Chapter 2:
Radiant advantages

History of radiant

There's nothing quite like radiant floor heating. Over the past several years, radiant heating has been the fastest-growing segment of the heating industry, offering numerous advantages over more traditional alternatives.

While some people may think of radiant floor heating as new technology, it actually dates back thousands of years. Archaeological finds date early radiant systems in China and Korea to approximately 5,000 B.C. Heated floors and walls are seen in Greek and Roman cultures around 500 B.C. While sophisticated, hydronic systems using crosslinked polyethylene (PEX) piping have replaced simple, wood and charcoal-fired systems, the end results are similar — a comfortable and economical way to heat homes and buildings.

Radiant and PEX today

With more than 35 years of service — longer than any other PEX manufacturer in North America — Uponor is the leader in PEX piping for radiant heating, plumbing and fire safety systems. More than two billion feet of Uponor PEX piping is in service in North America alone, and more than 12 billion feet of piping is installed worldwide.

Many demographic studies indicate that people are spending more time at home. As a result, home comfort has become a priority for many families. Homeowners are paying closer attention to benefits provided by the heating system. Greater comfort combined with unmatched fuel efficiency explains why residential radiant floor heating is becoming a popular alternative to forced-air heating.

Radiant floor heating also offers increased comfort and fuel economy for office buildings and other commercial applications, such as stores, schools, airport hangars, greenhouses and more. Aware of the benefits, a greater number of building designers and owners now provide their clients with comfortable, healthy buildings with lower fuel bills.

Radiant floor heating benefits

Radiant heating offers many advantages over other heating systems — primarily forced air.

Comfort — Radiant floor heating warms people, furniture and other things in a room. Since the objects and surfaces are warmed, people don't lose body heat to things in the room. Uponor's radiant heating system turns floors into radiators that can be zoned to provide comfortable and even heat throughout homes — even in difficult-to-heat areas such as bathrooms, entryways and garages. Warm radiant floors are ideal for today's homes and rooms with vaulted ceilings and expansive windows. The comfort system concentrates the heat near the floor — where people are located.

Efficiency — Radiant floor heating is an extremely efficient mode of heat delivery. Floor heating is a low-temperature system and can be precisely controlled in each room. Because floor heating warms people and objects directly (as opposed to heating air), comfort may be achieved at lower thermostat settings. Radiant floor heating systems can provide energy savings up to 30% over forced-air systems.

Buildings with high ceilings, large windows, high infiltration or a combination of these and other factors typically experience greater savings. Energy savings vary depending on building use, occupancy, design and construction.

Clean and healthy — Because radiant floor heating does not rely on circulating air (as forced air or convective baseboard do), dust particles do not readily spread throughout a home. Radiant also greatly reduces the spread of other airborne particles, such as pollen.

Quiet — Radiant floor heating is virtually silent when it operates. There are no noisy fans, clunky ductwork or pinging pipes.

Complete design freedom — Because the heating system is in the floor, radiant heating allows greater freedom for furniture placement – without having to worry about blocking vents or radiators.

More usable space — With no bulky radiators or baseboards, homes with radiant floor heating tend to have more usable floor space.

Aesthetically pleasing — Since the heating system is virtually invisible, radiant heating does not detract from the appearance of a room. There are no messy heating grills or bulky radiators to look at or to collect dirt.

Low maintenance — Floor-heating systems require very few moving parts. There are no fans, belts or blowers that need replacing, and no ducts to clean.

Increased property values — In many parts of the country, homes with radiant heating have enhanced property values compared to similar homes with other types of heating systems. In nearly all cases, homes with radiant heating systems tend to attract buyers.

Perfect for concrete slabs — Radiant floor heating is the only solution for basement slabs. Turning a cold slab into a cozy, warm floor can convert these traditionally difficult-to-heat areas into comfortable, livable spaces. This can also increase property values.

