2011 Emerging Technologies Coordinating Council Open Forum

Radiant Cooling: An Integrated Design Strategy to Reduce Building Energy Use

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Uponor

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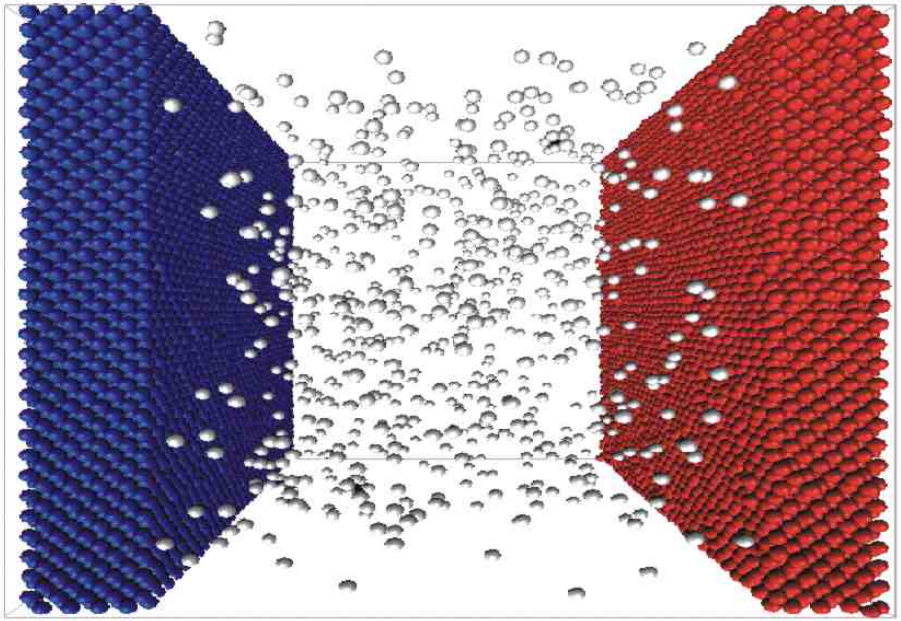
2nd LAW
of thermodynamics

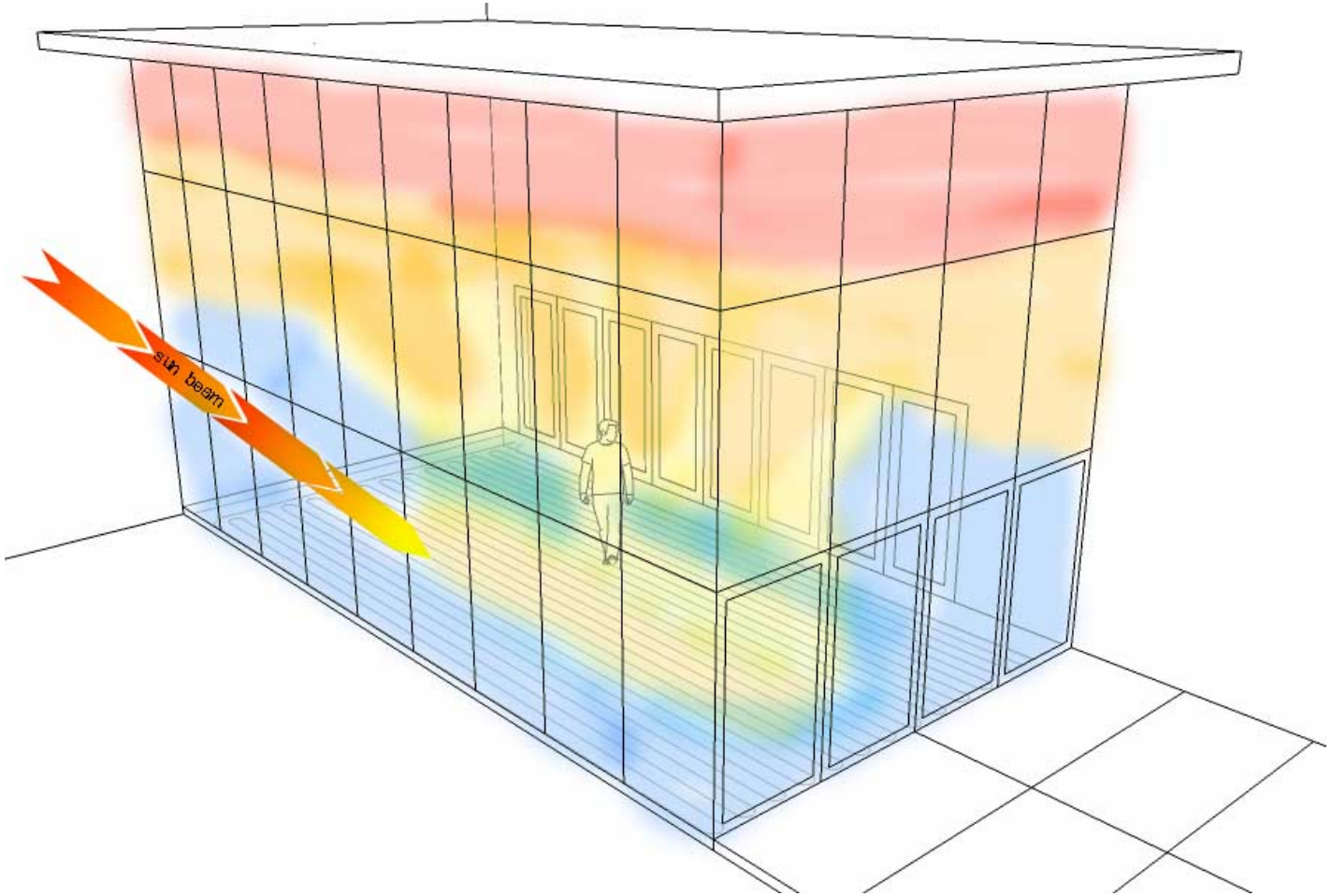
Clausius Statement:

