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Physics of radiant floor and constant circulation

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WHETHER YOU'RE installing radiant heat in a concrete slab or a wood frame floor structure, the principle of heat dissipation remains the same. The only differences are the mass, subsequent response time and controllability.

When dealing with hydronic tubing embedded in concrete, the Btuh output of a square foot is measured and calculated from the center of the level where the tubing is embedded in the slab; i.e., the centerline of the water-carrying tubing is the origin from where the heat travels in all directions to the surrounding concrete.

The heat conducting medium, the concrete, releases the Btus in two directions — up and down. The desired result is to direct as much heat into the heated space and as little as possible downward into the earth in slab-on-grade applications or, in suspended floor applications, downward into spaces such as basements, crawl spaces or other non-occupied areas.The Btu output of a radiant floor radiator is measured in Btuh/sq. ft. of floor space.

Computer programs using complex mathematical formulas can accurately calculate how many Btus are released from every square foot of the radiator slab up and down, by entering into the program the components of the total radiator sandwich above and below the tubing.

Every building material within the radiator slab has a given thermal conductivity value measured in Btuh/sq. ft./°F of Delta T per ft. of material. An established conductivity value for every existing building material is called k-value. The higher the k-value, the better the heat-conducting properties of a solid, liquid or gas.

Water and surrounding ambient air temperatures are the two biggest factors determining the Btuh output performance.

The following thermal conductivity values (k-values) are some examples:

- Air: k = 0.015
- Aluminum: k = 130.0
- Area rugs: k = 0.02
- Ceramic tile: k = 1.08
- Concrete: k = 1.05
- Fiberglass insulation: k = 0.022
- Gravel: k = 0.22
- PEX tubing: k = 0.202
- Polystyrene foam board: k=0.015
- Red oak: k = 0.099
- Water: k = 0.343
- White pine: k = 0.060

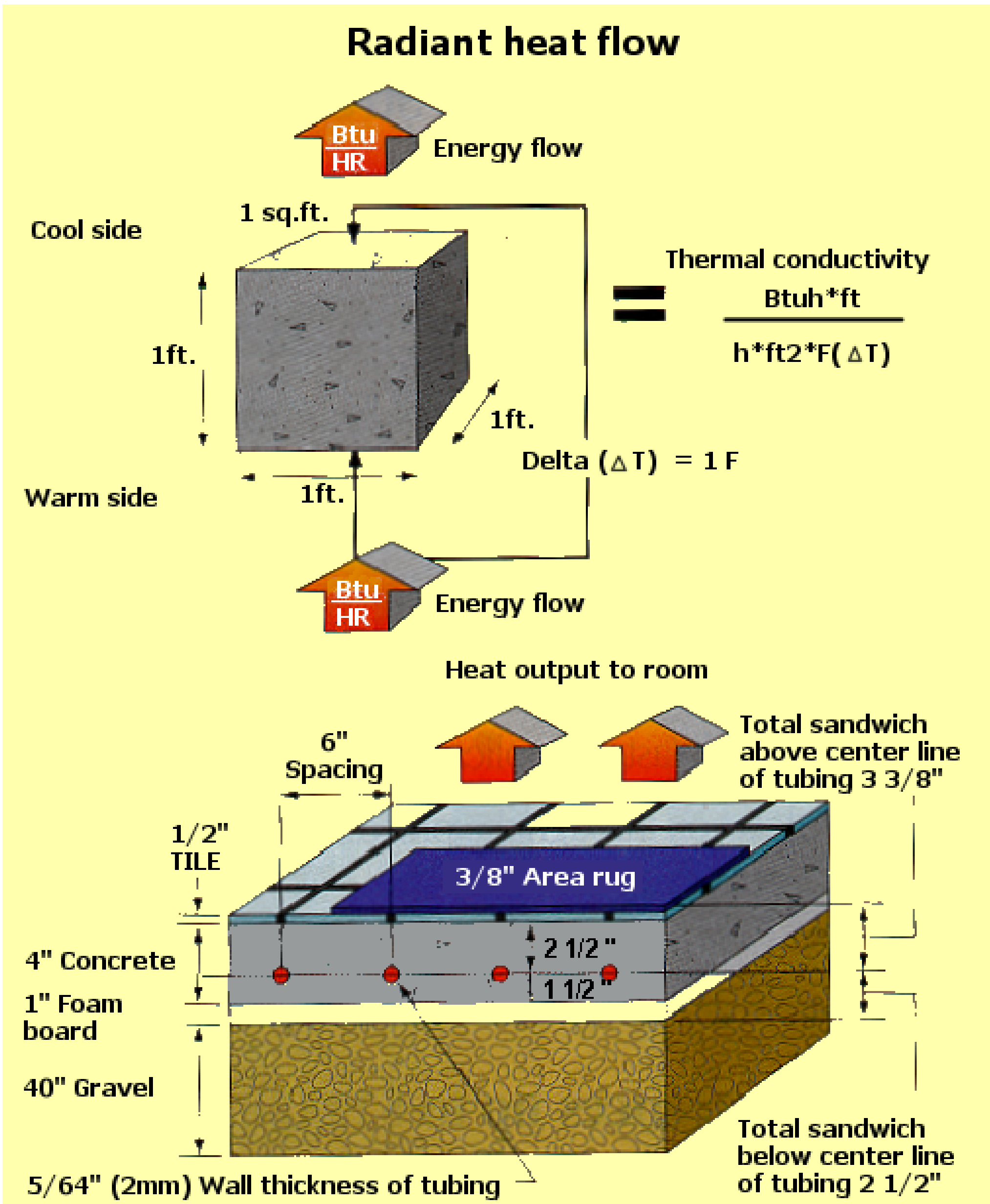
By entering these values and the corresponding thickness of each material layer of any radiant sandwich into the program, the will calculate the total heat resistance of the sandwich above and below the center line of the tubing.

