RADIANT ESSENTIALS

RADIANT PANEL HEATING BASICS
BUT ALSO MORE ADVANCED INFORMATION

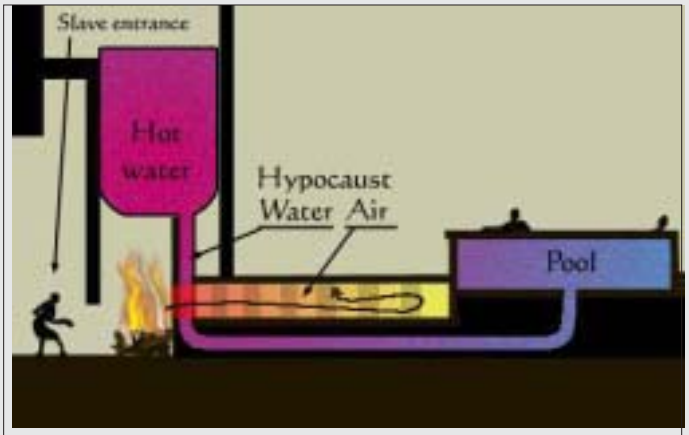
Panel Heating Radiates Comfort

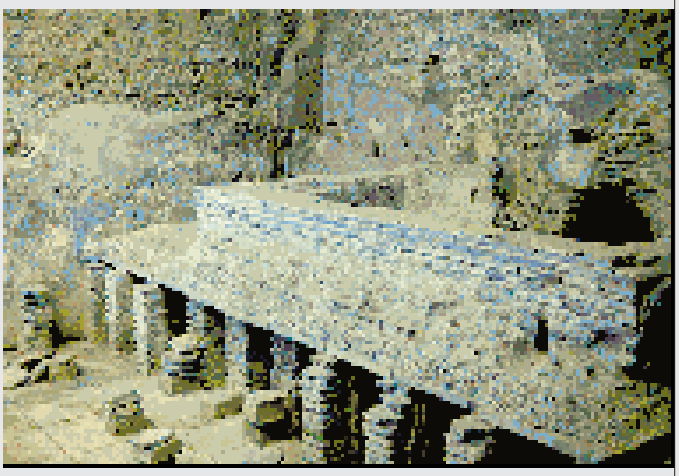
The benefits of radiant panel heating have been known for thousands of years. The Romans used "hypocausts" to heat large public baths, gymnasiums and other magnificent buildings by forcing warm air under the floors. The same principle was used in Asia as late as the 19th century. Several famous Korean Royal Palaces are equipped with such systems. In our century, radiant floors were installed during the 1950's in Europe and the US. Utilizing steel and copper pipes buried in the concrete slab, most worked fairly well. However, the life span for metal pipes buried in concrete proved to be fairly short. Many systems had to be abandoned after only 15-20 years, often sooner. The problems were mainly due to thermal expansion and contraction of the pipes. Since the concrete rigidly held them, the thermal movement was hindered and this caused stress and fatigue resulting in brittle cracks. But system failures also included corrosion of the pipes and shifting of the slab itself.

In the late 1960's and early 1970's radiant floors were reborn in Europe, using plastic pipes. Continuous lengths of flexible plastic pipes promised to solve the problems previously encountered with copper and steel pipes. But the low and medium density Polyethylene and Polypropylene used at that time, proved to have life span problems as well. They became brittle when subjected to higher temperatures, bending, and chemicals that induced stress cracking.

It was the introduction of Crosslinked Polyethylene (PEX) in the early to mid-1970's that created an ongoing radiant floor boom in Europe. This flexible material has high temperature/pressure ratings, outstanding stress-cracking resistance and proven durability. Today, two out of three new construction projects in continental Europe utilize radiant panel heating. Approximately 70% of these projects are installed with PEX tubing. But, even more impressive, the Korean hypocaust tradition has lead to PEX tubing radiant panel heating being used in virtually every new building project in that country.

