STYROFOAM Brand Insulation in Radiant Floors for Cozy Living

There is a growing demand in both the United States and Canada for the installation of radiant heating. There are several ways to heat a floor, including circulating water through cross-linked polyethylene tubing and blowing hot air through ducts in the floor. Radiant heating has many advantages over forced air heat, among them being a less drafty living area, quiet operation, less dust/spores circulating in the home, and a warm floor for your bare feet on a frosty morning. Such a heating system can be more comfortable and healthy for the home's occupants. The challenge for the builder is designing and installing the system properly, and a key feature of these systems is the insulation. The goals in radiant floor heating are to direct the heat upward into the room and to minimize vapor drive into the home.

The popularity of installation of radiant floors grew from the 1930's through the late 1940's building boom as the use of steel pipes gave way to copper tubing to conduct hot water. However, high installation costs led to its loss in popularity as less expensive forced air furnaces proliferated in the 1960's. When cross-linked polyethylene tubing became available, installation costs decreased. The costs of operation were tempered by the use of rigid board insulation, such as STYROFOAM* brand insulation, under the slab. Today, the systems popularity is growing due to the comfort factor and relatively low cost of achieving that comfort.

There are several floor designs which can be considered for radiant heat systems, namely, slab-on-grade with the water tubes within the slab, thin-slab systems with a plywood subfloor and about 1.5" of lightweight concrete or gypsum-based underlayment , or a dry system that is often used for retrofitting existing homes.

INSULATING RADIANT FLOORS

Slab-On-Grade Systems

Most builders will use radiant floor heating with a slab-on-grade home design. The reasons are varied, but this is the most logical combination of options. Although a few builders do not insulate the slab, the best practices parallel the Scandinavian techniques of using R-23 foam insulation on the slab edges and enough foam to give R-35 under the slab.[1] These techniques assure that the floor temperature is above the dew point, to eliminate any condensa-

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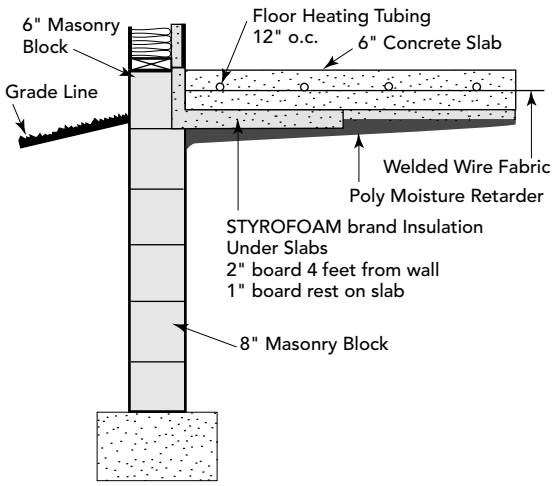
[1] Radiant Heating, Richard Kadulski, Solpan Review, March 1996, Page5

Styrofoam Brand Insulation

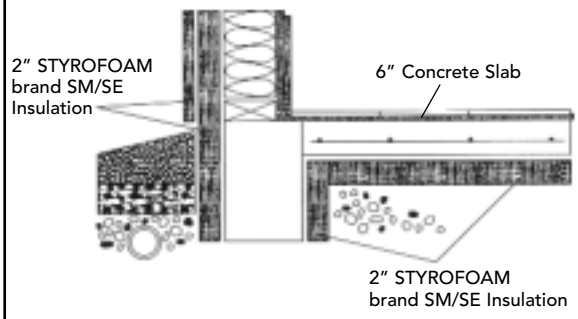
tion on the floor surface, especially around the outside perimeters. While this much insulation may seem extreme, one should consider the desire to operate a radiant floor system at a fairly low water temperature (below 140° F) to allow a hot water tank to be the boiler, and to provide maximum comfort at minimum cost. This water temperature should keep the floor surface temperature at or below 85° (above which the feet feel uncomfortable), and will result in a ceiling air temperature in the mid-60's (at which temperature a person's head feels comfortable, due to greater blood circulation in the head than in the feet).

Figure A



Insulating edges and under-slab in a radiant floor design.

Figure B



Insulating edges and under-slab in a radiant floor design.

