

Hydronic Heating: Two Systems Compared

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This article is a case history of an addition to an existing house. The project was designed and built in 1995–1996. It presents a practical engineering analysis intended for fellow practicing engineers. The article explores the design criteria and analysis that led to the choice of a hybrid (in-floor radiant/baseboard) hydronic heating system for the addition. After describing some coordination and installation considerations for various in-floor heating designs, it presents measured performance data from a side-by-side comparison of radiant and baseboard heat on the project. The article concludes with a summary of lessons learned and what in-floor radiant heat can and cannot do.

Design Criteria

The addition is built over an unheated crawl space. The room is used as a home office, so the owner spends hours sitting at a desk. The floor over the crawl space is well insulated (9 in. [23 cm] fiberglass batt/R-30). The crawl space is enclosed by foundation walls, and the band joist is caulked and insulated (R-30), so the crawl space stays warmer than the outside air. Nevertheless, the owner was concerned about discomfort (cold feet) from a cold floor surface. Avoiding that problem required either some type of in-floor heat or insulating and heating the crawl space.

The proposed furniture layout also influenced the HVAC system selection. The design called for several freestanding bookcases. The wall space required for the bookcases limited the wall space available for baseboard heat. Unlike a chair, desk, or couch that is open at the bottom, bookcases abutting the baseboard would need to be modified to let air in at the bottom. The opening required for airflow would make the bottom shelf unusable.

The design called for heating the new room by adding a zone to the existing gas-fired hot water boiler that heats the rest of the house. The boiler was installed when the house was built (around 1958) and provided both space heat and domestic hot water. Since that time, the walls and ceiling were insulated, and a separate gas-fired hot water heater was installed. In addition, the new construction replaced two large, leaky windows with a well-insulated wall, reducing heat loss from the existing house. Because of those changes, the boiler was assumed to have enough capacity to support the new zone. If boiler capacity proved inadequate, money would have been spent upgrading the envelope of the existing house rather than adding boiler capacity.

Load Calculations

Heat loss was calculated using ASHRAE methods as described in Chapter 25 of the *1993 ASHRAE Handbook—Fundamentals*. The load for the addition came to 14.7 MBH (4.3 kW) composed of 9.9 MBH (2.9 kW) transmission loss and

4.8 MBH (1.4 kW) infiltration loss. Those values include a 10% safety factor and 15% for pickup after night setback.

The project included several measures to control infiltration. A layer of “sill seal” foam was installed between the sill plate and the foundation. The outside walls were wrapped in a spun polyester “house wrap” infiltration barrier. The contractor did not caulk the bottom plate of the walls, but he did tuck the house wrap under the bottom of the sheathing, providing some protection for the wall-floor joint. The walls and ceiling were sealed on the inside with a 4 mil (0.1 mm) polyethylene vapor/air barrier.

The infiltration portion of the heat-loss calculations for the project started with a leakage area calculation using the data and method in the *ASHRAE Handbook—Fundamentals*, as shown in *Table 1*.

$$Q \text{ (cfm)} = L \times (A \times T + B \times v^2)^{0.5} (1)^*$$

$$= 153.711 \times 1.942 = 298 \text{ cfm}$$

where,

$$A \text{ (stack coeff., one story)} = 0.0156!$$

$$B \text{ (wind coeff., one story, no shielding)} = 0.0119$$

$$v \text{ (wind speed, mph)} = 15$$

$$T \text{ (temp. diff., } ^\circ\text{F)} = 70$$

! errata issued after calculations were performed corrected a typographical error in the Handbook. This value should be 0.0150.