Clean, dry, safe floors — Because the floor surface is warm, cleaning and drying are quick and easy. Quick-drying floors help prevent slick spots, especially in bathrooms, where people can slip and fall.

Choice of heat sources — Uponor hydronic radiant floors can be heated by any source of energy, such as gas, oil, electricity, geothermal, solar or wood. All the system needs is warm water.

This list is not all-inclusive. There are a myriad of benefits and advantages that make radiant floor heating the best choice to heat a structure.

What makes radiant floors so comfortable?

When considering the issue of personal comfort, it's important to fully examine the question, "Just what is comfort, and what are the elements that make a person comfortable?" It's more than simply feeling warm or not feeling cold. Most people think that comfort is a matter of supplying heat to the body. Rather, comfort is controlling the rate at which a body loses heat.

Think of a body as a heat source. Science has known for years that a human body generates more heat than it needs. In order to be truly comfortable, the body needs to lose the excess heat. A typical person at normal or light activity loses heat at a rate of about 400 BTU/h. That heat energy is lost in three specific ways. First, the body loses heat through convection, or air currents passing over the body surface. Second, the body loses heat through evaporation, by breathing and sweating. Third, the body loses heat through radiation, or the transfer of energy from a warm surface to a cooler surface.

A person feels most comfortable if the body loses its 400 BTU/h in a certain ratio: approximately 50% through radiation, 30% through convection and 20% through evaporation.

A common misconception, even among heating professionals, is that heat rises. In reality, hot air rises and cold air falls due to differences in density.

Heat goes to cold. Energy always travels from a hot surface or mass to a colder one. Think of how a stove heats water to a boil. A relatively cold pot filled with water is placed on a hot burner. The burner transfers its heat to the pot, which, in turn, transfers its heat to the water. This is why people feel uncomfortable when standing on a cold tile floor or next to a cold wall, even though the thermostat reads an air temperature of 70°F to 72°F. What is happening is that the colder floor or wall surface is drawing heat out of that person's body faster than it can be replaced.

A common response to this type of situation would be to simply turn up the thermostat and increase the air temperature. This response may offset the radiation heat loss to a small degree, but other comfort issues may decline. For instance, higher air temperatures generally result in stuffiness and dryness, both of which detract from overall comfort. In addition, since hot air rises, the air temperature at or near the ceiling is considerably warmer than the air temperature at the thermostat level. Consequently, people feel warmer near their head and colder at their feet, which also negatively impacts personal comfort.

Radiant floor heating delivers personal comfort by controlling the radiation heat loss of a body. When surrounded by surfaces that are roughly the same temperature as the body surface, natural heat loss via radiation is controlled.

Another way to help control natural heat loss is to reduce or eliminate unwanted air movement. Radiant floor heating virtually eliminates unwanted air movement because it doesn't use fans to circulate the heat. The only air movement in the room heated by radiant floor is natural air.

By combining these two factors — similar surface and body temperature and the elimination of unwanted air movement — a radiant system can control about 80% of the human body's natural heat loss.

In many rooms that are common in modern construction, this phenomenon can be dramatic. For example, in rooms with cathedral ceilings, large amounts of glass, hardwood, tile or vinyl floors, or anything built on a concrete slab, radiant floor heating is the only solution when it comes to delivering even, consistent, effective and efficient comfort.

Radiant floor heating generally also provides greater comfort levels at lower thermostat settings compared to baseboard or forced air. Experience shows that perfect thermal comfort may be achieved at thermostat settings of 65°F to 68°F. Review the ideal heating curve, illustrated in **Figure 2-1**.

