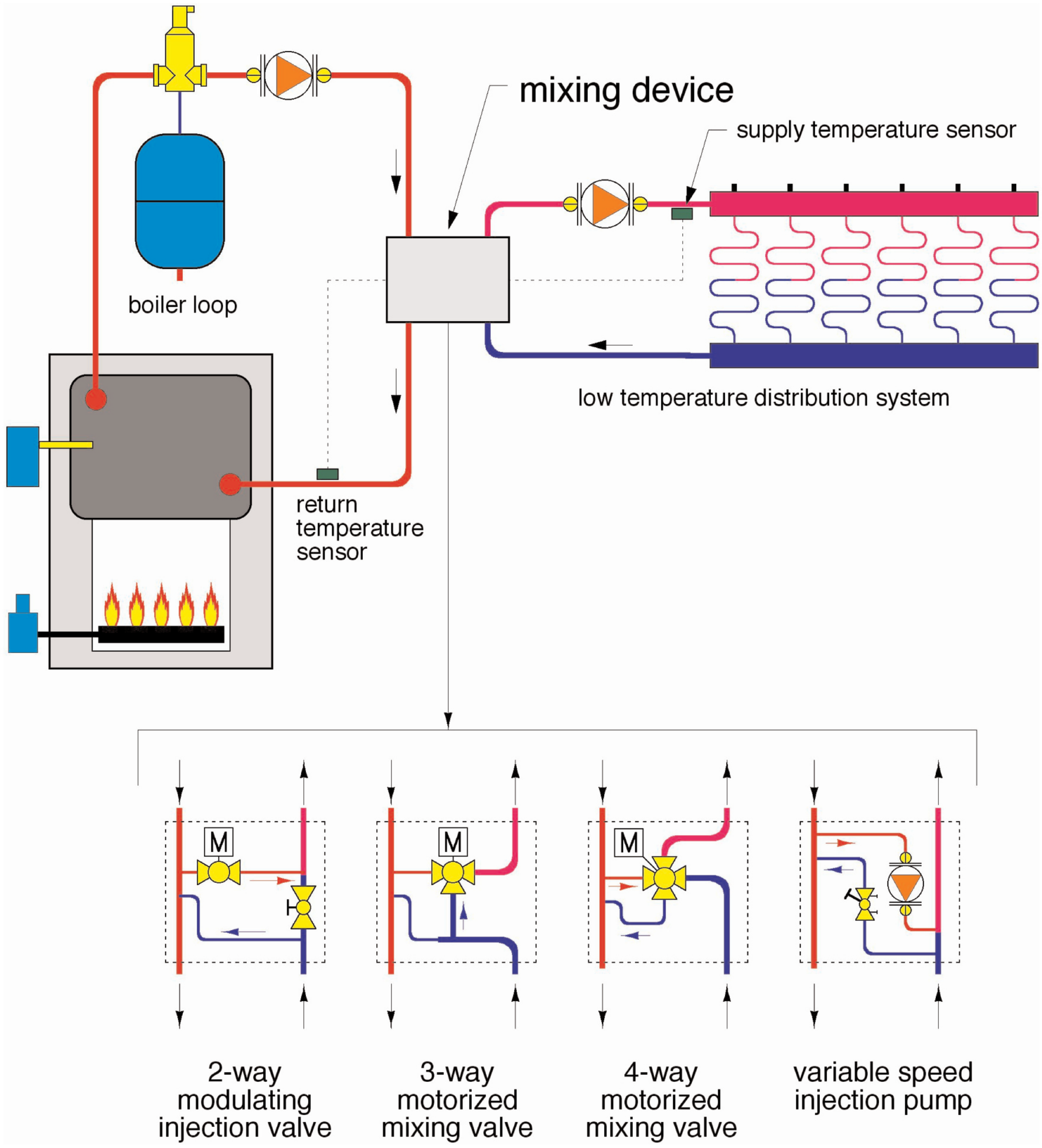

Four mixing options suitable for providing mixing reset control.

