PHRC Webinar Series | Tuesday, December 12th @ 1pm

Radiant Floor Heating

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Description

- The design of a radiant floor heating system goes beyond just heat calculations. The structure itself must be examined and correct materials must be used with this type of heat. This webinar will look into material compatibilities when installing radiant floor heat along with simple design methods.

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Learning Objectives

- Review the compatibility of materials for the installation of radiant floor heat.
- Review the construction limitation for installing radiant floor heat.
- Understand the how radiant floor heating can impact the finish materials and potentially cause occupant discomfort
- Review standard installation procedures which can formulate an outcome that will be comfortable to the occupant

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Outline

- What is radiant floor heat?
- General code requirements for radiant floor heating
- Types of radiant heating
- Common compatibility issues

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What is Radiant Floor Heating?

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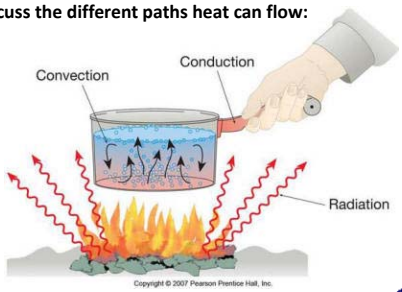
How does heat flow?

- First let's discuss the different paths heat can flow:
  - Conduction
  - Convection
  - Radiation



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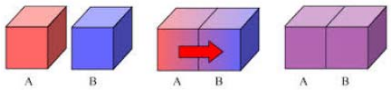
How does heat flow?

- Next let's take a look at how heat travels:
- Heat flows from warmer to cooler until there is no longer a temperature difference.



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Conductive Heat Loss

- **Q = U x A x ΔT**
  - Q = heat flow (Btu / hr)
  - U = thermal conductivity (U = 1 / R)
  - A = surface area (square feet)
  - ΔT = temperature difference across component (°F)

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Conductive Heat Loss

- Can you stop heat flow?

$$Q = U \times A \times \Delta T$$

  - Answer: **No**
    - Conductive heat flow can be managed, but not eliminated

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Movement of Heat in Radiant Floors

- First the boiler system must uses conduction to quickly and efficiently heat the water.

Source: highperformancehvac.com

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Movement of Heat in Radiant Floors

- Next the hot liquid being pumped throughout the house heats the concrete, tile, or other type of flooring through conduction as well as radiates heat into the room.

Source: lowtechmagazine.com

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Movement of Heat in Radiant Floors

- Lastly, the flooring surfaces then radiate the heat they gained from the hydronic system into the room.

Source: lowtechmagazine.com

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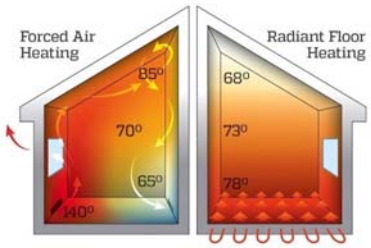
Movement of Heat in Radiant Floors

- **Comparison of air movement in a room with forced air and radiant heating**



Source: bobvila.com

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This is Why Materials Matter

- **Finished floor materials should take thermal mass and thermal resistance into account as well as aesthetics.**
  - Thermal Mass – The ability of the material to absorb and retain heat.
  - Thermal Resistance – The rate at which a material transfers heat through conduction.
- **The goal for an efficient radiant system is to choose materials that have:**
  - High thermal mass
  - Low thermal resistance

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This is Why Materials Matter

- **Vinyl Flooring**

Source: houseunderconstruction.com

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This is Why Materials Matter

- **Laminate Flooring**

Source: thespruce.com

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This is Why Materials Matter

- **Carpet**

Source: timbercreekflooring.com

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This is Why Materials Matter

- **Tile flooring**

Source: hgtv.com

But it Doesn't Stop There

- **Construction materials**
  - Insulation
  - Subfloor
  - Concrete
- **Location**
  - Above the subfloor
  - Below the subfloor
  - Slab on grade
  - Ceiling

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General Code Requirements for Radiant Floor Heating

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Slab Insulation

- **Table N1102.1 out of the 2009 IRC**
  - Slab R-value and depth
    - Zone 4 & 5 – R-10 for 2ft
    - Zone 6 – R-10 for 4ft
  - Footnote d
    - R-5 shall be added to the required slab edge R-values for heated slabs.