The wind blows in only one direction at a time so the maximum leakage area at any one time is the leakage area of two walls (wind on the diagonal). Since air cannot accumulate within a building, the leakage area of the other walls provides a path for exfiltration. On that basis, the

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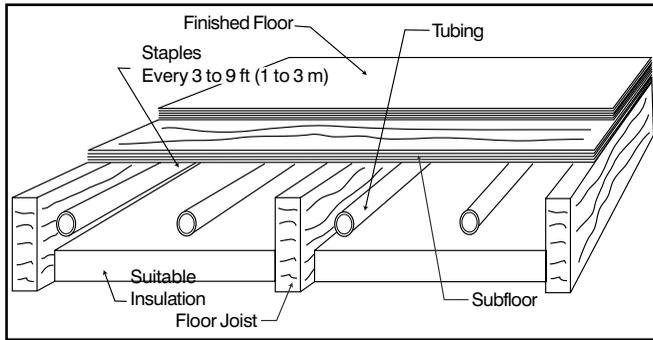


Figure 1: Staple-up job.

infiltration airflow calculated from the total leakage area can be cut in half to estimate the amount of infiltration for heating system design calculations. Even with that reduction, the calculated infiltration rate of 149 cfm (70 L/s) is a too high 2.7 air changes per hour. The leakage area method seems to overstate infiltration for modern, tight construction.

Applying engineering judgment based on the air-change method of calculating infiltration, the design-heating load included heat loss from 50 cfm (25 L/s) of infiltration at design conditions. That air quantity translates to 0.9 air changes per hour. While that air change rate seems high for modern, tight construction, the absolute value of 50 cfm (25 L/s) of infiltration is small.

A blower door test conducted several months after construction confirmed that the design infiltration rate is reasonable. The blower door test measured an infiltration rate of 2.2 air changes per hour at a 50 Pa (0.2 in.) pressure difference (ACH_{50}), which corresponds to a 20 mph (32 km/h) wind. The blower door depressurizes the entire building, so infiltration during a blower door test enters through all four walls. However, the wind blows from only one direction at a time, so actual infiltration at a 20 mph (32 km/h) wind would be on the order of half the measured blower door value, or just over one air change per hour in this case. Scaling down to the 15 mph (24 km/h) wind local design criterion, the design air infiltration rate proved reasonable in light of the blower door test data.

Cost Comparison

For the systems and equipment used on this project, hydronic baseboard heat cost \$20/MBH (materials only, purchased at a home center). In-floor radiant heat using a sandwich over subfloor design cost \$86/MBH for materials only (tubing, manifolds, etc.) without labor, special materials like underfloor insulation, or the extra subfloor. Therefore, the total installed cost for in-floor radiant heat will likely be four to six times as much as a hot water baseboard system.

System Selection

With a 424 ft² (39.4 m²) floor area, the heating load came to 34.7 Btu/h-ft² (109.5 W/m²). That density is higher than a typical house because the addition is relatively small. The addition has almost as much building skin area as a larger (wider) structure that has 50% to 80% more floor area.

A heating load density of 34.7 Btu/h-ft² (109.5 W/m²) is

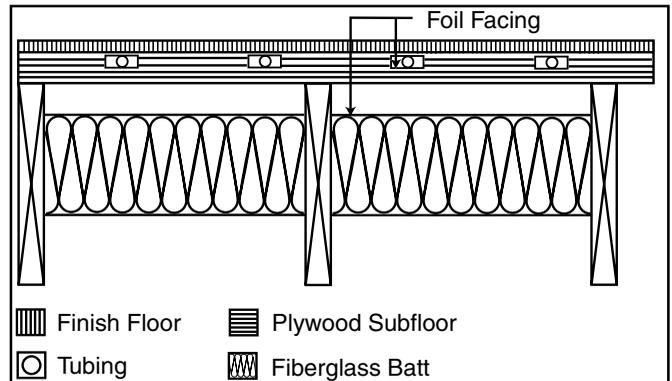


Figure 2: Sandwich construction with foil-faced batts under subfloor and thin nailers.

