John Siegenthaler, P.E. | John@hydronicpros.com

Looking up to radiant cooling

We need one controller for year-round comfort.

Hydronic heating has long been known for providing superior cold weather comfort. Even so, a question that often arises from a potential client — one who already has been convinced about the benefits of hydronic heating — is: "What about cooling?"

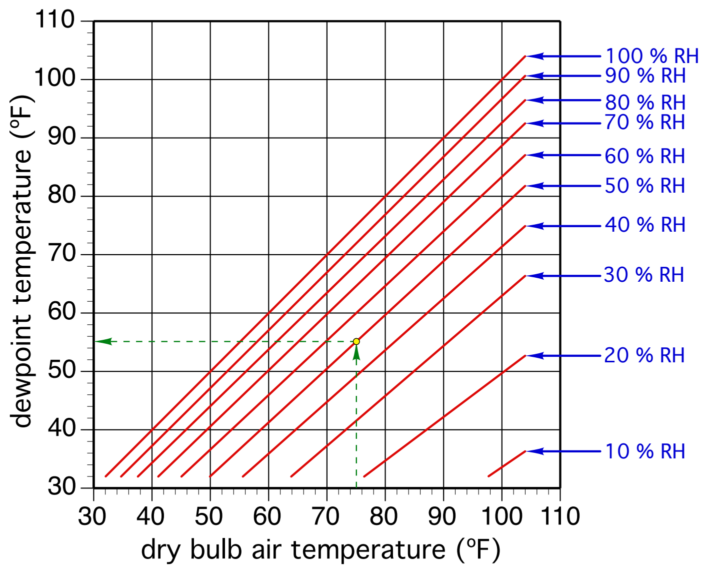
There are a range of answers depending on budgets, zoning preferences and the equipment used for the heating portion of the system. One of the lesser-known possibilities, at least at present, is using a radiant panel as a "heat absorber" for sensible cooling.

Not just floors

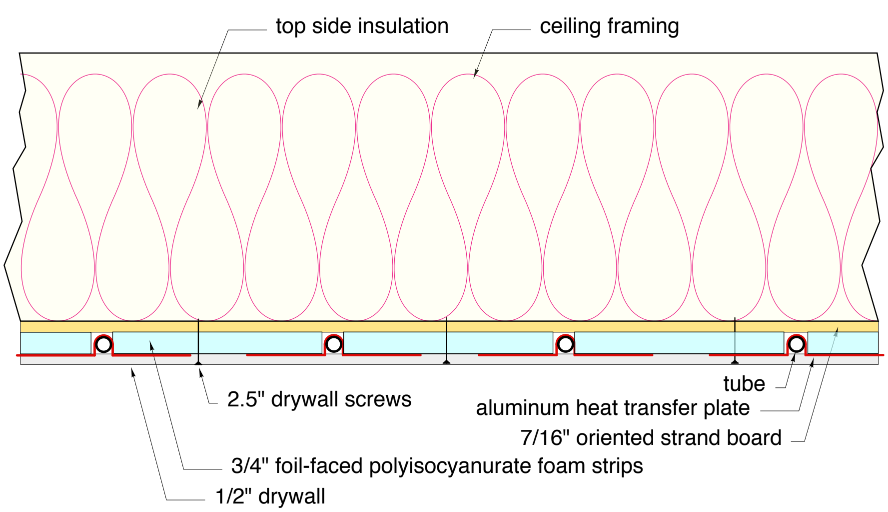
The term "radiant heating" makes most people think about warm floors. Although it's certainly true there are many excellent applications for radiant floor heating, it's not the only type of radiant panel that can deliver excellent comfort.

A hydronic radiant *ceiling*, when properly applied, serves as an excellent low-temperature heat emitter. Some designs, such as the panel shown in Figure 1, can deliver a heat flux of 28 Btu/ft^2 when operating at an average circuit water temperature of 110° F. This makes them well-suited for "traditional" low-temperature heat sources such as mod/con boilers, as well as renewable heat sources such as solar-thermal collectors, heat pumps and biomass boilers. The low thermal mass of this panel allows it to quickly respond to changes in factors such as internal heat gain and changes in thermostat settings. When properly constructed, this radiant ceiling panel should last for decades, probably outliving several heat sources that will take turns supplying it.

> Figure 2.



> Figure 1.