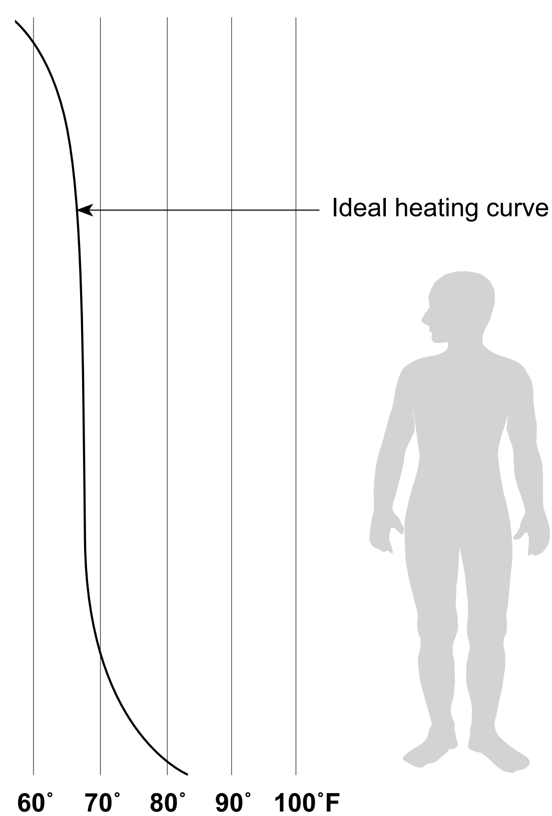

Figure 2-1: Ideal heating curve

Think of the body as a hydronic heating system with a priority-zoning package. Priority number one is the central torso and its critical organs. Priority two is the head, and priority three is the extremities. When placed in a cold environment, the body takes care of the central torso and head first, while restricting blood flow to the hands and feet. This is why people feel cold in those areas first. The head, however, is filled with blood vessels that provide plenty of body warmth. As a result, the air temperature needed at head level to create comfort does not need to be very high. Science and experience both indicate that most people are more comfortable and more alert with head-level air temperatures around 65°F to 68°F.

The goal of the ideal heating curve is to achieve a temperature just below skin temperature at the floor. Moving toward the ceiling from the floor, the air temperature lowers to about 65°F right at and slightly above head level. Closer to the ceiling, the air temperature decreases slightly.

Forced air — The common forced-air system heats air to the temperature necessary to overcome the heat loss of the structure. Hot air is then forced into the occupied space by blowers through ductwork. The heat loss of the structure determines both the temperature and speed of the air the occupants must endure.

If the heat loss is high, the air temperature must be uncomfortably high to maintain the thermostat setting (typically 70°F to 72°F). If the heat loss is low, the thermostat can be satisfied by blowing short blasts of excessively high-temperature air or by blowing low-temperature air more steadily. Either approach leaves people feeling uncomfortable.

In **Figure 2-2**, notice how a forced-air heating curve differs greatly from the ideal heating curve. Since hot air rises, the air temperature at head level and above is higher than ideal, and the closer to the ceiling you go, the warmer the air. Hot-air systems do not distribute heat to the extremities, where the body needs it most. In order to meet those needs, the air must be heated to a level that is much too hot and uncomfortable for the upper body. The choice is either cold feet or hot heads.

The temperature at floor level never reaches the desired level, and the temperature of the ceiling is too hot. Add to this equation unnatural convection, or air movement, that can alter the delicate heat-loss balance of the human body. Also note that the area between the forced-air curve and the ideal curve represents wasted energy and, as a result, higher energy bills.

Convective baseboard — Hot water and electric baseboard systems provide virtually all their heat through convection, although a relatively small amount is delivered via radiant means. Baseboard has very little surface area and operates at high temperatures. Air passes over the heated element of the baseboard and creates a convective warm-air current.

Since baseboards are generally placed on outside walls, the warm air then flows along the outside wall and collects at the ceiling. This air movement is the result of natural convection, compared to the forced convection from forced hot air. The actual air movement with a baseboard system is less objectionable than that created by a forced-air system. However, this air movement tends to create uneven pools of warmth and can adversely affect the ideal convective heat loss of the body.

