

sdl urop meeting

heat transfer, radiative conditioning systems

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heat transfer | governing physical laws

Radiative systems utilize 2 of the 3 types of heat transfer:

1. radiant heat transfer
2. convective heat transfer

These are governed by the Stefan-Boltzmann Law and Newton's Law of Cooling, respectively.

Stefan-Boltzmann Law

$$Q = \epsilon \sigma T^4 A$$

Where:

- $Q \equiv$ heat energy radiated (W)
- $\epsilon \equiv$ emissivity constant (dimensionless)
- $\sigma \equiv$ Stefan-Boltzmann constant (W/(m²K⁴))
- $T \equiv$ temperature of body (K)
- $A \equiv$ surface area of body (m²)

Newton's Law of Cooling

$$Q = h_c A dT$$

Where:

- $Q \equiv$ heat energy convected (W)
- $h_c \equiv$ convective heat transfer coefficient (W/m²C)
- $dT \equiv$ differential temperature of body (K)
- $A \equiv$ surface area of body (m²)

radiant heating | types

2 main types of radiant heating: **floor heating** and **panel heating**.

They operate off of the same physical principles, but the thermodynamics are slightly different because of the geometry.

floor heating:

works on principle of radiation & convection: air adjacent to the floor is heated radiatively, then rises to heat the rest of the room convectively.

radiant air: air is used as the heating medium; systems contain heating coils within gap between subfloor and floor -- the heating coils heat the air in the gap, which then heats the floor, and the room. Least efficient of the three methods (air has much lower heat capacity than water/heating fluid).

electric radiant: floor is heated through direct contact with resistive heating coils. This system is the most efficient but also the most expensive, due to relatively high cost of electricity. Are best utilized with floors of large thermal mass (thick slabs of concrete) that can be “charged” with heat during off-peak hours.

hydronic: floor is heated by heated fluid (from boiler) flowing through tubing laid beneath. System is the most widely implemented form of radiative heating in colder climates.

radiant heating I types (cont.)

panel heating:

- works on principle of radiation primarily (convection plays less of a role).
- operate on a “line of sight” basis: the further away someone is from the panel, the less they will feel the radiated heat (inverse square law) --> this can lead to uneven heating over someone's body

A few relevant classifications:

electrical v. fluid: as with radiative floor heating, panels can be heated either through electrical resistance coils or heated fluid tubing.

wall panel v. ceiling panel: different positions result in different thermodynamic characteristics for the zone.

radiant cooling | types

Radiant cooling works the same way as radiant heating, but energy is flowing in the opposite direction.

Unlike radiant heating, there is only one type of radiant cooling system: **hydronic**, although there are two subtypes within hydronic radiant cooling.

slab integrated: fluid piping run within the slab (either floor, ceiling, or both). Cooled fluid is pumped through, absorbing heat and cooling the room. This type of cooling relies on both radiant and convective heat transfer and is thus best utilized in the ceiling (for best convection).

panels: operate off of the same mechanics as the slab-integrated systems; panels are usually installed hanging from ceiling to maximize convective action.

- **note:** one of the key differences between radiant heating and cooling is that radiant cooling needs to be utilized with a humidity regulation system. If not, water will condense on the chilled tubing and damage the floor/ceiling/wall/building envelope.