Heat generally cannot flow spontaneously from a material at lower temperature to a material at higher temperature.

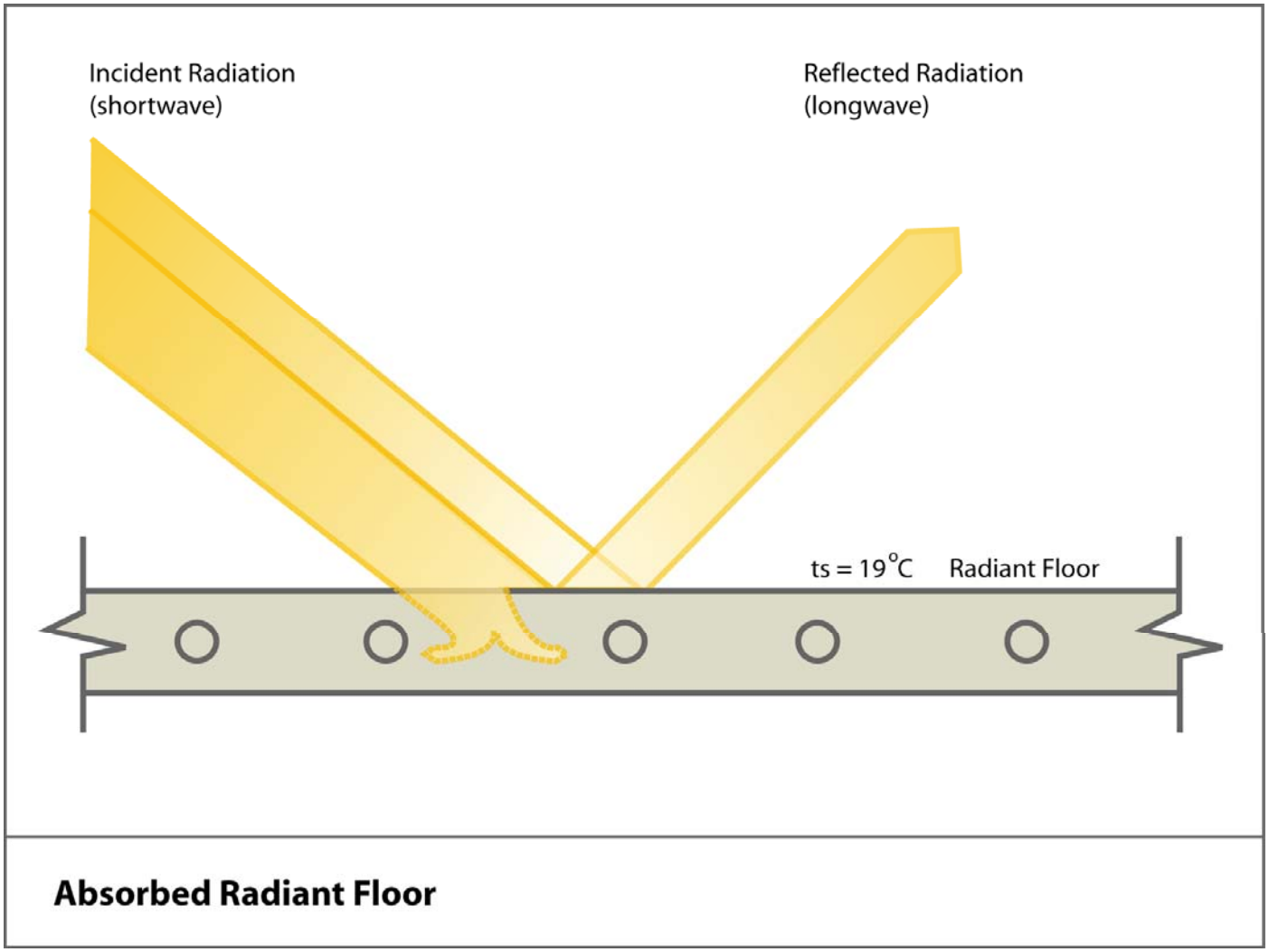


SOLAR GAIN

SOLAR GAIN

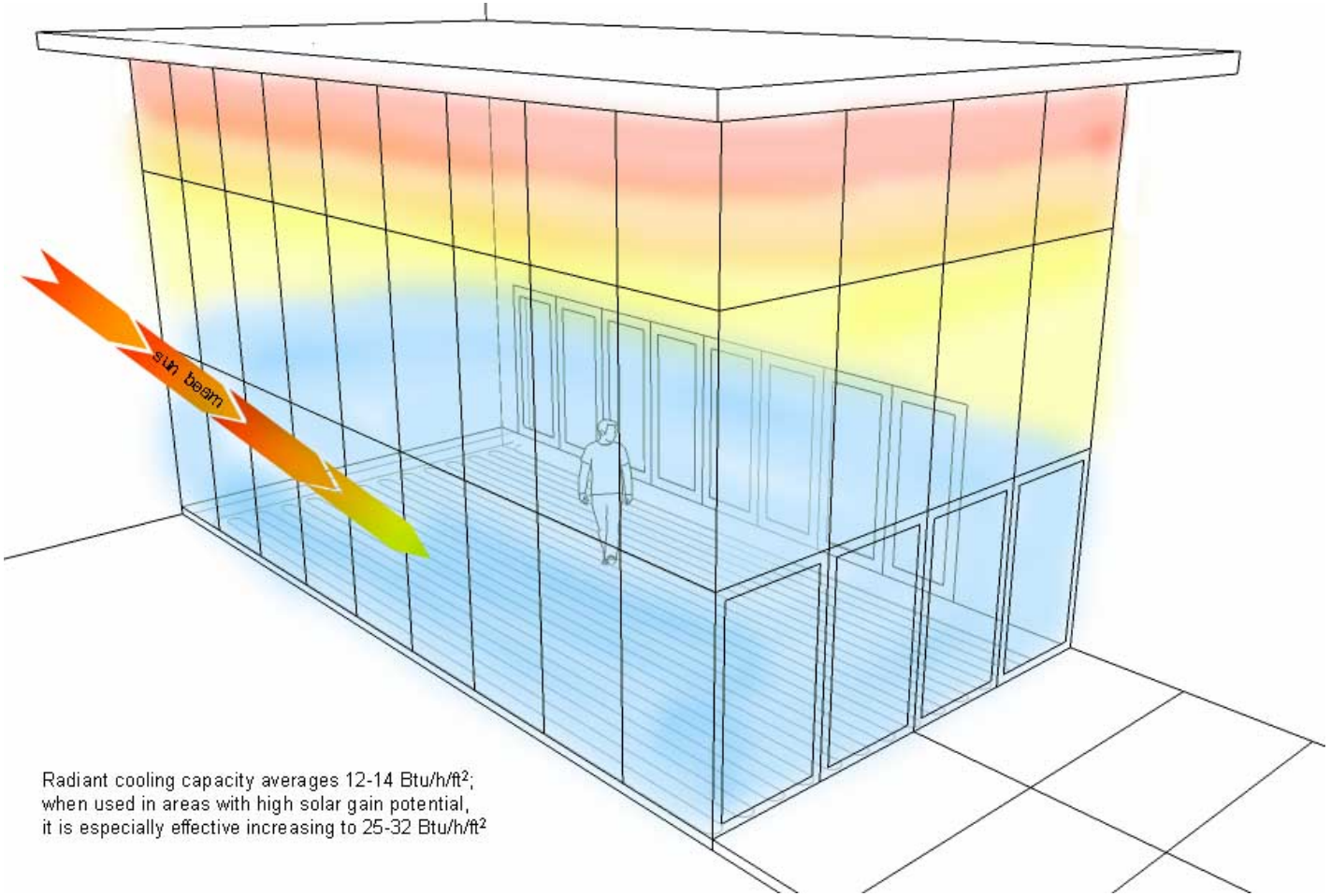


SOLAR GAIN



Absorbed Radiant Floor

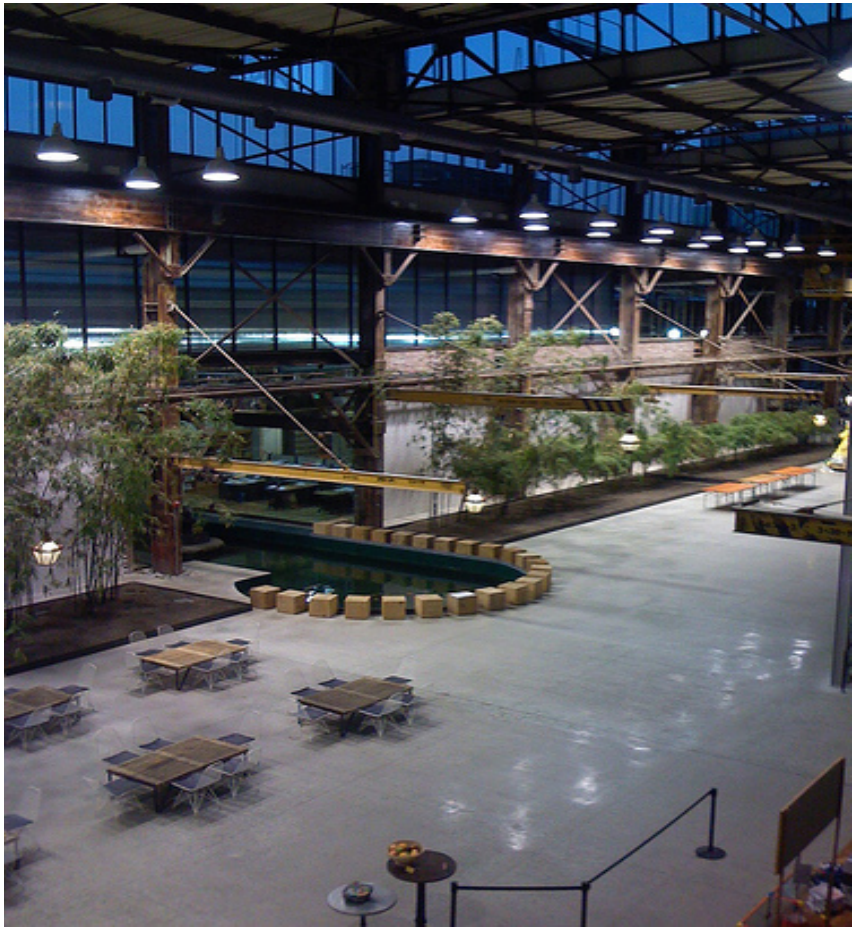
SOLAR GAIN



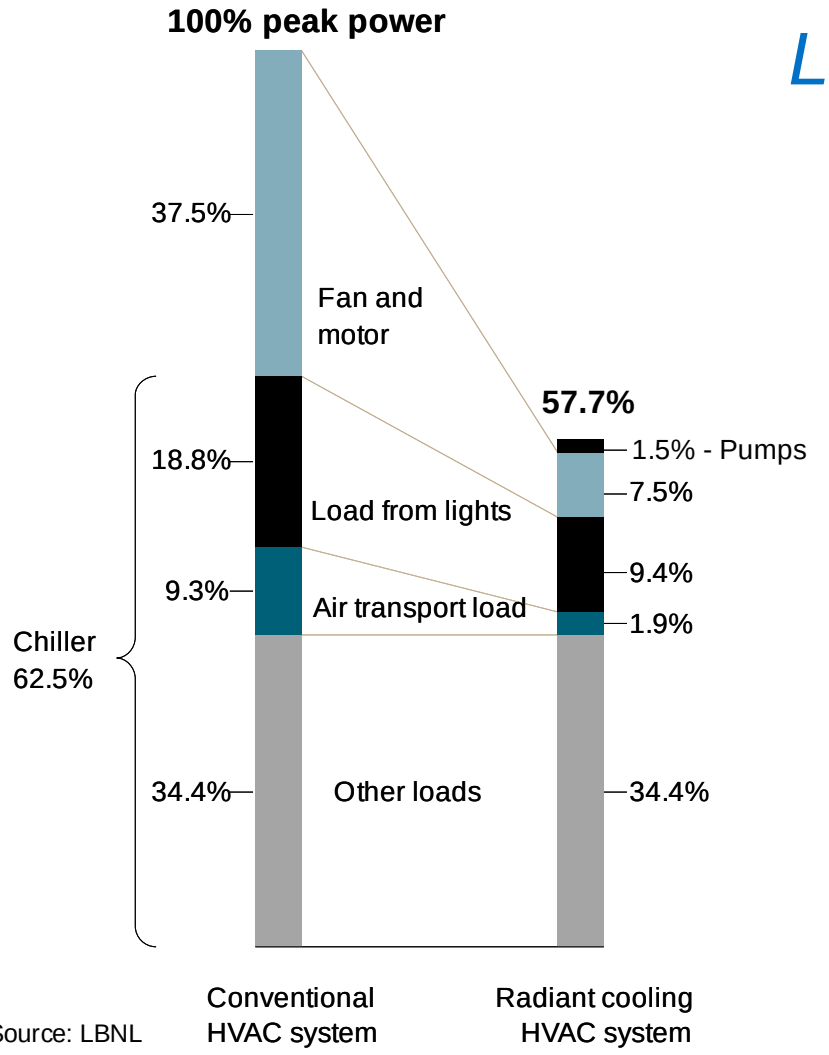