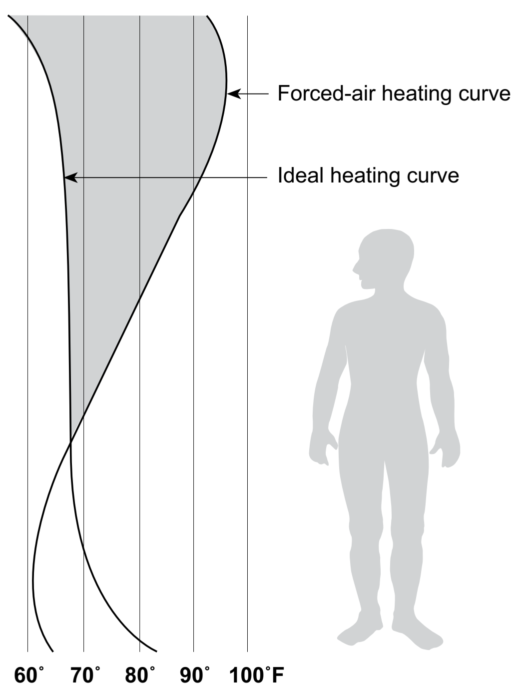

Figure 2-2: Comparison of ideal and forced-air heating curves

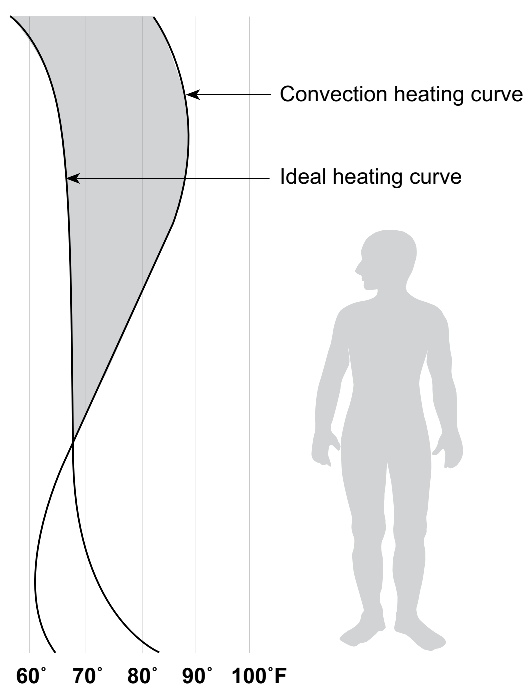

Figure 2-3: Comparison of ideal and convection heating curves

Although closer to the ideal curve than forced air, baseboard heating is unable to distribute heat where the body needs it. As with forced air, the temperature at the floor is too cool for true comfort, and the temperature at head level and the ceiling is too warm. Note the area between the baseboard convection heating curve and the ideal heating curve in **Figure 2-3**, representing wasted energy.

Radiators — Radiators, made of either cast iron or decorative aluminum, have more mass than either baseboard or forced-air delivery systems. Accordingly, they are able to provide a higher degree of radiant heat. As a result, radiators are much more comfortable than baseboard or forced-air heating systems. However, most of the heat delivered by radiators is still through convection because the surface area is relatively small. Radiators also require higher water temperatures. As with baseboards, air passes over and through the radiators, creating convective warm air currents. Radiators tend to create uneven pools of warmth, with the warm air currents affecting the ideal convective heat loss of the body.

The heating curve for radiators is closer to the ideal heating curve than either forced air or baseboard. However, radiators, like the others, cannot deliver needed warmth at or near floor level. In **Figure 2-4**, as with other non-radiant heating methods, the area between the two heating curves represents wasted energy.

Radiant floor — Radiant floor heating is the only heating system that comes close to matching the ideal heating curve. The entire floor surface area becomes, in effect, a low-temperature radiator. Since a person in that room is always in contact with the floor, or in contact with something that's in contact with the floor (e.g., furniture), that person is warmed directly by the floor, rather than chilled by losing heat to a cold surface. In addition, the floor acts as a radiator by warming surfaces in that room, which helps keep about 80% of a person's heat loss in balance.