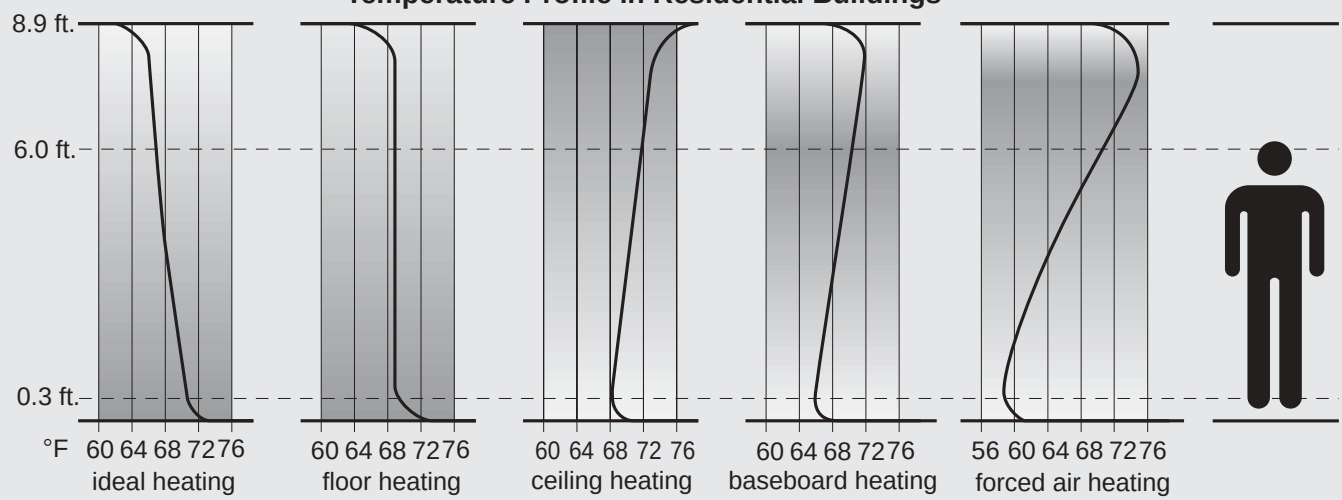
As American consumers learn more about the comforts of radiant panel heating systems, and contractors learn more about design and ease of installation, these systems are capturing an increasing share of the U.S. heating market. In central Europe, radiant panel heating systems are now installed in nearly 3/4 of all new residential homes and over half of the commercial market. Due in large part to the enhanced comfort and the proven energy savings of radiant panel heating systems, sales in the US are currently growing by more than 25% annually. But radiant panel heating systems also provide important health and safety benefits, and we will look closer at it's features.





The Roman Baths often had an underground heating system, called a Hypocaust, which heated the men's and women's hot bathrooms. Floors in the heated rooms were held up by short pillars floors. Smoke and hot air passed under the floors and up the walls of the heated room. The furnace often also heated a water tank connected to the pool. This meant that the water, the flooring and the walls were all kept warm. Even some private larger houses had the Hypocaust system.

Panel Heating Radiates Comfort (continued)



The ideal temperature distribution for human comfort is generally accepted to be 73 degrees at foot level and 67 degrees at head level. Radiant floors provide the best heat distribution followed closely by radiant ceiling installations. The illustration shows how close the temperature distribution is to the ideal heating distribution curve. Although the ideal installation is warmest at our feet, most air-heating systems waste heat at the ceiling level. The illustration to the right magnifies the difference even more. As ceiling height increases, conventional systems waste even more heat.

The #1 Reason for Selecting Radiant Floors: Comfort! Given its many advantages, having warm feet without needing thick carpets is a daily sensation with radiant panel heating. Feet are actually the thermostats of the human body. Cold feet make you feel cold; warm the feet and you are comfortable. But the comfort does not stop here:

Radiant Panel Heating is Quiet. Blowers suddenly starting up can be annoying and controlling heat by reducing air register openings may lead to hissing and whistling noises. Air channels, although large in size, convey this noise when too much air is rushed through. Because water is much denser and can transport so much more heat (3,200 times more per volume), it can run slowly through noise-absorbing plastic tubing. And you can't hear the small circulator pumps, not even inside the utility room.

It is invisible. Because tubing is installed behind floors or ceiling panels, radiant heat requires no unsightly wall or floor openings. A new world of opportunities is opened to the interior designer and design conscious homebuilder. You are completely free to decorate as you wish, since you need not take into consideration the locations of heat registers, baseboard, radiators, etc. The heat distribution is there but it is invisible. This also makes it virtually vandal proof.