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TABLE N1102.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE	MASS WALL *R*-VALUE[k]	FLOOR *R*-VALUE	BASEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE AND DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	1.2	0.75	0.35[i]	30	13	3/4	13	0	0	0
2	0.65[i]	0.75	0.35[i]	30	13	4/6	13	0	0	0
3	0.50[i]	0.65	0.35[e, i]	30	13	5/8	19	5/13[f]	0	5/13
4 except Marine	0.35	0.60	NR	38	13	5/10	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.35	0.60	NR	38	20 or 13 + 5[h]	13/17	30[g]	10/13	10, 2 ft	10/13
6	0.35	0.60	NR	49	20 or 13 + 5[h]	15/19	30[g]	10/13	10, 4 ft	10/13
7 and 8	0.35	0.60	NR	49	21	19/21	30[g]	10/13	10, 4 ft	10/13

a. *R*-values are minimums. *U*-factors and solar heat gain coefficient (SHGC) are maximums. R-19 batts compressed in to nominal 2 × 6 framing cavity such that the *R*-value is reduced by R-1 or more shall be marked with the compressed batt *R*-value in addition to the full thickness *R*-value.
b. The fenestration *U*-factor column excludes skylights. The SHGC column applies to all glazed fenestration.
c. The first *R*-value applies to continuous insulation, the second to framing cavity insulation, either insulation meets the requirement.
d. R-5 shall be added to the required slab edge *R*-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less, in zones 1 through 3 for heated slabs.
e. There are no SHGC requirements in the Marine Zone.
f. Basement wall insulation is not required in warm-humid locations as defined by Figure N1101.2 and Table N1101.2.
g. Or insulation sufficient to fill the framing cavity, R-19 minimum.
h. "13+5" means R-13 cavity insulation plus R-5 insulated sheathing. If structural sheathing covers 25% or less of the exterior, R-5 sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25% of exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.
i. For impact-rated fenestration complying with Section R301.2.1.2, the maximum *U*-factor shall be 0.75 in zone 2 and 0.65 in zone 3.
j. For impact-resistant fenestration complying with Section R301.2.1.2 of the *International Residential Code*, the maximum SHGC shall be 0.40.
k. The second *R*-value applies when more than half the insulation is on the interior.

2009 IRC Table N1102.1

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Hydronic Piping

- **M2103.1.1 – Slab on grade installation.** Radiant piping used in slab-on-grade applications shall have insulating materials having a minimum R-value of R-5 installed beneath the piping
- **M2103.2.2 – Suspended floor installation.** In suspended floor applications, insulation shall be installed in the joist bay cavity serving the heated space above and shall consist of materials having a minimum R-value of R-11

2009 IRC M2103

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How to Achieve Insulation Values?

- **Rigid foam is one of the easier ways to accomplish the sub slab insulation requirements.**

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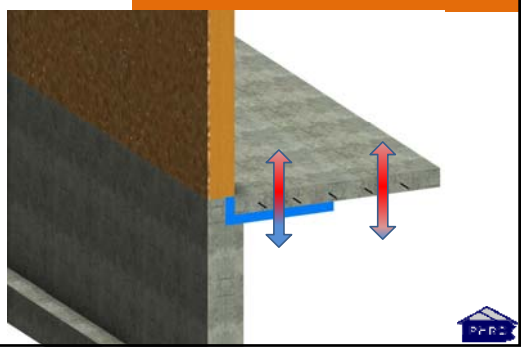
Heat Flow Without Insulation