In much of the United States, builders use two inches of rigid foam insulation on the perimeter of the slab and two inches under the slab (or two inches for the outer four feet of the perimeter and one inch under the rest of the slab). Due to its high compressive strength (25 psi), its great resistance to moisture, and its proven long-term R-value (R5 per inch), STYROFOAM brand Square Edge or Tongue and Groove insulation is the best choice. Note that these recommendations are higher than for insulating homes with forced air heat, but the criticality of preventing heat loss through the slab is higher, also. Moisture Retarder under the slab are an important part of this system and a 6-mil polyethylene film installed beneath the foam insulation is advised. See Figures A and B for typical installations of insulation in a slab-on-grade radiant panel system.

When polymeric tubing is installed in a concrete slab, the concrete becomes the conductive medium which disperses the hot water heat across the surface of the floor. Since concrete is a conductor of heat (that is, it has a low R-value, or reisistance to heat), the tubing can be spaced at 6-12" and the floor will be heated fairly uniformly. Unfortunately, heat will flow horizontally to the edges of the slab and be lost to the outside of the home, or it can flow downward and be lost to the soil beneath the slab. Rigid foam such as STYROFOAM brand insulation installed at the edges and under the slab is the only practical way to keep this from

happening. While the difference in temperature between the slab and the soil will not be as dramatic as that between the slab edge and the air, there is still considerable heat loss because of the large surface area. The result of such heat losses for an inadequately insulated slab is that the temperature of the floor near an outside wall can be 15 to 20° F cooler than at the center of the room[2]. This deviation from the ideal temperatures leads to personal discomfort for persons standing near a wall, and to the potential for moisture to condense on the wall.

Thin Slab Systems

If the floor construction is to be a wood-framed floor deck, then the use of a thin slab radiant panel system is a good choice. In this technique, a plywood subfloor is laid over the joists, the polymer tubing is installed by stapling it to the plywood, and a 1.25 to 1.5 inch thick layer of lightweight cement or gypsum-based underlayment is poured over the tubing. The cement or gypsum weighs about 12-15 pounds per square foot, and this additional weight has to be considered when selecting joists and flooring. Often, sleepers must be installed to raise kitchen cabinets to allow for the thickness of the thin slab, and shims are used to raise toilet flanges. Hardwood floors, carpeting, or vinyl flooring can then be installed over the thin slab. Insulating these systems is different from the slab-on-grade design, but no less critical. A rule of thumb is to provide at least five times more R-value below the floor than above it, in order to keep the heat flow in the upward direction. Thus, if thin carpet and a half-inch urethane pad or laminated oak floor with thin foam pad is to be installed over the thin slab, it is desirable to have R-10 insulation installed under the floor. However, if the floor is positioned over a partially heated basement or a vented crawl space, then the insulation level should be R-19 to R-30.[3] A combination of batt insulation and STYROFOAM brand insulation may be the best choice, especially if the ceiling of the lower level will be gypsum board (a code approved thermal barrier).

Dry Systems

In a dry system, thermal efficiencies are often less than with the slab on grade or thin slab systems, because there is no heat conductive matrix to disperse the heat uniformly. Their advantage is that they add very little weight to the floor and they can be easily retrofitted to an existing floor. In construction, these systems can be installed above the plywood deck, but in retrofit situations, they are usually installed below the current plywood deck. The concept is for the tubing to be stapled directly to the deck (usually the underside of the deck, between the joists), with aluminum heat transfer plates positioned either above or below the tubing. The conductive aluminum provides uniform lateral floor heating. Some people consider these systems to be less thermal efficient than those where the tubes are fully covered by concrete or gypsum, since the heat transfer depends on the tubes being pushed into intimate contact with the aluminum plates. The aluminum plates may be fairly noisy if improperly installed, due to

[2] Ibid, Page6
[3] *Modern Hydronic Heating*, John Siegenthaler, P.E. Delmar Publishers, page 306

expansion and contraction or to being walked over.

If little or no insulation is used with this "staple-up" radiant panel construction, the water temperature may have to be elevated enough to cause discoloration of vinyl flooring, especially if the flooring is installed over plywood. The plywood can bleed volatile chemicals which react with plasticizers and additives in the vinyl to leave dark stripes or spots, for example where there is a knot in the plywood.[4]

To insulate a dry system, the builder may install batt insulation between the floor joists or a combination of batts and STYROFOAM brand insulation, if the foam will be covered with a thermal barrier.

[4] ***On the House*, column, Journal of Light Construction, December 1998, pages 26-27**

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