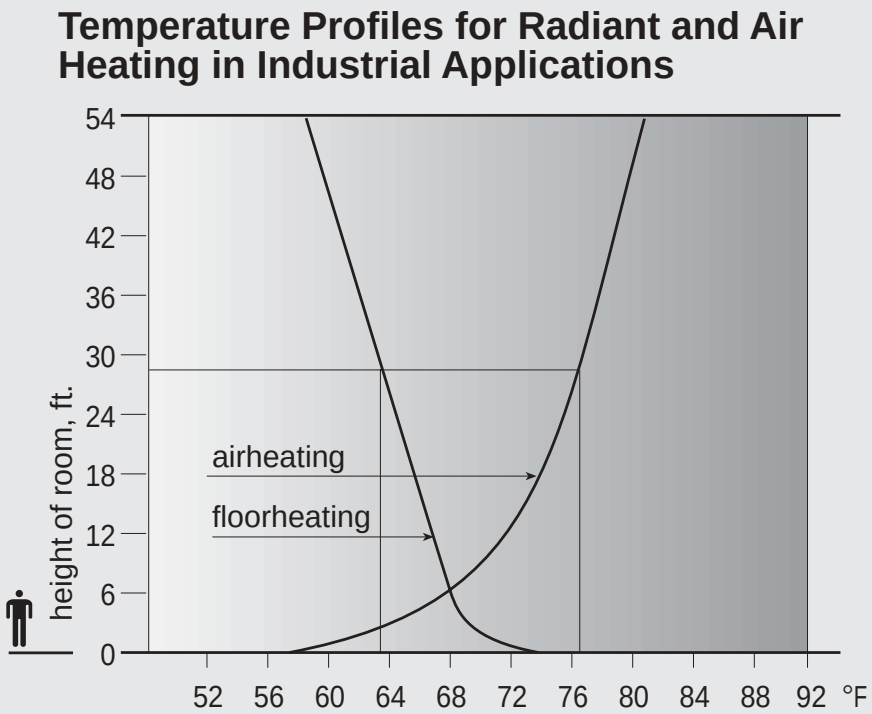
No drafts and less dust. There are no drafts with radiant heat because air heated by floor or ceiling panels moves slowly. Contrast this with forcing the huge amount of warmed air (with dust) required into a room just to take the chill out of the air.

Make a comfortable basement. The cellars of old times were cold and damp, often only used for storage and utilities. With radiant heat, warm floors keep rooms dry, and basement floors are as comfortable as those on any other level. What was previously a cellar has become a prime living area thanks to radiant heat.

The floor is a drier…. Warm floors don't stay wet. Bathroom spills dry up. A damp towel left on the floor does not start to smell. Wet shoes dry faster. Garage floors are quickly free from snow, ice, and water.

…..but does not dry up the air. During the cold winter the outside air contains very little moisture. Forced air heaters need considerable amounts of makeup air to partly replace the indoor air. The result is a very low humidity in forced air-heated buildings, which leads to uncomfortable static electric discharges, dry skin, general discomfort, and dying flowers. Panel heating does not consume indoor air, so normal humidity can be maintained during the winter.

Panel Heating Radiates Comfort (continued)



Using the graph, let's assume that an industrial building has a ceiling height of 28 ft. A horizontal line is entered on that level in the graph. This line intersects with the "floorheating line" at approximately 63°F, and with the "airheating line" at approximately 77°F. These temperatures are the approximate air temperatures at the ceiling level for radiant heating resp. forced air heating at this ceiling height.
The average outdoor temperature during the heating season may be, for example, 40°F at the selected building location. That means that the temperature difference between the inside of the ceiling and the average outside air is (63 - 40 =) 23°F for the floor heating, and (77 – 40 =) 37°F for the air heating. The difference in heat loss through the ceiling is directly proportional to this difference and proves the radiant heat waste only (23/37 =) 62% of the heat lost this way for an air heating system.

The above chart assumes that a room thermostat on the level 6 ft. is set on 68°F to control the temperature on that level (this is where the two lines intersect). In reality, the room temperature would be selected considerably lower for radiant floors and higher for air heating to reach the same comfort level; 3 – 6°F. This provides additional energy saving in addition to above calculation.

Our experience, when comparing commercial/industrial buildings heating costs, is that the average energy saving is in the magnitude of 40 to 45% with radiant floors over air heating.