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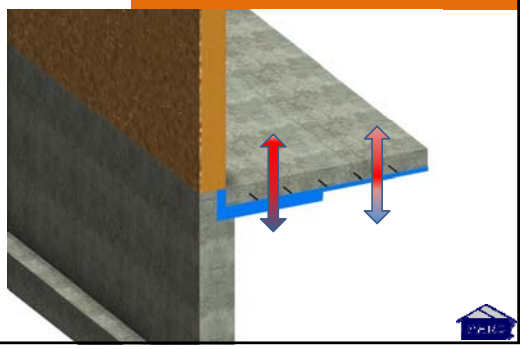
Heat Flow With Insulation



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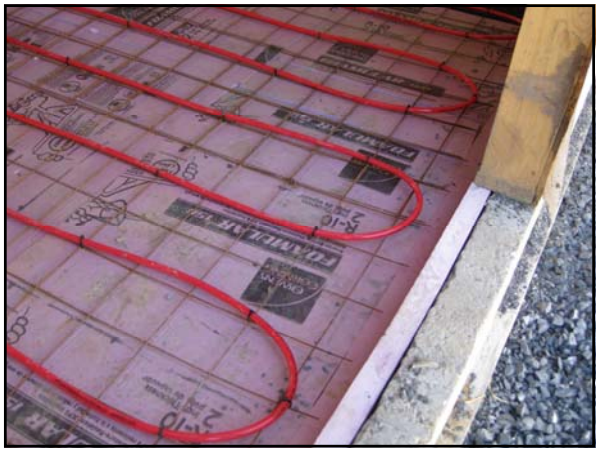
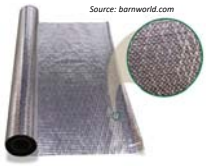


Reflective Insulation?

- Be careful of installation details.
- Review ICC-ES report to ensure printed details are also part of the documented ICC-ES report

Source: barnworld.com



- Some manufacturers recognize the importance of an airspace.

Note regarding R-Values: RadiantGUARD bubble insulations can provide R-Values as high as R-17, however, the R-value is *completely dependent on where and how the product is installed.* Any bubble insulation that is approximately ¼" thick can ONLY achieve an average r-value of 1 to 1.5 on its own. Any additional R-value is achieved by the use of DEAD air spaces around the reflective product or in used in conjunction with other mass insulation products like fiberglass, foam, etc. *Source: radiantguard.com*

Types of Radiant Floor Heating

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Electric Radiant Floors

- Electric radiant floors are usually installed within the thermal mass of the flooring. In most cases, this means it will be installed between the subfloor / concrete floor and the finished flooring material.

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Source: radiantprofessionalsalliance.org

Electric Radiant Floors

- Electric radiant floors typically are not used to "heat" the space, but used as a secondary system to focus on specific areas of the home. (Floor Warming)
- This is why electric radiant floors are more commonly found in bathrooms but this does not mean it can't be designed as a whole house heating system.
- Another electric system would include an electric ceiling radiant heating system

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Hydronic Radiant Floors

- Potentially one of the more popular forms of radiant floor heating systems and arguably one of the most efficient.
- There are several types of systems to choose from:
  - Underfloor Radiant Loops

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Source: blog.buildllc.com

Hydronic Radiant Floors

- **Potentially one of the more popular forms of radiant floor heating systems and arguably one of the most efficient.**
- **There are several types of systems to choose from:**
  - Baseboard Heaters / Radiators

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Source: levittowncomfort.com

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Source: telegraph.co.uk

Hydronic Radiant Systems

- **Potentially one of the more popular forms of radiant floor heating systems and arguably one of the most efficient.**
- **There are several types of systems to choose from:**
  - Radiant Wall Systems

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Common Material Compatibility Issues

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Material Compatibility issues

- **Material compatibility must be at the top of the list when designing a radiant heating *system*.**
- **Items to consider when choosing a finished flooring material to be installed over a radiant system:**
  - Thermal conductivity of the flooring material
  - Moisture content of the flooring material
  - Temperature limitation of the flooring material
  - Furniture type and placement