Radiant floor heating can be designed around water temperatures lower than those used in baseboard or radiator systems. Floor surface temperatures are generally designed to remain at or below 87.5°F for all types of finished floors except hardwood, which has a maximum floor surface temperature of 80°F. See **Chapter 16** for more information about hardwood floors.

As shown in **Figure 2-5**, the radiant floor heating curve very closely mirrors the ideal heating curve. There's plenty of warmth at floor level, 65°F at head level and temperatures dropping off from there. There's very little difference between the two curves, clearly demonstrating radiant floor's superior energy efficiency.

Since there is a maximum floor surface temperature (87.5°F) with radiant floors, there is a maximum BTU/h/ft^2 output the floor can provide. The thermal transfer coefficient for radiant floor is 2 BTU/h/ft^2/°F. Therefore, when the room setpoint temperature is 65°F, the radiant floor can deliver a maximum of 45 BTU/h/ft^2, with the floor surface temperature being the limiting factor. Requirements beyond 45 BTU/h/ft^2 can be satisfied with the second best form of heating available — radiant ceiling (addressed later in this chapter).

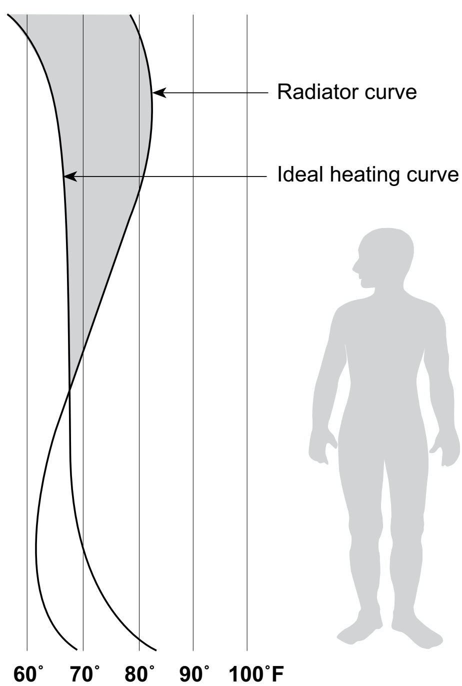

Figure 2-4: Comparison of ideal and radiator heating curves

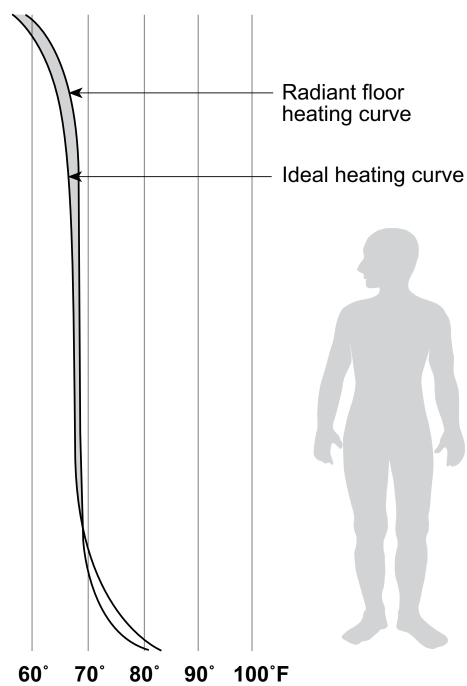

Figure 2-5: Comparison of ideal and radiant floor heating curves

A few words about efficiency — The true seasonal efficiency of a heating system is often misunderstood. True efficiency depends on several factors, including the actual and rated efficiency of the heating appliance and how effectively the heat-delivery system uses what the appliance creates. For example, an extremely efficient heating appliance connected to an inefficient delivery system does not produce an efficient system.

Radiant heating makes maximum use of the energy produced by the heating plant and provides comfort that other delivery systems cannot. Efficiency ratings on boilers and other hot-water heating plants, as well as those on hot-air furnaces, only reflect laboratory estimates of how efficiently that unit turns fuel into energy compared to other similar appliances. These ratings do not reflect the true seasonal efficiency of the entire heating system.

