Radiant Heating & Cooling—Residential

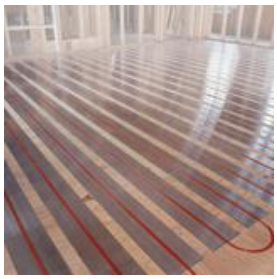
[STRATEGY]

BRIEF DESCRIPTION

Unlike conventional heating and cooling systems that condition spaces primarily through convection, radiant systems condition the floor, ceiling, or walls, which in turn either radiate heat directly to occupants or objects, or absorb heat from occupants or objects. Radiant heating or cooling systems can be installed separately, or can utilize the same infrastructure to provide both heating and cooling. Heating systems are typically most efficient when installed in floors, whereas cooling systems usually operate most effectively when installed in ceilings; thus consideration should be given to the optimum placement for a specific project given the required heating and cooling loads.

Radiant systems provide heating or cooling by moving air or water through flexible tubing installed in the floor, ceiling, or walls (floor systems are the more common means of installation). "Wet" systems are installed in concrete floors, while "dry" systems are installed under a finished floor system. Commercial applications typically utilize wet systems, while residential systems are often dry. To achieve maximum benefits, radiant cooling systems are best used in dry, arid climates, and often in conjunction with a large thermal mass (i.e. concrete floors) to provide an optimum heat transfer medium. The table[1] on the following page illustrates the differences between radiant cooling panels and flooring systems.

Applications **Homes, apartments, dormitories, barracks**



(a)

(c)

(d)

(a) Dry installation (http://na.rehau.com/construction/heating...plumbing/radiant.heating/raupanel.shtml)
(b) Dry installation (http://www.viega.net/productcatalog.html#scope-group1960338530756)
(c) "Wet" installation in dormitory (http://www.dartmouth.edu/~opdc/hpb/sradiant.html)

[1] Center for the Built Environment (CBE).Centerline Newsletter. 2007. *Opportunities with Radiant Cooling.* Accessed August 2010 at http://www.cbe.berkeley.edu/centerline/winter2007.pdf

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	Slab-integrated Systems	Panel Systems
Thermal Mass	High	Low
Thermal Inertia	High	Low
Typical Surface Area	Up to 100% of ceiling/floor area	50% to 70% of ceiling area
Cooling Surface Temp	64-75° F (18-24° C)	56-59° F (13-15° C)
Cooling Capacity	24 Btu/hr-ft2	30 Btu/hr-ft2
Cooling-mode ventilation supply air temperature	Just below space temperature	44-55°F
Best Applications	Buildings with high-performance envelopes Moderate climates Use with natural ventilation and/or low-energy cooling or heating sources	Buildings with greater variation in skin loads Buildings with spaces with highly variable internal loads Mixed-mode buildings with zoned or seasonal operation
Condensation Avoidance	Robust design strategies, rather than controls	Dehumidification, sensors, and controls
Additional Opportunities	Use to remove solar loads from structural elements, or to create a "constant-temperature" slab or pre-cooled building Lower cost per unit surface area	Good for retrofit applications, including supplementary space conditioning Some designs integrate acoustical solutions

Adapted from Moore, Bauman, and Huizenga. "Radiant Cooling Research Scoping Study." Center for the Built Environment, Internal Report: April 20, 2006.

Design Notes

- Knowledgeable design and proper installation is important due to the complexity of radiant systems.
- Adequate insulation should be installed beneath flooring systems.
- Manifolds are used to ensure proper zoning.
- Controls should be connected to the system to optimize temperature set points and maximize savings.
- For humid climates, separate dehumidification or ventilation systems may be necessary to maintain optimum indoor environmental conditions.
- Condensation may be an issue if heavy carpets are installed in a residence. Proper design including specifications for maximum and minimum floor temperatures is required to avoid this issue.

Related Technologies

- For dual heating and cooling systems, geothermal heat pumps can be used to provide the required energy. Condensing gas boilers, solar hot water

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heaters, or waste heat from other processes could be used for heating only applications.

- Similar to purple piping systems that use reclaimed water (i.e. greywater), purple tubing systems have recently been developed that function in coordination with a greywater system. Local code restrictions may prohibit use of this technology.