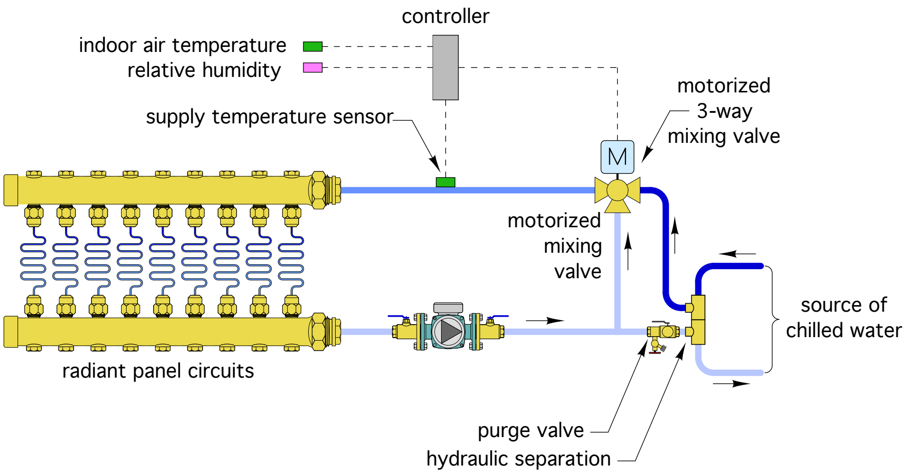
Graphics courtesy of John Siegenthaler

Heat absorbing

Radiant ceilings have another benefit. They are ideal surfaces for absorbing heat from occupied spaces. This happens when the surface temperature of the ceiling is maintained slightly lower than that of the air and objects in those spaces. This is called radiant cooling and I think it has the potential to become a viable (and even highly desirable) option in some residential and light-commercial building applications.

Radiant ceiling cooling is not as simple as circulating chilled water through tubing embedded in the ceiling. To prevent condensation on or within the panel, the temperature of the chilled water supplied to it should be maintained about 3° *above* the current dew-point temperature of the room.

> Figure 3.