| | Qty. | Unit Leakage Area | Leakage Area |
|--------------------------------------|------|-------------------|----------------|
| Ceiling (ft²) | 424 | 0.026 | 11.024 |
| Surface mtd. lights (ea) | 2 | 0.13 | 0.260 |
| Door frame (ea) | 2 | 1.9 | 3.800 |
| Door (ea) | 1 | 0.16 | 0.320 |
| Electric outlets (ea) | 6 | 0.38 | 2.280 |
| Floor (ft²) | 424 | 0.032 | 13.568 |
| Ceiling/wall joint (lin. ft) | 85 | 0.76 | 64.600 |
| Floor/wall joint (lin. ft) | 85 | 0.4 | 34.000 |
| Wall (ft²) | 611 | 0.0022 | 1.344 |
| Window frame (ft²) | 69 | 0.025 | 1.725 |
| Windows (lin. ft) | 63 | 0.33 | 20.790 |
| Total Leakage Area (L) | | | 153.711 |

Table 1: Infiltration calculation.*

difficult to meet with in-floor radiant heat and a carpeted floor. Figure 9 in Chapter 6 of the 1996 ASHRAE Handbook—Systems and Equipment shows a maximum available heat flux of about 25 Btu/h-ft² (79 W/m²) from a carpeted floor without exceeding the recommended 85°F (29°C) maximum surface temperature. Therefore, an in-floor heating design for the project would require some form of supplementary heat. Conventional hot water baseboard was selected. Tubing in the ceiling or the walls could also have been used. Tubing in the walls would have to coordinate with the furniture layout. Since the owner rearranged the furniture after construction was complete, supplementary tubing in the walls might have been a poor choice. Tubing in the walls might also be susceptible to physical damage from activities like hanging pictures. That risk is small because the tubing usually runs only a few feet up the wall. Pictures are normally mounted higher.

After considering the relative costs for baseboard and in-floor radiant heat along with the need to avoid a cold floor surface, the addition was designed with a hybrid baseboard and in-floor heating system. The design philosophy was to maximize the amount of baseboard that would fit under the windows and a few feet to either side where bookcases would not be located and to meet the balance of the load with in-floor radiant heat. The in-floor heat solved the cold floor problem and maximized wall space available for bookcases. The room

* (cfm × 0.4719 = L/s); [(°F - 32) ÷ 1.8 = °C]; (ft² × 0.0929 = m²); (ft × 0.3048 = m)

wound up with two 8-ft (2.4 m) lengths of baseboard (one on each side) that delivered a total of 6.2 MBH (1.8 kW) at the design water temperature (145°F [63°C] average) and flow. The rest of the capacity required for the project (8.5 MBH [2.5 kW]) was provided by in-floor radiant heat. The resulting radiant heating density was a workable 19 Btu/h·ft² (60 W/m²) supplied to the room and an estimated 4 Btu/h·ft² (13 W/m²) of edge and back losses. The required capacity was provided with 153°F (67°C) entering water and tubing spaced on 9.5 in. (24 cm) centers.

On this project, the in-floor heat provided 58% of the installed heating capacity. Other projects might end up with other splits, and either baseboard or in-floor radiant heat could dominate.

The radiant system selected is a sandwich-over-subfloor design. The features of this system compared to other in-floor heating designs. The driving factors that led to that choice on this project were:

- Avoid working overhead in a shallow crawl space,
- Avoid the need for special tools to install the tubing,
- Flexibility in tube spacing, and
- The heating system does not need to be complete before insulating under the floor.

Radiant Heating Heat Loss Calculation

The heat loss calculations for the project were completed using standard ASHRAE methods as described in Chapter 25 of the *1993 Handbook—Fundamentals*. No special adjustments were made based on the choice of a radiant heating system. Some radiant heat proponents advocate modifying traditional heat loss calculations when radiant heat is used. The following paragraphs describe some of those modifications and explain why they were not applied to this project:

(1) “68 feels like 72.” Some radiant heat proponents advocate reducing design capacity because radiant heat can achieve the same comfort as convective (baseboard or warm air) at a lower room temperature. This philosophy is based on the theory that radiant heat increases comfort by raising the mean radiant temperature of the surrounding surfaces.