Uponor radiant ceiling heat

Radiant ceiling acts as a supplemental heat source. See **Figure 2-6** for the radiant ceiling curve. Like radiant floor heating, radiant ceiling uses the same three types of heat transfer: conduction, radiation and convection.

Radiation heat transfer — Radiant ceiling panels radiate heat to furnishings, floors and occupants the same way the sun radiates heat to the earth. The space between the sun and earth is cold, but the surfaces that heat radiation strikes are warm.

Conduction heat transfer — Heat radiation warms room surfaces, furnishings and floors. Those surfaces then provide secondary transfer through conduction (direct contact) and re-radiation. When people walk across the floor or touch a table that is warm as a result of heat radiation, some of that heat is transferred to them. That's conduction. Note that the effect of conduction with radiant ceiling is less than that of radiant floor.

Convection heat transfer — Radiant ceilings heat the objects in a room. Heat from the ceiling and objects in the room then warms the air, driving natural convective air currents. Convective currents (warm air) come into contact with other objects and again transfer heat. Convective heat transfer becomes pronounced when surface temperatures reach approximately 7°F above the room setpoint temperature.

The thermal transfer coefficient of radiant ceiling heat takes into account the transfer of heat energy due to convection and radiation. The coefficient of radiant ceiling heat is about 1.1 BTU/h/ft^2/°F difference between the ceiling surface temperature and room setpoint temperature (with radiant floor, the heat transfer coefficient is 2.0). For example, a room setpoint temperature of 70°F, with a ceiling surface temperature of 100°F would yield a maximum of 33 BTU/h/ft^2.

Uponor radiant ceiling heat advantages

Radiant ceiling heat, like radiant floor heating, offers many advantages.

Responsive — Radiant ceiling heat is very responsive because it's a low-mass system, using highly conductive gypsum sheetrock.

Effective — Radiant ceiling heating systems are effective because they are suitable for surface temperatures as high as 100°F with normal 8-foot ceilings and 110°F for ceilings higher than 8 feet, but lower than 12 feet. Radiant ceilings produce 33 BTU/h/ft^2 at a 70°F room setpoint temperature.

Adaptable — Radiant ceiling heating systems adapt easily to retrofit installations. Radiant ceilings are typically lowered less than 1½ inches.

Accessible — Radiant ceiling panels have clear access to heated space. They're not subject to changes in floor coverings or use patterns.

Economical — As a supplemental heat source, radiant ceiling offers the opportunity to concentrate additional heat in the area with the greatest heat loss. They also require low-water temperatures, typically no higher than 120°F.

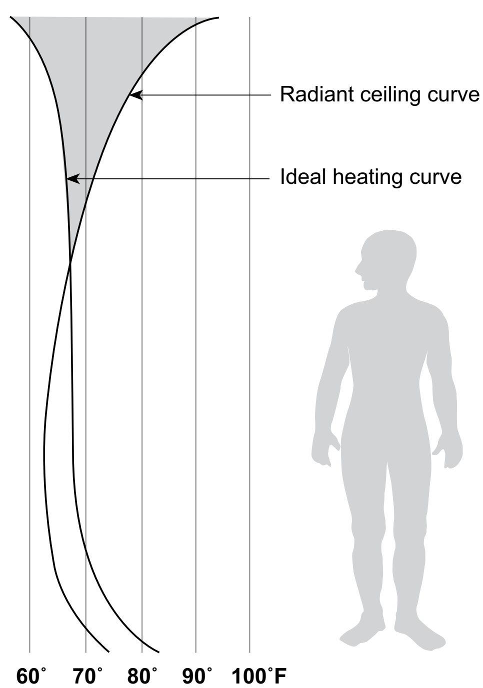

Figure 2-6: Comparison of ideal and radiant ceiling heating curves