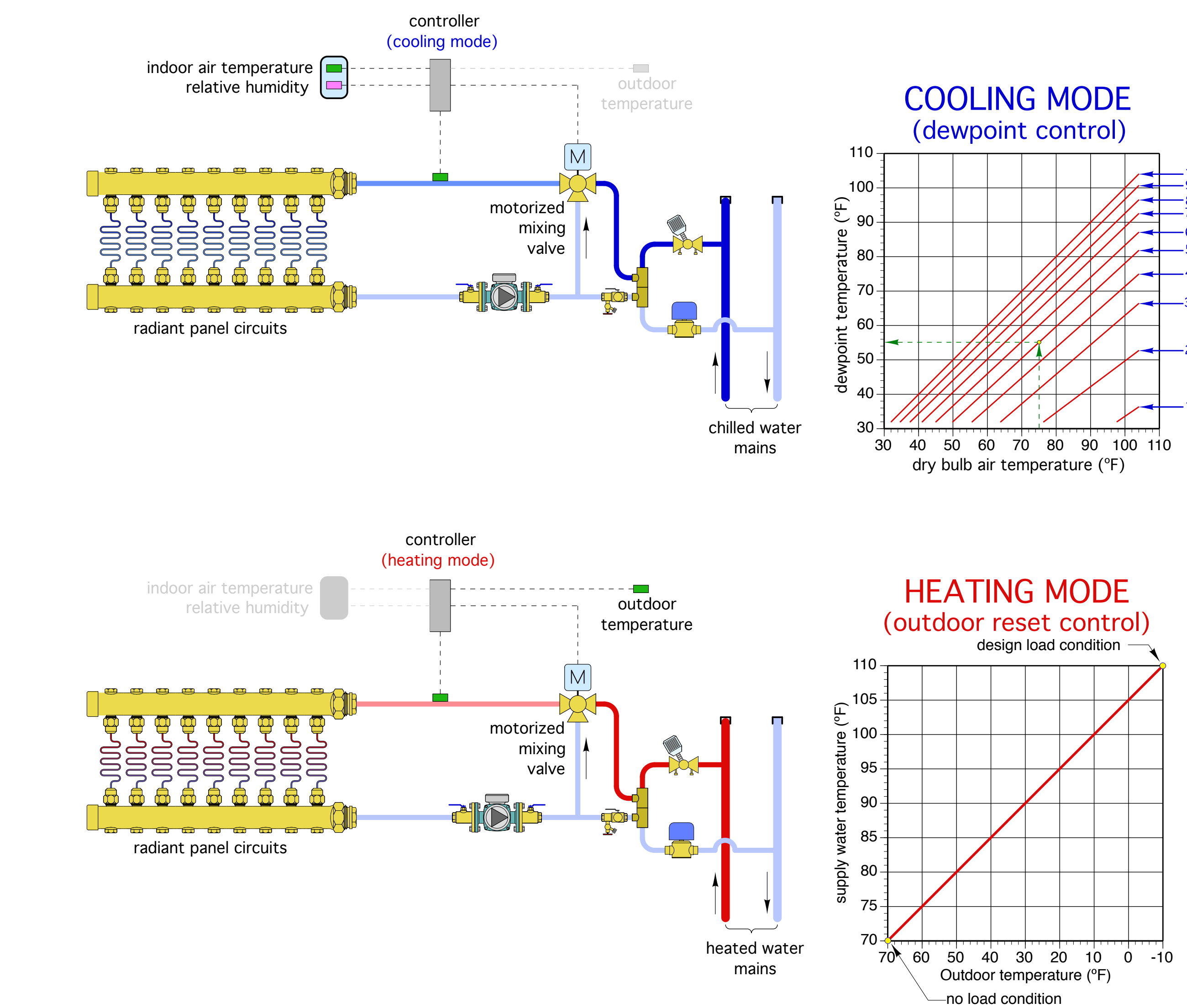


The dew-point temperature depends on both the dry-bulb temperature of the room air and its relative humidity. It can be calculated, determined from a graph such as Figure 2 (on page 10) or referenced from a psychometric chart.

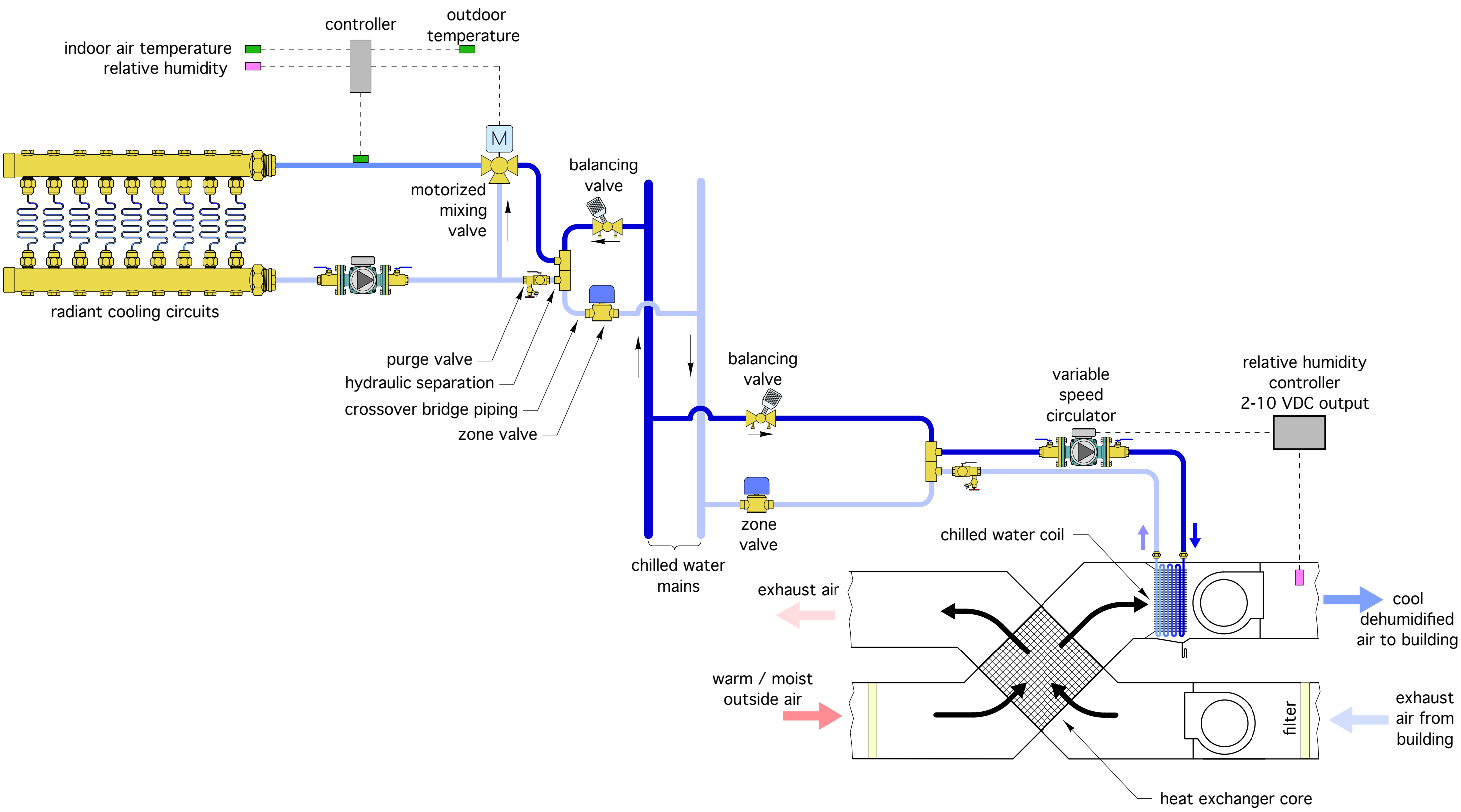
A change in dry-bulb temperature or relative humidity will change the dew-point temperature and thus require a change in the chilled-water temperature supplied to the radiant ceiling panel.