Mean radiant temperature does not account for local conditions or cold spots from cold surfaces. These cold spots are analogous to drafts from an air-distribution system. Someone walking by or sitting in front of a large window is likely to feel a cold draft, especially at night, even with radiant heat and even if the person’s mean radiant temperature is satisfactory. After all, 60°F (16°C) and 80°F (27°C) average out to a satisfactory 70°F (21°C), but neither 60°F (16°C) nor 80°F (27°C) is satisfactory. Depending on the type of room and the amount

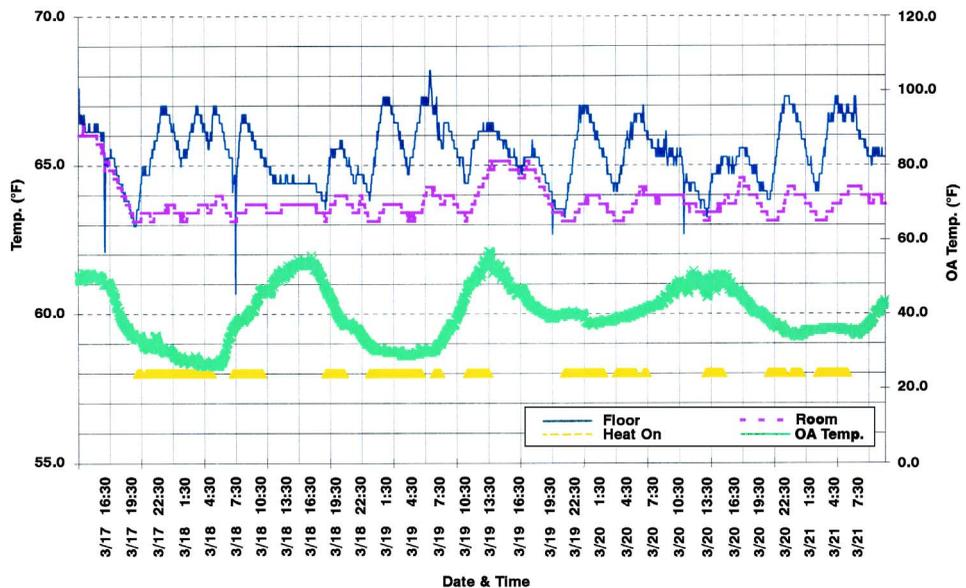


Figure 3: Radiant heating performance.

of glass, 68°F (20°C) might not feel like 72°F (22°C).

Reducing design capacity on the basis that “68 feels like 72” raises a design criteria dilemma: Does the radiant heating design promise a specified indoor temperature at a specified outdoor temperature, or does it promise subjective and immeasurable “comfort?” Designers and installers who reduce design capacity and promise “comfort” run a serious risk if the occupants complain they are cold at 68°F (20°C) or that 68°F (20°C) does not feel like 72°F (22°C) to them.

Personal experiences indicate that continuous baseboard circulation with water-temperature reset warms wall and glass surfaces, thereby raising mean radiant temperature. This approach seems to achieve the same functional result as radiant heat, thereby providing comfort equal to radiant heat (except for floor surface temperature, which is only important if the floor is over an unheated space). No one advocates reducing capacity or lowering room temperature setpoint on baseboard systems with continuous circulation and water-temperature reset.

There appears to be no published, generally accepted engineering basis for reducing capacity or lowering room temperature with radiant heat. The risks associated with promising “comfort” as opposed to a measurable room temperature may outweigh any benefit from reducing capacity based on the choice of a radiant heating system.

(2) Add 0.5 to R-values. One radiant heating system manufacturer advocates increasing R-values by 0.5 hr·ft²·°F/Btu (0.09 m²·kW) when radiant heat is used. The theory is that radiant heat induces smaller air currents in the room, so the inside air film resistance increases. The theory makes sense, but little or no scientific evidence has been presented to substantiate the theory or to show that 0.5 is the correct adjustment. As a practical matter, the adjustment makes almost no difference for well-insulated opaque surfaces. It makes some difference on glass. The overall impact on the size of the heating system is quite small in most cases. Therefore, until the basis for the adjustment is substan-

tiated, published widely, and generally accepted in the engineering community, business sense dictates sticking with conventional heat loss calculation techniques.

