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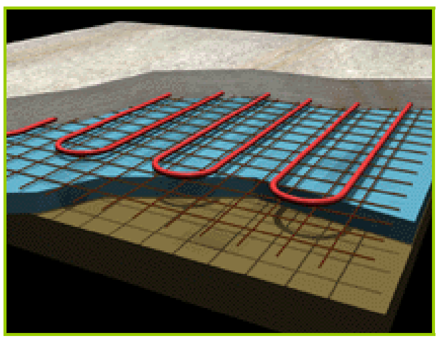
Radiant Floors for Hydronic Heating & Cooling

Prepared For:
The Los Angeles Community College District


Typical Radiant Floor Construction

Radiant Floor Tubing Manifold

DESCRIPTION OF TECHNOLOGY

Radiant floors for hydronic heating and cooling consist of PEX tubing built into the floor construction. The tubing carries heating hot water or chilled water to heat/cool the floor, which in turn heats/cools the rest of the room. Many installation methods are available, including embedding the tubing in a concrete topping slab, which is the most common installation method in institutional projects. This layer of concrete acts as an excellent heat storage device, stabilizing the space temperature.

A layer of rigid insulation is required under the radiant slabs. The rigid insulation is most often sandwiched between the topping slab and the structural concrete slab. An insulation thickness of 4" is recommended where located above an unconditioned space such as a parking garage. At grade or above a conditioned space, insulation is not required, but if provided, a 2" layer of insulation would be adequate.

Radiant floors work best with hard floor finishes such as tile or stone. Carpet is not preferable, but may work if it is very thin (i.e. R-value less than 1).

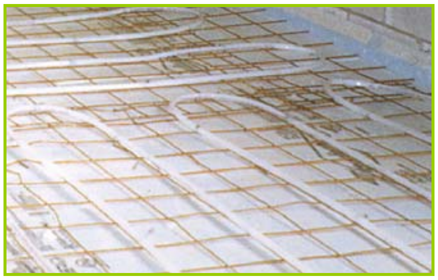
COMFORT

Radiant systems work by controlling the amount of heat an occupant loses. If the occupant loses too much heat, they will feel cold. Likewise, losing too little heat makes a person feel hot. The average person feels comfortable when they lose 450 BTU/hr while performing typical indoor activities. This heat loss equals the heat generated by the body, producing a state of equilibrium. Some 50% of the heat loss is through radiation (to surrounding surfaces), 30% through convection (to the air), and 20% through evaporation (breathing, sweating). So, by controlling the surrounding surface temperatures, radiant floors have a large impact on a person's heat loss and therefore on their comfort.

Modes of heat loss / comfort	Controlled variable
Radiation (50%)	Surrounding surface temperatures
Convection (30%)	Air temperature
Evaporation (20%)	Humidity

In a typical indoor environment, the wall temperatures equal the air temperature, and humidity is within an acceptable range. Therefore, the indoor air temperature, as set at the thermostat, is the only controlled variable used to maintain comfort.

However, comfort cannot be maintained in all spaces by a constant air temperature alone. For example, at perimeter rooms with large windows, the uncontrolled surface temperature of the large glazing surface can be a large source of radiant heat gain or loss. In this circumstance, occupants will often


PEX tubing prior to concrete pour


Manifold installation in wall


Manifold installation undercounter

complain of discomfort and adjust the thermostat to raise or lower the air temperature in an attempt to compensate for the radiant effect. The end result is higher energy use and decreased comfort.

ENERGY SAVINGS

Radiant systems reduce HVAC energy consumption in two primary ways: air temperature setback and pump vs. fan power savings.

The indoor air temperature can be setback to allow higher temperatures in cooling mode and lower temperatures in heating mode. This is possible because the radiant system will maintain the occupants' comfort at this wider range of air temperatures. The energy benefits are a reduced building envelope load due to less convection through the walls and windows, and extended economizer hours due to a higher return air temperature in cooling mode.

In addition, transporting energy with water uses much less energy than air due to the higher heat capacity and density of water. A one inch water pipe carries the equivalent energy of an 18"x18" air duct. The pump power to move 1000 MBH of cooling capacity in water over a distance of 1000 feet is ~3 hp, compared to fan power of ~10 hp to transport the same amount of energy the same distance using air. About half of the energy savings associated with radiant systems is due to reduced fan power requirements

Other means of energy savings are also possible for certain types of system designs. For example, radiant heating systems require lower water temperatures than other types of HVAC systems, which can translate into significant boiler efficiency gains with condensing boilers.