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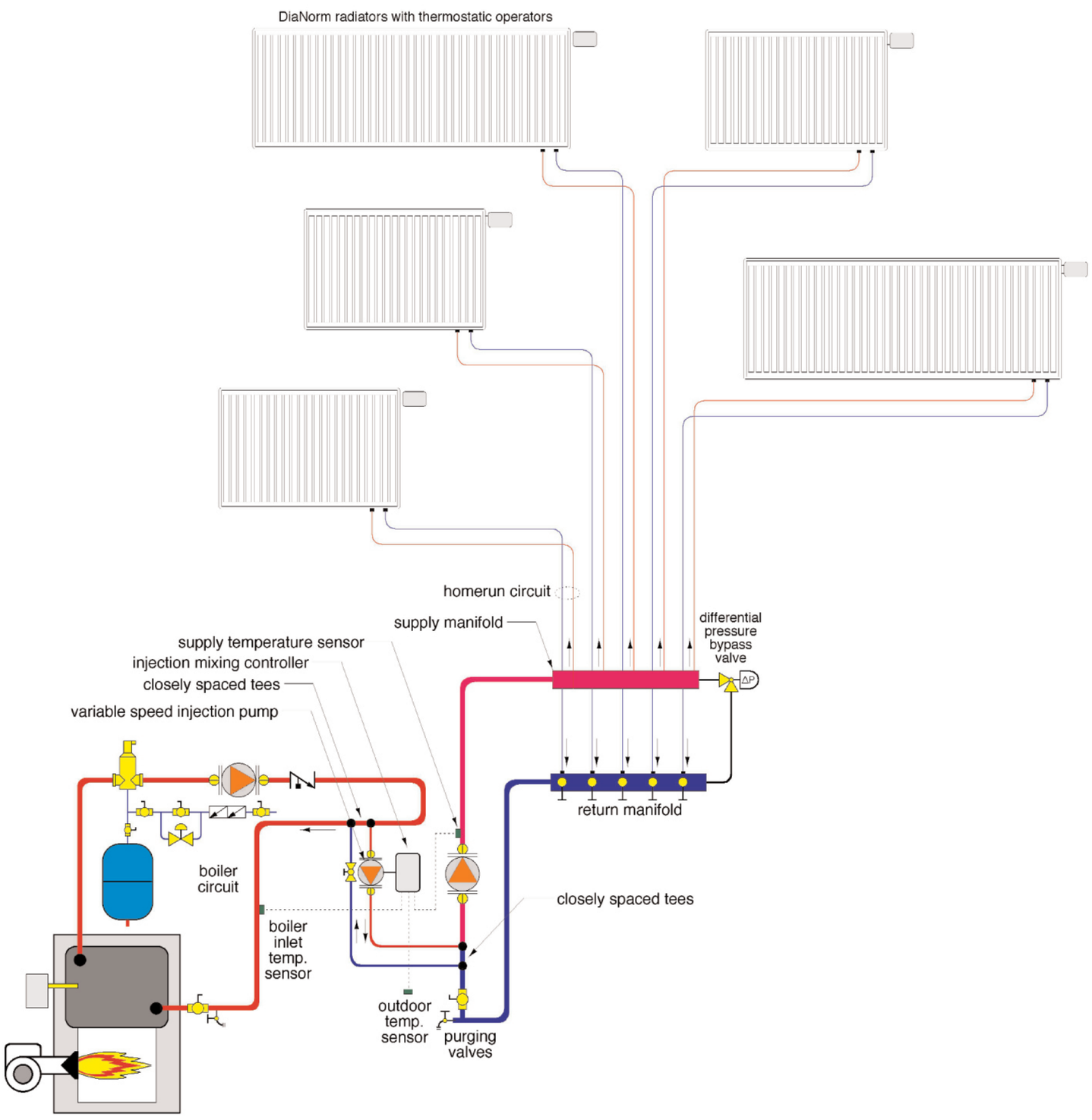
The figure below shows a homerun distribution system supplying several DiaNorm panel radiators. The temperature of the water supplied to the manifold is regulated by a variable speed injection pump. The reset line of the injection mixing controller has been set to provide 160 ºF water to the manifold at design load when the outdoor temperature is -10 ºF. The water temperature is reduced to 80 ºF when the outdoor temperture is 65 ºF. Thermostatic radiator valves are provided on each panel radiator to allow individual room temperature adjustment and prevention of overheating due to internal heat gains.

It is possible to use **both** boiler reset and mixing reset in the same system. The boiler supply temperature decreases as the outside temperature increases, as does the water temperature supplied to the panel radiators. Such systems increase seasonal boiler efficiency as well as provide the ideal supply water temperature for optimal comfort.