(3) Cut I=B=R heat loss by 20%. Some commentators, especially those who target trades people, advocate cutting the I=B=R heat loss by 20% when using radiant heat. The recommendation may have some merit, but not because of radiant vs. convective heat.

The I=B=R heat loss calculation method is essentially the same as the ASHRAE method. The only difference is that the tables in the I=B=R *Heat Loss Calculation Guide H-21* have infiltration heat loss built in. The infiltration heat loss is based on an outside air infiltration rate of one air change per hour (1 ACH).

For a typical house of modern construction in the northeast quadrant of the United States, the infiltration rate at heating system design conditions is about one-third to one-half ACH. The infiltration heat loss is also typically about the same mag-

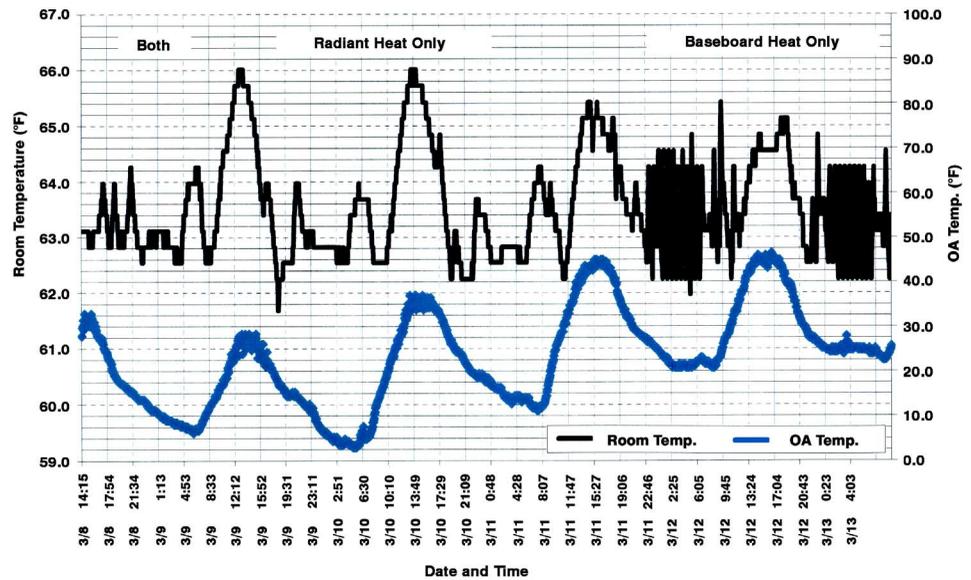


Figure 4: Radiant and baseboard performance.

nitude as the transmission heat loss. If the transmission heat loss is “ x ,” the infiltration heat loss is also “ x ,” so the building heating load is “ $2x$.”

If actual infiltration rates for modern construction are one-third to one-half ACH, the 1 ACH infiltration heat loss built into the I=B=R tables is two to three times the actual infiltration heat loss. If transmission and actual infiltration heat loss are about equal so each is “ x ,” the heat loss derived from the I=B=R tables is “ x ” for transmission plus between “ $2x$ ” and “ $3x$ ” for infiltration or “ $3x$ ” to “ $4x$.” Cutting the I=B=R heat loss by 20% results in a design heating capacity of “ $2.4x$ ” to “ $3.2x$ ” for a building with an actual heating load of “ $2x$.” Therefore, cutting 20% off the heat loss derived from the I=B=R tables is unlikely to cause a problem, not because of radiant heat but because today’s infiltration rates are lower than when I=B=R developed the tables.

Special Considerations for In-Floor Radiant Heat

As with any system type, in-floor radiant heat presents some unique design considerations.