DESIGN CONSIDERATIONS

Radiant floors should be considered in lobbies, atria, or any other large public spaces on LACCD campuses. A tall space with a large amount of glazing is the perfect candidate for radiant floors since the heating and cooling is handled at the occupant level, and the radiant solar loads can be efficiently offset by the radiant floor.

Radiant floor heating systems can typically be designed to provide all of the heating capacity needed for a space, particularly in Southern California. Radiant floor cooling systems alone do not provide enough cooling capacity and must be supplemented by an air system. With all radiant floor systems, an air system is required to provide ventilation air to the space.

Typical capacities of radiant floors are 30-35 Btuh/sq.ft. for heating. The cooling capacity will vary depending on the floor surface temperature and whether the floor is in direct sun. Without direct sun, the cooling capacity is typically limited to 10-13 Btuh/sq.ft. In direct sun, the solar load is absorbed by the floor before it reradiates into the space. In spaces with high solar gains, the cooling capacity may be as high as 25-32 Btuh/sq.ft.

Condensation Prevention

In cooling mode, prevention of condensation on the radiant floors is a consideration. The LACCD campuses have a dewpoint of 67-69°F (0.4%

Manifold installation in janitor closet

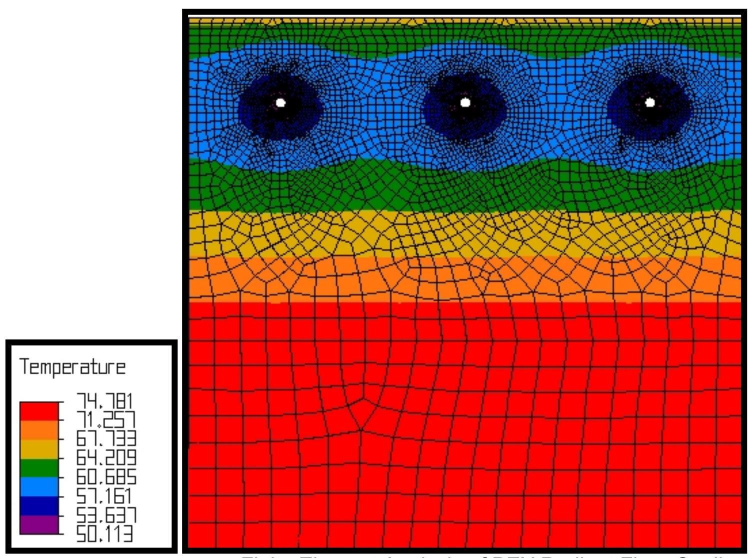
Manifold installation in storage room

ASHRAE condition). Good design practice would be to provide a safety margin of ~2°F and maintain a surface temperature 69-71°F or higher to prevent condensation on the floor surface. Radiant cooling would be ineffective at these temperatures.

One design strategy to mitigate condensation in this climate is to locate the radiant floor in a controlled interior environment which is dehumidified, so that the radiant floor can operate at lower temperatures.

In some situations this is not possible, such as in an entrance lobby where the exterior doors will be frequently opened. In this case, the radiant floor can be operated at lower temperatures to achieve the required capacity, but it may need to be turned off when the dewpoint temperature is too high. The airside HVAC system would be sized for the full cooling load.

During the design process, a finite element analysis model can be used to calculate the heat transfer and temperature distribution through the floor. The cooling output of the floor is determined for a surface temperature that is above the design dewpoint, so that cooling output and thermal comfort will be known for the design conditions and condensation will not occur. The HVAC controls system incorporate humidity sensors, floor surface temperature sensors, and controls logic to ensure that condensation does not occur during all operating conditions.



Finite Element Analysis of PEX Radiant Floor Cooling

ADDITIONAL RESOURCES

Government websites

- www.doe.gov
- www.eere.energy.gov

Manufacturer websites

- na.rehau.com/construction/index.shtml
- www.uponor-usa.com
- www.wattsradiant.com