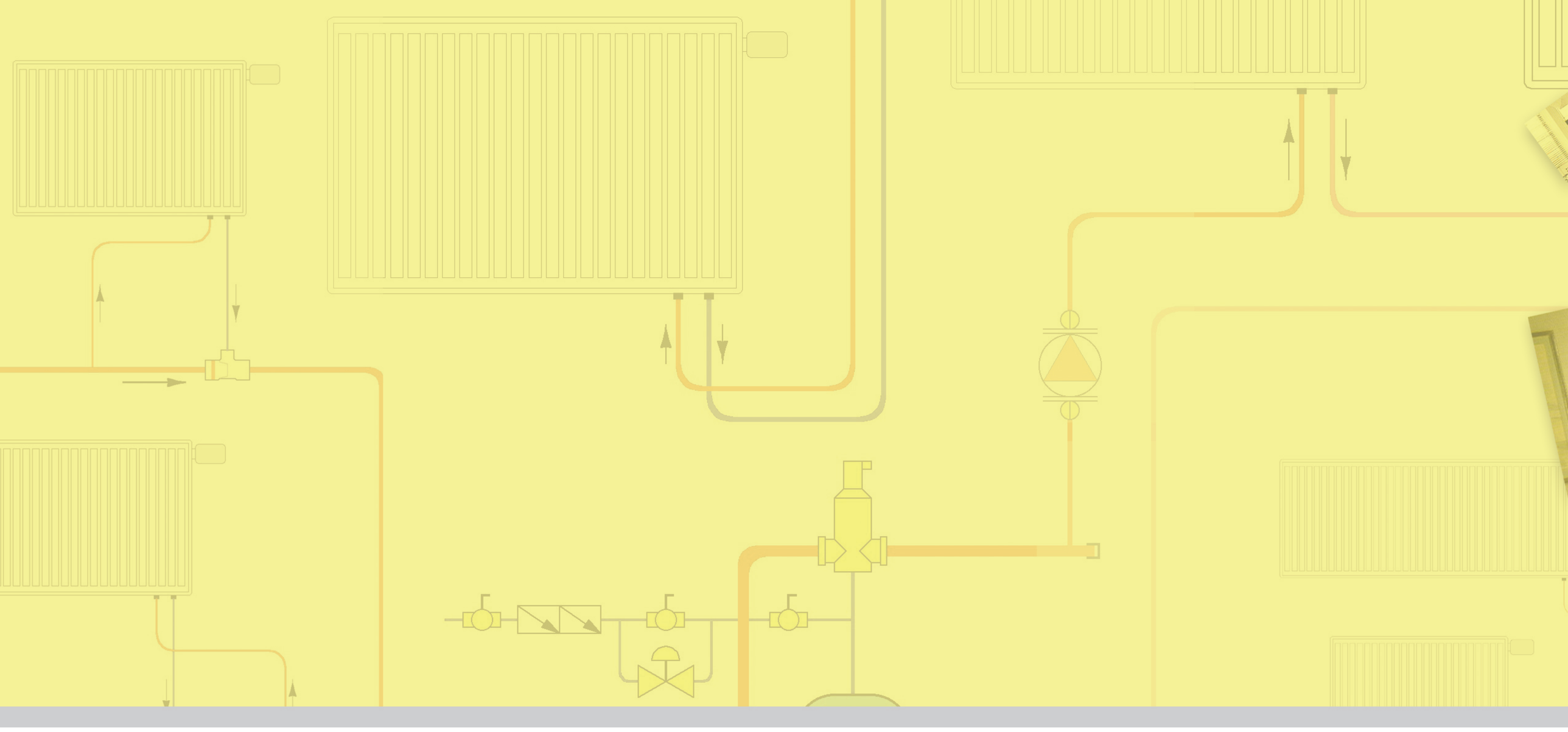


This manual is dedicated to the memory of Thomas Walsh Senior, founder of Rood Utilities in Auburn NY. Tom, who passed away in 2004 at the age of 82, was an innovator in hydronic heating. He recognized the advantages of applying state-of-the-art products and systems, and enthusiastically shared his passion for hydronic heating with countless others over 52 years in the industry.

"Senior," as he was often called, was an ardent supporter of panel radiators and even retrofitted his home with them. He was also instrumental in having this manual produced.

Those who knew Tom remember him as passionate about his work, as well as an incessant learner and educator. He created a training facility at Rood utilities in 1964, and used it to teach modern hydronics to thousands of heating technicians over the years. At an age when others had long since retired Tom was still hard at work sharing his knowledge with the next generation of heating professionals.

Tom leaves a legacy for others in the hydronic heating industry to follow. He would revel in knowing this manual will help others provide the same uncompromising comfort he sought for his customers.



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