Capacity Limits

The first consideration is the limit on the amount of heat an in-floor system can deliver to the space. That limit is a function of floor surface temperature, which generally should not exceed 85°F (29°C). The 85°F (29°C) maximum is based on comfort and keeps the floor surface temperature from exceeding typical skin temperature. Figure 9 in Chapter 6 of the 1996 *ASHRAE Handbook—Systems and Equipment* shows that an 85°F (29°C) surface temperature translates to a heat flux of 30 Btu/h·ft² (95 W/m²) for a room temperature of 70°F (21°C) and an average unheated surface temperature (AUST) of 68°F (20°C). Depending on floor covering and the system water temperature, the maximum available heat flux might be less than 30 Btu/h·ft² (95 W/m²). For example, using Figure 9, a hardwood floor with staple up tubing on 12 in. (25 mm) centers in a 70°F (21°C) room reaches the 85°F (29°C) surface temperature limit with approximately 145°F (63°C) average water temperature. By comparison, the same system with

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a carpeted floor would require 180°F (82°C) average water temperature to reach 85°F (29°C) surface temperature. If the boiler water temperature setpoint is a typical 180°F (82°C), the average water temperature will ordinarily be 170°F (77°C), and a carpeted floor would deliver 29 Btu/h-ft² (91 W/m²).

Edge and Back Losses

Edge and back losses can be substantial and should not be overlooked. They increase the amount of heat that must be delivered to the panel, and they are a heat gain to the space below. On one project, an owner planned to install a refrigerated (55°F [13°C]) wine room in the basement below his radiantly heated kitchen. Even with R-30 insulation under the floor, the 15°F (8°C) temperature difference from the room above to the wine room added 450 Btu/h (30 W) to the cooling load for the 1000 ft² (93 m²) wine room. That heat gain had to be included in sizing the wine room refrigeration system.

Thermal Mass and Thermal Lag

Depending on the mass of the floor heating system, thermostat overshoot might occur. A heavy concrete floor with embedded tubing continues emitting heat for hours after the thermostat shuts off. Even a staple-up or sandwich-over-subfloor design has more thermal mass than a conventional baseboard heating system so it continues emitting heat after the thermostat is satisfied. For that reason, radiant heat might be a disadvantage where precise temperature control is required or where the load changes rapidly.

Thermal mass and thermal lag considerations may limit the use of night setback control with in-floor radiant heating systems. The system might have to come back on hours before occupancy to reach occupied temperature at the scheduled time. Night setback is a powerful energy-saving tool. The more thermal mass in the in-floor radiant heating system, the less suitable it is for night setback. That potential energy saving might not be practical to capture.

Radiant Heat Coordination and Installation Issues

Radiant heating systems present coordination and installation issues that differ from conventional hydronic heating systems and that vary with the in-floor heating system design.

Tube-in-Slab Systems

A successful tube-in-slab system requires adequate insulation under the slab. The insulation must be installed early in the project, long before the HVAC contractor is normally on the job. A successful tube-in-slab system needs a responsible person to see that the insulation is installed according to plans and specifications. The only practical remedy for omitted insulation may be to increase the radiant heating system capacity and accept excessive operating cost for the life of the building.

A tube-in-slab system requires selecting the HVAC contractor before the concrete pour. On fast-track jobs with conventional heating systems, the HVAC contractor is often not selected that soon. The general contractor might not have the interest or skills to supervise the tubing installation in the slab.

After the tube is placed, it must be pressurized during the concrete pour. Otherwise, the weight of the concrete might collapse the tube. On a green field site, a pressurized water supply might not be available. While air can be used, air is dangerous if the tube breaks. Also, there might not be any electricity to power an air compressor during the pour and for several hours thereafter until the concrete cures and the tube is no longer at risk of collapse.

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Installing the tube in the slab requires a firm architectural design. Changing rooms or moving partitions and appliances could be expensive if those changes would affect the tubing layout.

While those obstacles are not insurmountable, they are coordination issues for a tube-in-slab system that other system types do not face.

Staple-Up Systems

On a staple-up job (see *Figure 1*), the tubing is attached to the underside of the heated floor. This arrangement avoids some of the coordination issues of the tube-in-slab system but presents coordination factors of its own.