Floor Heating Provides Huge Energy Savings

In buildings with radiant panel heating, thermostat settings are typically 3 to 6°F lower for three reasons:

1. Temperature distribution all over the room is close to ideal. Therefore, normal thermostat settings can be decreased.
2. About half the heat is provided as radiant heat, which most thermostats do not read correctly. They mainly read air temperature; the portion of heat generated by convection or movement of warmed air.
3. Because the feet are the thermostats of the body, when a radiant panel directly warms your feet, you feel comfortable at a much lower room temperature.

Panel heating systems require comparatively low water temperatures, so a winter water temperature of less than 110°F is enough for many buildings and floor constructions. This allows for the utilization of alternate warm water sources. Panel heating provides excellent efficiency with heat pumps and solar collectors. In addition, warm wastewater from industrial processes, cogeneration plants, large freezers or chillers, etc., can be utilized for heating. With low water temperatures, heat losses from mains and system components are minimized. Also, modern radiant floor systems allow you to zone each room, or group of rooms, individually so you can heat them individually to exactly the degree you want.

Heat recovery Imagine that maintenance of a jumbo jet airplane is complete and the hangar doors are open for 5 minutes to let the giant out. Virtually all warm air inside the building is lost. With a radiant floor system, 50% of the heat will be recovered instantly after the doors are closed! Because half of the total heat is provided by radiation (which travels at the speed of light), and the large thermal mass of concrete floors virtually eliminates temperature fluctuations. A great deal of energy can be saved in buildings with high ceilings such as schools, churches, shopping centers, gymnasiums and industrial buildings when the air above the people inside is not overheated. The typical energy savings for a good radiant floor system is 15 - 30% for residential projects and even more for commercial and industrial installations.

Panel Heating Radiates Comfort (continued)

Don't Forget Radiant Health & Safety Benefits

Warm Feet Cold feet may not be proven to worsen flu symptoms - "but everyone says so".

Allergies Many persons have allergic reactions to dust-mites and other creatures living inside textile fibers like those in carpeting. With radiant panel heating carpeting is not desirable. Tile, vinyl, and wood become attractive and healthy flooring alternatives.

The Clean Air Act In commercial installations, dust, germs, viruses and molds entering rooms through dirty air channels is a concern and cleanliness of air distribution channels has to be tested with annual cleaning of ducts. Residential air channels need cleaning, too…. Radiant panel systems provide an obvious advantage because they do not blow germs, dust, pollen, or particles around. And there is no visible heating system to clean.

Carbon monoxide When a furnace malfunctions, poison gases can be circulated by the forced air system and distributed throughout the building. Although radiant panel heating systems do not use furnaces, it's recommended that everyone install smoke and CO detectors, anyhow.

Molds. Most types of molds need moisture to grow and any condition contributing to long term moisture retention (flooding, leaks, condensation, etc.) is a great environment for mold growth. Radiant panels can help in curing that "sick house syndrome", because heated floors dry quickly and dry wood does not rot or promote mold buildups.

The Versatility and Reliability of Radiant is Unsurpassed.

For most projects, a radiant panel heating system provides the ideal solution. Radiant panels can be fitted into virtually all floor constructions and can be installed in walls and ceilings as well. Whatever the application - a comfortable home, a nice business atmosphere, a healthy day-care environment, a maintenance garage with dry floors, a illness free hog barn, a snow-free emergency entry, invisible and tamper-proof penitentiary heating, a hangar that doesn't waste heat, a warm floor in a chilly kennel, or winter football on live turf - all can be built utilizing a radiant panel system. Can any other heating system accomplish this?

Easy to use, PEX Tubing is the material of choice for Radiant Panel Systems. With nearly 30 years of field experience and laboratory testing, manufacturers now offer 25-year warranties. Plastic tubing doesn't rot or corrode and metal components are typically high-quality brass making radiant panel systems extremely reliable. No wonder that radiant panel heating, already the most popular way of heating Europe and Asia, is rapidly growing in North America.