Other important values influence Btuh output and heat dissipation and must also be entered into the program to complete the calculations. These values include mean water temperature, tubing spacing and diameter, and ambient temperatures surrounding the radiator sandwich.

These calculations result in the system manufacturer's Btuh output tables and graphs, which you use for designing your system.

Surprisingly, the tubing diameter has the least effect on the Btuh-out-put performance of the radiator slab. Tubing spacing primarily affects the evenness of the surface temperature of the floor, the circuit length and the mean water temperature of the system. Water and surrounding ambient air temperatures are the two biggest factors determining the Btuh output performance.

In our example, an average of 5% of the heat, depending on actual operating water temperature, will be lost into the ground after the gravel temperature has been equalized during the initial cold start. This leaves 95% of the remaining heat being released into the space above. Other information such as surface temperature, flow rates and pressure drops are generated by the programs as well.



The most important factor of this output calculation is the ambient air temperature, i.e. the air temperature surrounding the floor surface within the heated space. Heat always travels from a warmer to a cooler environment, trying to equalize itself.

The amount of heat released from a square foot of floor space rises as the Delta T increases. This is what makes a radiant floor a selfregulating radiator. A square foot of floor space near a sliding glass door, for instance, will release 40 Btuh on a winter day when cold air is pouring into those high heat-loss areas, whereas an interior square foot in that same room might release 20 Btuh, where the ambient temperature is 70°F.

This is a naturally occurring benefit of radiant floors created by the laws of physics. More importantly, it's free. It contributes to the comfort and even temperatures everybody raves about when living within a radiant heated environment.

This is why constant water circulation in radiant floor systems is so important. Recirculating 70% to 100% of the system return water at all times during the heating season, even if there is no demand for heat, assures a constant temperature equalization across the whole surface of the heat sink, carrying the Btus to high heat loss areas where they are needed and inhibiting output in areas where ambient and surface temperatures are almost equal (0 Delta T). The system is capable of absorbing solar and internal heat gains in areas where it is not needed to transport free energy into colder sections of the dwelling.

Constant circulation is the only logical approach to accomplish this.

As far as dry systems are concerned, the same basic rules apply whether the tubing is attached to the subfloor from below or above. As long as aluminum heat transfer plates take the place of concrete, the heat conductivity value of aluminum, which is 120 times that of concrete, allows us excellent and even heat distribution to a wood frame structure even with relatively thin aluminum sheeting material. The heat transfer from the tubing to the floor structure is as good as or better than a massive concrete slab because the difference in the conductivity value compensates within our computer formula.

The necessary floor mass for our heat sink is provided by the 2-in. to 2½-in. finish and subfloor structure itself. The preferred method for dry installation is always on top of the subfloor, simply because less sand-

sandwich and "R" value is added to the formula and on top of the heat transfer plate. However, attachment of the tubing plate from below the subfloor is, in many cases, the only practical method for retrofit. But by using this method, an R-value of I is added to the sandwich due to the thermal resistance of the ¾-in. subfloor.

Tubing without plates, stapled to the bottom of the subfloor, uses the surrounding trapped air between the insulation and the plywood as a heat transfer medium, essentially creating a hot air pocket below. The thermal conductivity value of air is 0.015 or 1/8,600 of that of aluminum. The heat transfer from the tubing walls to the floor sandwich is impeded because the k-value of the air now becomes part of the calculation. The end result is high mean operating water temperatures, defeating the purpose of low-temperature radiant systems, resulting in poor system efficiencies and high fuel consumption.

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