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Carpet as a Finished Floor

- **Carpet can be considered an insulator over a radiant heating system.**
- **Example conducted by the Georgia Institute of Technology School of Textile Engineering:**
  - 24 oz. Plush carpet had an R-value of R-1.12
  - Bonded Polyurethane 4lb padding had an R-value of R-2.09
  - Total R-value of R-3.21
  - Equivalent to over ½" of XPS

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Vinyl as a Finished Floor

- **Some types of vinyl floors can be installed over a radiant floor:**
  - Luxury Vinyl Flooring (LVF)
    - Luxury vinyl planks (LVP)
    - Luxury vinyl tile (LVT)
- **Vinyl products that may need special attention**
  - Vinyl sheet material that must be glued in place. Off-gassing of the adhesives may occur.

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3/4" Solid Hardwood as a Finished Floor

- Because ¾" hardwood is a natural material, it is subject to movement based on the environment in which it is installed.
- Solid hardwood, if installed over a radiant heated floor, should be quartersawn, narrow planks should be selected. This has the greatest chance to resist horizontal expansion and distortion.
- The surface temperature of the subfloor should not exceed 80°.
- Most if not all hardwood floor manufacturers will not warranty hardwood installed over a radiant floor heating system.

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Floating Engineered Hardwood as a Finished Floor

- Due to the product's engineered design, it can be more forgiving to the introduction of heat and moisture.
- Because a floating floor is not nailed to the subfloor, but instead locked together, it allows the whole floor to move as a single unit if a dimensional change within the wood floor takes place.
- Most manufacturers of engineered floating floors provide a warranty for installations over radiant systems (with the possible exceptions of their Maple and Brazilian Cherry species)

Source: hoskinghardwood.com

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Tile or Stone as a Finished Floor

- Due to the thermal mass and thin profile, tile and stone can be one of the best flooring materials for the transfer of heat
- These materials are highly conductive which can lead to a more effective system

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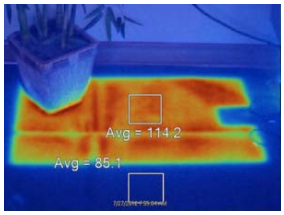
Furniture and Trapped Heat

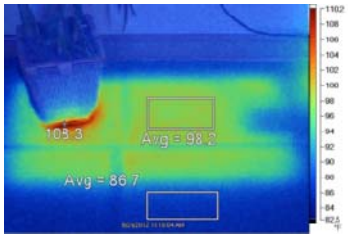
- What is trapped heat?
- Heated mat placed over a laminate floor for 30 minutes



46 Source: warmlyyours.com

Furniture and Trapped Heat

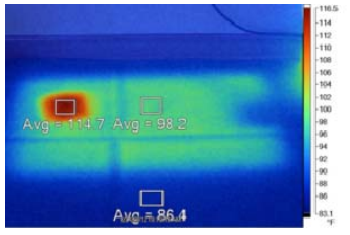
- After the removal of the mat



47 Source: warmlyyours.com

Furniture and Trapped Heat

- After the removal of the flower pot



48 Source: warmlyyours.com

Furniture and Trapped Heat

- Never install radiant heating under permanent fixtures
- Ensure there is a minimum 2-3 inches between the floor covering and the underside of the furniture
- Avoid placing furniture such as bookcases, closed-bottom furniture and stands that have shape points as feet over a radiant floor system
- The goal is to allow free movement of air as to reduce hot spots or trapped heat

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Summary

- Radiant floor heating can be an efficient way to heat a home
- Proper insulation must be installed to promote heat flow in the desired direction
- Flooring materials must be chosen to reduce an insulating type reaction
- The compatibility of flooring materials must also be taken into consideration when installing a radiant floor heating system
- The type and placement of furniture must be taken into consideration when using a radiant floor heating system

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