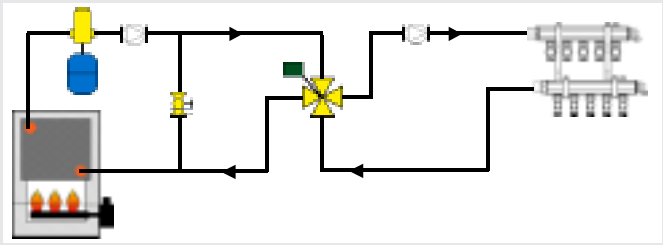
Radiant Panel Heating Basics

The trend is: Radiant!
In a previous article we looked at the amazing benefits of Radiant Panel Heating Systems using Crosslinked Polyethylene (PEX) tubing. Considering the major advantages over other conventional systems, we may wonder why the usage has not exceeded the current pace of 25-30% per year. When forced air systems became the standard many years ago, the people familiar with hydronic (water carried) heating became difficult to find. This article will provide some highlights about how these systems work and how they are installed.

So how does it work?
The basic principle is actually quite easy to understand. Since radiant panel heating requires comparatively low water temperatures, hot water from a boiler is mixed with return water from the tubing loops by means of a mixing valve. The mixing valve setting should be adjusted for each season so that water is distributed at the correct temperature. The mixing valve may be equipped with an electronically controlled motor which automatically provides the right water temperature for the current outdoor conditions.

A small circulator pump pushes the mixed water through the manifolds that serve as headers for 2 - 10 pipe loops. The length of each tubing loop is normally between 150 and 350 ft., and, since the most common center distance between the pipes is 1 ft., each loop serves an area of about 150 to 350 sq. ft. ≈ a typical room size. Supply and return manifolds are centrally located in a closet or in a wall cavity, serving adjacent areas. The manifolds include valves for balancing the water flow because short tubing loops need less water flow than long loops. However, most buildings have floor covering materials such as carpets, hardwood, tile, or vinyl that differ in each room. The heat flow through each floor will differ as well, and balancing this by adjusting the flow is not sufficient. For this reason, most systems include individual room thermostats controlling small electrical (24 Volt) valve heads that automatically shut off the flow at intervals. The result is an evenly warm floor and a maintained, set room temperature.

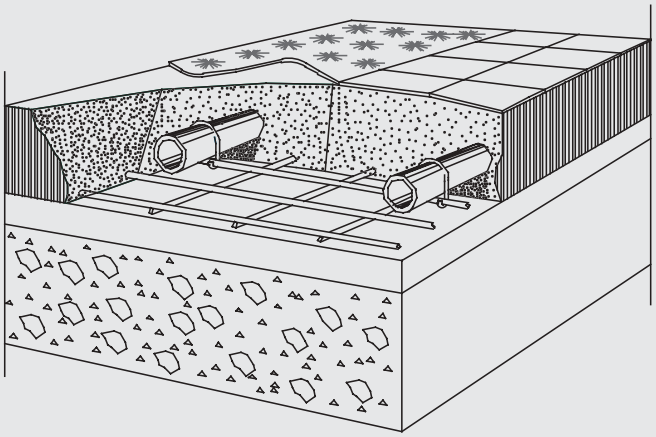
Easy Installation into Concrete Floors
There are huge benefits that should warrant the installation of radiant heat in every building project. If the builder or first owner does not select radiant heat, future owners of the building will see the added value of having it available. With tubing already installed in the floor, the house will be prepared to utilize any future alternative energy source - the heating system will only require lukewarm water. It is essential to install tubing before pouring any concrete floor - after pouring it is not possible to retrofit pipes into that floor and the radiant heating option is gone forever.