Installing the tube requires working overhead, which no one likes to do. The problems of working overhead translate to increased cost and possible reduced quality or attention to detail.

As a practical matter, tube spacing is usually limited by the joist bay spacing. For example, with 16 in. (40 cm) joist spacing, tube spacing can be 8 in. (20 cm), 5.33 in. (13 cm), or 4 in. (10 cm) on center. Spacing of 10 in. (25 cm) on center is not practical. A zone that uses 8 in. (20 cm) spacing with lower water temperature is a more expensive installation than if 10 in. (25 cm) spacing were feasible.

A staple-up job generally requires holes in the joists to connect the tubing runs in each joist bay. While joists can accommodate some properly placed holes, any holes compromise the structure.

The subfloor and floor are thermal resistances between the tubing and the heated space. That increased thermal resistance requires either warmer water or closer tube spacing than a tube-in-slab design to deliver the same heating capacity to the space. Although raising the water temperature might save tubing (and money), spacing the tubes too far apart can lead to “striping.” The room still heats adequately, but occupants tend to notice temperature differences across the floor surface.

As a general rule, regardless of spacing, a staple-up job requires warmer water than a tube-in-slab job. That warmer water temperature may be an advantage for a hybrid system. If the radiant and baseboard systems can be sized for the same temperature water, the radiant loop will not require a mixing valve and associated controls. Eliminating a mixing valve reduces both cost and complexity. Warmer water temperature also reduces the concern about flue gas condensation and might allow using a conventional boiler instead of the more expensive units designed to tolerate flue gas condensation.

Sandwich-Over-Subfloor

Like a tube-in-slab job, a sandwich-over-subfloor or lightweight topping slab over a subfloor (see *Figure 2*) can accommodate any tube spacing. Tube spacing and water temperature can be adjusted and balanced to match job requirements. If the top layer of the sandwich is plywood or other poor heat conductor, the sandwich over subfloor design will require the same higher water temperatures as a staple-up job with the same advantages and disadvantages.

Compared to staple-up, sandwich-over-subfloor offers the advantage that the tubing contacts the flooring material on three sides compared to only one side for staple up. The extra contact area should improve heat transfer from the tube to the floor.

The major installation and coordination issue for this design is planning and allowing for the additional floor height. With the lightweight concrete topping slab, the structural design must accommodate the added weight.

Unanswered Questions

In-floor radiant heat is a growing industry with many manufacturers and systems on the market. Although the concept is old, the new popularity and new equipment on the market open up some questions that remain unanswered:

1. Some manufacturers recommend aluminum heat emission plates on staple-up jobs. These conductive plates supposedly help spread heat over the floor surface. In one manufacturer’s technical seminar, the presenter advised that heat emission plates approximately double the heat output per foot of tube. However, the presenter also admitted that heat emission plates cost

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more per foot than the tube. The proponents of heat emission plates do not have an answer for why a designer should use those expensive accessories rather than just double the tube density (cut the spacing in half).

2. Some manufacturers recommend foil-faced insulation under the radiantly heated surface, especially on staple-up and sandwich-over-subfloor designs. The foil facing supposedly reflects heat. Most of the published research on radiant barriers addresses attic and roof heat gain and effects on air-conditioning loads. The jury is still out on how much benefit the foil face provides over kraft- or unfaced insulation for in-floor radiant heating installations, especially if the insulation is of relatively high R-value.

Performance and Data Analysis

The hybrid in-floor/perimeter hot water baseboard project described in this article provided an opportunity to collect actual performance data and compare radiant and convective heating systems in the same room under similar conditions, including weather and occupancy.

Figure 3 is a graph of room temperature, floor temperature, and outdoor temperature monitored with data loggers. It shows the benefit of in-floor heat in keeping the floor surface temperature warm. The floor temperature was measured by simply placing a data logger on the floor, so it is not truly the floor surface temperature but the air temperature with a 0.5 in. (12.5 mm) of the floor. However, it shows generally what happens to the floor temperature. The data show that the floor-surface temperature dipped well below the room temperature at the end of the longer off-cycles. Prolonged exposure to a cold floor surface leads to discomfort and occupant complaints.