References/Useful Resources:

[1] Department of Energy (DOE) Energy Savers: Radiant Heating. Accessed August 2010 at http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12590

[2] Department of Energy (DOE) Energy Savers: Radiant Cooling. Accessed August 2010 at http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12470

[3] Wilson, Alex. 2002. *Radiant-Floor Heating: When It Does –and Doesn't – Make Sense*. Environmental Building News. Accessed August 2010 at http://www.buildinggreen.com/auth/article.cfm/2002/1/1/Radiant-Floor-Heating-When-It-Does-and-Doesn-t-Make-Sense/

[4] Cunniff, Greg. 2009. *High Efficiency Radiant Cooling.* Heating, Piping, and Air Conditioning Engineering (HPAC). Accessed August 2010 at http://hpac.com/plumbing-piping-pumping/highefficiency_radiant_cooling/index1.html

[5] Radiant Panel Association (RPA). Accessed August 2010 at http://www.radiantpanelassociation.org/i4a/pages/index.cfm?pageid=471

[6] Dieckmann, John, Kurtis McKenney, James Brodrick. 2009. Radiant Floor Cooling in Practice. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Journal, November 2009. Accessed August 2010 at http://tiaxllc.com/publications/ashrae/november2009.pdf

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Energy Savings

Lower/Higher Thermostat Set Points

- Occupants generally feel warmer/cooler at lower/higher ambient air temperatures when heated/cooled by radiant heating systems. Energy savings can be realized if thermostat set points are lowered/raised accordingly

Reduced Fan Energy Consumption

- Can reduce the amount of fan energy required with conventional heating systems. However, required ventilation rates must be maintained.

Social Benefits

Increased Occupant Comfort

- Occupants typically feel warmer with radiant heating systems, which could result in fewer temperature related complaints.
- Quieter space, due to reduced fan noise.
- Fewer particulates/dust that with conventional systems.

Guiding Principles[2]

Optimize Energy Performance (Energy Efficiency)

- Reduce the energy use by 30 percent compared to the baseline building performance rating per the ANSI/ASHRAE/IESNA Standard 90.1-2007.

Associated LEED Credits (NC 2009)[3]

EAc1: Optimize Energy Performance (1-19 points)

- Demonstrate a percentage improvement in the proposed building performance/rating compared to the baseline building performance rating per ASHRAE/IESNA Standard 90.1-2007

[2] Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings www.wbdg.org/pdfs/hpsb_guidance.pdf
[3] USGBC LEED Reference Guide for Green Building Design and Construction, 2009 Edition

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Product Images

(a) (b) (c)

(Source:
(a) http://www.viega.net/productcatalog.html#modeldetail-group248091617103
(b) http://na.rehau.com/construction/heating...cooling/radiant.heating/everloc.shtml
(c) http://na.rehau.com/construction/heating...cooling/radiant.heating/pro-balance.manifolds.shtml

Components

Tubing, joints, manifold

Cost Range

Components	Cost	Unit
Tubing	$0.50-$3	Per square foot. Varies according to tube diameter,
Joints	$0.25 – $10	Per unit. Varies according to type of fitting.
Manifold	$200-$500	Per unit. Varies according to the desired number of circuits.

Product Types

PEX tubing

- Tubing for radiant heating and cooling systems is typically made of flexible cross-linked polyethylene, or PEX. Recent PEX technology is designed to use reclaimed water, or wastewater, which can contribute to reduced water consumption

Mat tubing systems

- Some vendors offer tubing systems in mat-form, which can simplify the installation process and reduce time required to install. Mat systems are available for both floor and ceiling installation.

Radiant Panels

- Typically consisting of tubing attached to metal sheets, these panels are installed in the ceilings or walls and respond more quickly to thermostat adjustments.

Slab on Grade Floor Systems[4]

[4] Remaining product listing copied from the UFGS. Accessed August 2010
http://www.wbdg.org/ccb/browse_org.php?o=70

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- Typical concrete floor system with tubing imbedded in concrete.

Thin Slab System

- Tubing imbedded in a thin light weight concrete on top of a wooden sub-floor.

Above floor plate system

- Tubing installed in channels with reflective metal barriers above a wooden sub-floor. The tubing is then covered with thin sheets of plywood.

Below floor plate system

- Tubing is installed below the wooden sub-floor using reflective metal barriers.

Below floor suspended tube system

- Tubing is suspended within the interstitial space between a wooden sub-floor and insulation. (Seldom used due to higher water temperature requirements).

Below floor staple-up system

- Tubing is stapled to the underside of a wooden sub-floor. This system is available; however, the below floor plate system is more energy efficient

Vendors

Watts Radiant
http://www.wattsradiant.com/

Viega Radiant Heating
http://www.viega.net/780.htm

REHAU
http://na.rehau.com/construction/heating...cooling/radiant.heating/radiant.heating.shtml

PEX Supply
http://www.pexsupply.com/

Uponor
http://www.uponor-usa.com/en.aspx

Warranty Info

Varies according to vendor and product.

Code Restrictions

None, unless greywater systems are used.

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GENERAL[5]

Products included:

1. Tubing
2. Joints
3. Manifold

PRODUCT DESCRIPTION

Although this specification deals with heating water produced by boilers, other sources of heat such as solar, domestic water heaters, waste heat, or heat pumps may also be used for radiant floor heating.