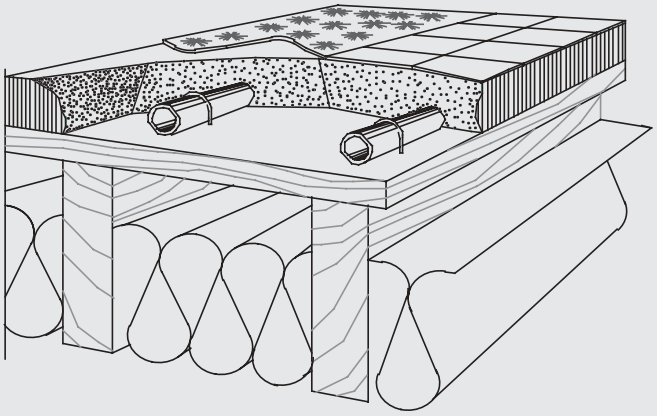
A typical radiant panel heating system schematic. The boiler water temperature is typically around 180°F. A circulating pump for the boiler circuit (often called the “primary circuit”) pushes the water around through the mixing valve and back to the boiler. After leaving the boiler, the water passes through an air scope that traps possible air bubbles and vent them out. Also shown is an expansion tank. This is a chamber partly filled by water and partly by air. Since air is easily compressible, this tank will absorb the water’s expansion and contraction caused by temperature variations in the system. There is a boiler bypass valve before the water reaches the 4-way valve. The reason is that many boilers need adequate flow and fairly high return water temperatures. By adjusting the bypass valve, any suitable bypass flow can be achieved. (Some 4-way valves have a bypass built-in).
The mixing valve mixes the hot water from the boiler with return water from the Radiant Panel Heating System. Some of that water goes back to the boiler to be reheated, but most of it recirculates to the manifolds. After the mixing valve there is another pump which provides constant water flow through the manifolds and the PEX tubing connected to it. (This part of the system is called the “secondary circuit”).
This figure displays a supply and return manifold that can serve 5 PEX tubing runs that may be looped in the floors of 5 different rooms. The flow may be shut off and on by built-in loop valves controlled by room thermostats, so that room temperature remains constant at the set temperature.

Radiant heating projects should be properly designed prior to installation, but if a design is not available, tubing should still be placed in the floor. The predominant tubing is 1/2" PEX with an oxygen barrier that prevents corrosion of system components. They are typically installed 12" on center. If tubing is tied to mesh or rebar over slab insulation, and tubing loop lengths do not exceed 250 ft., the floor is prepared for radiant heating, right away - or in the future. As long as the tubing is in the concrete floor, a post-installation design can be adapted and the system made to work.
Start by hooking one pipe end up to the secured manifold while the pipe coil is placed in a tubing uncoiler outside the working area. Then loop the pipe close to the outside walls and work inwards. After the room is done the tubing is cut and this end attached to the return manifold. Simple!

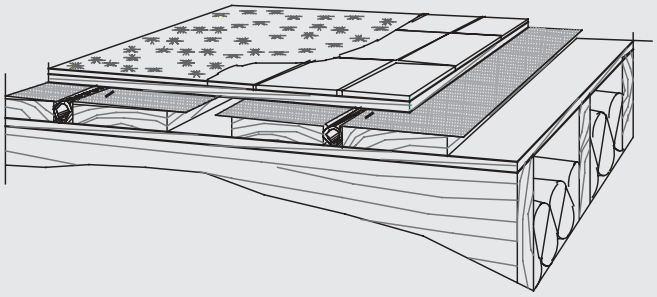
Radiant Panel Heating Basics



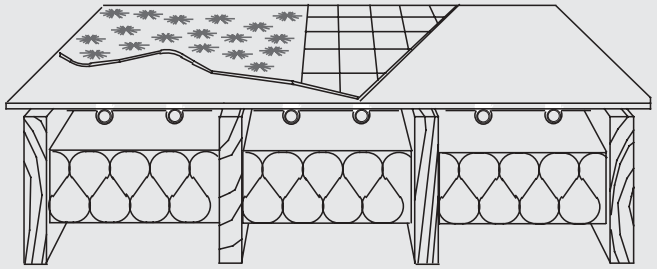
PEX Tubing in Concrete Floors over insulation board and compacted base.



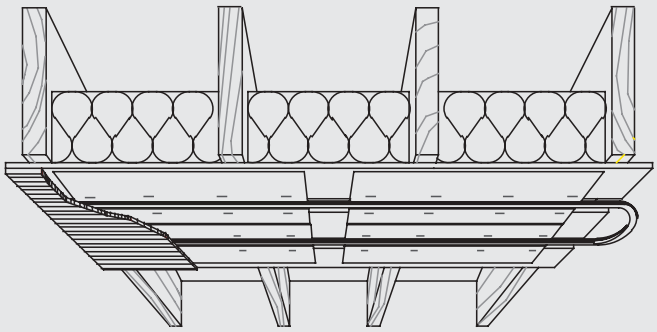
PEX Tubing in Gypsum Overpour on top of suspended floor



PEX Tubing with Alu Panels over suspended floor



PEX Tubing installed from underneath in suspended floor



PEX Tubing in Ceiling Heating

Some building codes require that the pipes be pressurized while the concrete is poured. PEX tubing is made for rough handling at a building site, so it can be virtually ignored (walked on, etc.) during the pour. 1/2" PEX tubing is flexible, installs quickly and easily, and the installed cost is a fraction of its value as a lifelong insurance towards future energy crises and the resale value of the building.