Figure 4 shows the results of a direct comparison between the in-floor and baseboard heating systems. To avoid introducing variables like pick up after setback and P+I control algorithms, temperature was controlled at a fixed setpoint using a simple, on-off, “round” wall thermostat. The system was first allowed to stabilize with both radiant and baseboard circuits active. Then the system operated with radiant heat only (baseboard valved off) for two days. After that, the radiant circuits were valved off, and the system ran for two days on baseboard heat only. The data lead to the following observations:

1. The room temperature cycle time was much longer for the radiant system compared to the convective system. That unsurprising observation is due to the greater thermal mass of the in-floor heating system (even a sandwich-over-subfloor design) compared to baseboard. While not supported by scientific research and therefore speculative, the longer cycle might contribute to increased comfort. People are less likely to notice a 3°F (1.5°C) temperature change that occurs gradually over a four- to five-hour period than the same 3°F (1.5°C) temperature change that cycles five or six times in that same four to five-hour period.

2. The in-floor radiant system exhibited considerably more room temperature overshoot than the baseboard system in the same room under roughly the same weather conditions. Modern, sophisticated controls might be able to reduce that overshoot.

3. Looking at *Figures 3* and *4* along with the occupant’s comments reveals that the in-floor heat did a good job of avoiding a

cold floor problem. The occupant terminated the baseboard-only test early because his feet were very cold when sitting at the desk for long periods.

Lessons Learned

Proponents of radiant heat make many claims of benefits over other types of heating systems. Some of those claims are truly attributable to radiant heat. Others result from comparing well-designed radiant systems to poorly designed other systems. The following describes some of the author’s conclusions from this project about what in-floor radiant heat can and cannot do:

1. There is no question that the principle benefit of in-floor heat is the ability to keep the floor surface warm. This advantage is particularly important when the floor is over an unheated space. The cold floor problem can exist even if the unheated space is enclosed and stays well above the outdoor temperature. In commercial buildings, floors over unheated space are often kept warm by insulating and heating the soffit below. That technique is not popular for residential construction.

2. In-floor radiant heat makes wall space available for furniture placement. This advantage is less important at windows because there is usually free space in front of windows for access to open them. Bookcases would not back up to a window. The wall space required for baseboard heat is less of a problem behind a couch or chair that might be in front of a window. That furniture has openings near the floor that allow air to reach the baseboard inlet.

The flip side of this coin is that baseboard heat might be an advantage in high heat-loss areas, such as under a window. Baseboard heat typically delivers more heat per linear foot than radiant heat.

3. There is much debate over whether radiant heat saves energy. To the extent people are comfortable at a lower temperature, radiant affords some savings. For a typical 70°F [39°C] design temperature difference (0°F [–18°C] outdoors to 70°F [21°C] indoors) using convective heat, a radiant heating system that achieves the same comfort level at 67°F [19°C] saves a little under 5%. However, night setback typically saves 15% to 20% of the annual heating bill. If night setback becomes impractical due to long recovery/pick-up time with radiant heat, a radiant system might not produce actual savings.

4. Some radiant heat proponents claim savings from reduced stratification. The hot air near the ceiling increases the local indoor-outdoor temperature difference thereby increasing heat loss. Radiant heat is less prone to stratification so avoids that problem, the argument goes. Radiant heat is popular in residential and light commercial construction where the ceiling height is in the range of 8 ft (2.4 m) to 9 ft (2.7 m).

A well-designed and operated heating system of any type is unlikely to produce tremendous temperature stratification over that distance. Claims that radiant heat produces appreciable savings by reducing temperature stratification need to be investigated scientifically so they can be substantiated or rebutted.

Those conclusions result from the author’s general experience, engineering judgment, and evaluation of data from this case study. They may need further testing before they can be generalized or extended to other situations. ●