Designers should keep in mind that different areas of a building can have different dew-point temperatures at the same time. For example, a vestibule in which the exterior door is frequently opened on a hot and humid day likely will have a higher dew-point temperature compared to an interior

> Figure 4.



> Figure 5.



space with minimal sources of moisture. Buildings with such spaces should be divided into zones and *the chilled-water temperature to each of those zone needs to be independently controlled.*

One of the simplest ways to maintain the chilled-water temperature supplied to a radiant panel above dew-point temperature is with a three-way motorized mixing valve — the same type of valve that would regulate the temperature of warm water supplied to the panel during heating mode. In cooling operation, the valve mixes chilled water, supplied from some source, with slightly warmer water returning from the radiant panel.

The controller operating the three-way valve would continuously sense the dry-bulb temperature and relative humidity within a space. It would use this information to determine the current dew-point temperature. It would then compare this temperature to that of the water being supplied to the panel. Its objective would be to maintain the supply water temperature about 3° above the dew-point temperature.

Figure 3 (on page 12) shows how this controller would connect with the mixing valve and associated chilled-water distribution piping.

This is the same piping one could use to control the temperature of warm water supplied to the radiant panel circuits for heating. *The only difference is the control logic used to regulate the mixing valve.* For cooling, it would be the previously discussed dew-point control. For heating, it would be outdoor reset control, where the water temperature supplied to the panel increases as the outdoor temperature decreases.

So wouldn't it make sense to have a *single* electronic controller that includes both control algorithms? This would allow the same panel that provides excellent thermal comfort in winter to provide sensible cooling in summer. The concept is shown in Figure 4 (on page 12).

More smarts

Because condensation must be avoided, radiant panels only can provide *sensible* cooling (e.g., lowering the air's dry-bulb temperature). Proper system design also must address latent cooling (e.g., lowering the moisture content of the air). The latent cooling load can only be handled by a device that allows condensation to form within it and properly dispose of that condensate. Most systems use one or more air handlers equipped with chilled-water coils and drip pans for this purpose. The volume of air passing through the air handler often is determined by the ventilation load of the space.

Figure 5 shows the concept for such an air handler. It includes a heat-recovery unit that scavenges some of the cooling effect of the exhaust air stream and uses it to precondition the incoming ventilation air. This assembly also includes a multiple tube-row chilled-water coil that is very effective in dehumidifying the air passing through it. The goal is to dry the air supplied to the space to a condition that allows it to absorb sufficient moisture from the space to maintain a comfortable relative humidity.

The cooling capacity (and rate of moisture removal) of the air handler in Figure 5 is controlled by the flow rate of chilled water through the coil. In this case, that flow is regulated by a variable-speed circulator that responds to a controller that measures the relative humidity of the supply air stream and compares it to a setpoint value such as 50%. The controller outputs a signal which is compatible with the speed controller driving the circulator. When the relative humidity starts to rise above setpoint, the circulator speeds up to increase the capacity of the coil and vice versa.

The air handler system also could be used for ventilation in winter. In cold climates, the circuit through the cooling cool, which could be used to warm incoming ventilation air in winter, would need to be protected by antifreeze.

The chicken or the egg?

I would welcome control manufacturers to offer this combined functionality (e.g., dew-point and relative-humidity control in summer with outdoor reset and ventilation air warming in winter) into a simple, standalone "plug-and-play" controller. I believe having such a controller would enable those who already install radiant heating systems to easily expand into radiant cooling. It's really the only piece missing from the "puzzle" at present.

One longstanding criticism of residential hydronics has been its perceived inability to provide cooling. Here's an opportunity to end that perception by offering not only the ability to provide cooling, but do it using state-of-the-art methods that improve comfort, leverage modern devices such as heat pumps and significantly reduce the "distribution energy" required to cool the building. It's also a great way to merge the best attributes of modern hydronics technology with air-side subsystems for ventilation and latent cooling.

For manufacturers reading this, please consider building this controller. It's an opportunity to deliver a truly new and unique product — one that could significantly expand the possibilities of modern hydronics technology. **pme**

John Siegenthaler, P.E., is principal of Appropriate Designs, in Holland Patent, N.Y., and author of the text "Modern Hydronic Heating." He teaches two, 10-week, design-focused online courses: Mastering Hydronic System Design and Hydronic-Based Biomass Heating Systems.