The radiant floor heating system should be designed in accordance with the latest edition of the ASHRAE Systems and Equipment Handbook, HYI-400, and the Radiant Panel Association's (RPA) Standard Guidelines for the Design and Installation of Residential Radiant Panel Heating Systems.

All pipe layouts, zones, pipe sizes, and pump sizes should be clearly shown on the drawings. The designer should provide a cross sectional detail of the integrated floor and piping system that clearly shows the floor design. Floor insulation, floor coverings, floor load bearing characteristics, and manifold access panel should be coordinated with the architect and structural engineer. The method of insulating the floor is different from typical construction. If the insulation is not properly designed, the system will not work. The drawings should also address the desired control sequence for the radiant heating system. The drawings should indicate which loops will require temperature control, in order for the manufacturer to provide a proper manifold. Various control strategies can be found in HYI 400 and the RPA standard guideline for the Design and Installation of Residential Radiant Panel Heating Systems. The control sequence should consider the required circulation of water through the boiler. High mass radiant floor heating systems do not typically respond quickly to a change in load due to the thermal mass of the floor. Therefore, night setback control is not feasible for high mass floor radiant heating systems, unless long durations of unoccupied spaces occur such as in a chapel.

The radiant floor heating system shall include all piping, manifolds, valves, pumps, expansion tank, pressure relief valves, relief valves, and controls to provide a complete and operational heating/cooling system.

A. Tubing

The tubing material shall comply with ASTM F 876. The pipings shall be provided with a

[5] Specification language modified from UFGS 23 52 00 *Heating Boilers* (April 2008). Accessed August 2010 at http://www.wbdg.org/ccb/DOD/UFGS/UFGS%2023%2052%2000.pdf

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factory applied oxygen barrier with a diffusion rate that does not exceed 0.1 grams per cubic meter per day. The piping shall be rated at 100 psi (pounds per square inch) and 180 °F.

B. Joints

The manifold manufacturer shall be consulted to determine the proper joint for connection of tubing to the manifold. The joints required to connect the tubing to the manifold shall be compression type fittings using crimp rings, a combination of inserts and O-rings, gripper type fittings using a retainer ring and O-rings, or as otherwise recommended by the manifold and tubing manufacturer.

C. Manifold

The design and construction of the manifold shall be compatible with the tubing manufacture's requirements. The piping manifold material shall be compatible with the piping material. The manifold shall be capable of providing the number of circuits as indicated on the drawings. The manifold shall be suitable for an operating pressure of 100 psi (pounds per square inch) and 180 °F. Balancing valves shall be provided for each circuit. Isolation valves shall be provided for each supply and return connection. Each manifold shall be provided with an air vent. The manifold shall allow for the measurement of temperature for each circuit. The manifold shall be provided with all required mounting hardware.

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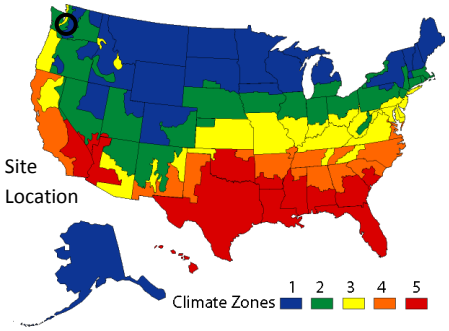
Ballard Manor Retirement Center[6]

Seattle, WA

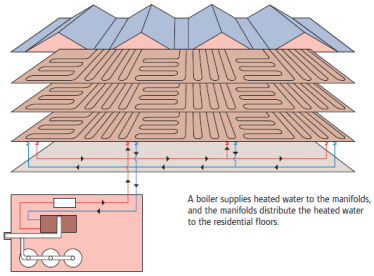


Facility

- 5 story, 45,000 square feet, 65-unit retirement facility
- 670,000 Btu/h capacity boiler provides a room temperature of between 75 and 80 °F, with water supply temperature ranging between 90 and 130 °F.

Approach

- 3/8 inch tubing was installed in plywood decking with poured floor underlayment
- The following figure illustrates the installation diagram for the facility:



Results

- The facility has seen reduced energy costs in comparison to typical buildings located in the Seattle climate.
- Increased occupant comfort with minimal thermostat adjustment
- Maintenance requirements for the system are minimal.

[6] Case Study courtesy of Uponor. Available at http://www.uponor-usa.com/~/media/Files/Technical%20Documents/Commercial%20Related%20Docs/CS_Elderly%20Care_03%2006.aspx?sc_lang=en . While this case study covers only radiant heating, successful installations providing both heating and cooling have occurred in college dormitories, such as Dartmouth's McLaughlin Residential Cluster. Fort Carson and Fort Eustis are among the military installations with current construction projects featuring radiant systems.

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