Suspended Floors Can Also Radiate.
Although radiant floor heating in a concrete slab is most common and cost-effective, there are other options. These are also feasible retrofit alternatives. Tubing can be put in concrete or lightweight aggregate overpours applied over slab floors or wood joist floors. The efficiency of these constructions is very similar to in-slab installations with low heating water temperature requirements.

Another alternative is to make room for tubing by nailing 1 x 4 boards 6" on center across floor joists or on top of a subfloor. Tubing may then be fitted in special Alu Panels (with a groove for tubing) to spread the heat. Finish the floor with a 1/2" conventional flooring board. Tubing with Alu Panels may also be stapled to flooring boards from below. Although this method requires additional labor, it has become quite popular because it does not interfere with the height of the finished floor. When installing tubing in wood floors some contractors eliminate the Alu Panel. This saves on cost, but there's a corresponding decrease in system efficiency. Also, water temperatures need to be quite high, so the benefits of having a versatile low temperature system adaptable to various kinds of heat sources is lost when compromising the system in this way.

And Don't Forget the Ceiling Heating Option
Ceiling heating is a feasible alternative method to wood joist floor installations. Wood battens nailed across ceiling joists provide adequate openings for PEX Tubing with Alu Panels in tight contact with the sheetrock finish. Because sheetrock boards have good heat conduc-

Radiant Panel Heating Basics

tivity, the ceiling temperature will be even and water temperatures can be kept low. The restriction of heat transfer by carpeting or other floor covering materials does not exist here, and most of the ceiling is normally available for installation of radiant heat panels. Additionally, when the wood joist floors constitute the upper level(s) of a house, there is no cold floor problem to care of (there is a warm room underneath). But also: heated ceilings radiate heat down to the floor surface below making it comfortably warm.

Installation into ceilings is cost-effective, can give high heat output, and provides excellent comfort. Also, by running the circulation during the summer, the cooler tempered lower level slab can draw heat out of upper level ceiling panels helping to even out the building temperature. So, there are many reasons to not forget the ceiling when talking about radiant panels!

There is a Limit to What Radiant Heat Can Provide. The radiant panel heating floor temperature should normally not exceed 84°F (but, an occasional temperature of 89°F may be acceptable in some areas) to provide maximum comfort. This limits the heat output to about 35-40 Btu/h. sq. ft. at normal room temperature (lower room temperatures allow for higher heat output). However, this is hardly a limit since the energy saving codes of today are pushing for heat requirements of less than 25 Btu/h. sq. ft.

In exceptional cases where there is wood joist floor construction, high heat requirements, and thick carpet and padding, unacceptably high water temperatures may be needed to provide sufficient heat. On those rare occasions we may recommend lessor thickness of carpet/padding, or that an additional heat source is used during the coldest winter days.

How Do I Get My Radiant Panel Heating System? The above system description and installation hints are provided to give a basic understanding of the systems; not to actually design and build it. A contractor with experience should do this. There are several suppliers of complete radiant panel heating systems, including PEX tubing, manifolds, fittings, valves, controls, fasteners, accessories, and tools along with instructions as how to use or apply them. By selecting such a system approach you can rely on receiving compatible components. The system suppliers also provide installation handbooks, design methods, even computer design software, and warranties. Wholesalers and system suppliers in cooperation are providing training to contractors and installers to make appropriate designs and correct installation. For areas where it is difficult to find experienced contractors, the system suppliers may provide the design of your system and their representatives may assist a local installer as necessary.

A proper design starts with a room-by-room heat loss analysis followed by a system layout where floor construction and floor covering materials are considered. That means that you have to provide drawings to the system designer, including a description of your selection of floor materials. You will also need to indicate your preference regarding individual room temperature control (for maximum energy saving and flexibility) or a more basic zoning. Should your garage be heated (providing warm and dry garage floors) and are there special requirements for any area?

Since radiant panel heating systems have become quite popular over the last decade, pricing is competitive in most areas. Your heating system may initially cost somewhat more than a “conventional” system, but with heating bills for the first 5 years included, the radiant system is always the economical alternative. And after that you can enjoy it’s added benefits and the outstanding comfort for free!