Radiant cooling capacity averages 12-14 Btu/h/ft^2;
when used in areas with high solar gain potential,
it is especially effective increasing to 25-32 Btu/h/ft^2

RADIANT COOLING
System Advantages

- Ability to Deal with High Direct Solar Gains
- Superior Human Comfort
- Greater Architectural Freedom
- Reduced Drafts and Noise
- Energy Efficiency



ENERGY EFFICIENCY



Source: LBNL

LBNL Findings:

Depending on the climate, a radiant cooling system in conjunction with a dedicated outside air system (DOAS) could save between 17% - 42% over the baseline VAV system

ENERGY EFFICIENCY

Pacific Northwest National Laboratory

A radiant cooling system in conjunction with a dedicated outside air system (DOAS) could save as much as 53% over the baseline HVAC system

National Renewable Energy Laboratory / U.S. Department of Energy

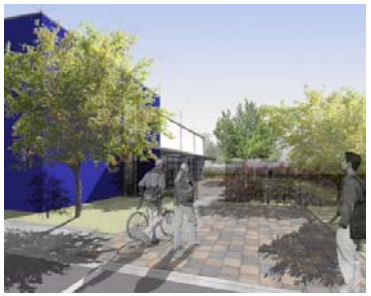
50% Energy Savings over ASHRAE 90.1 can achieved using a radiant heating and cooling system

American Institute of Architects

ENERGY EFFICIENCY

Case Studies

Suvarnabhumi Bangkok Airport
Bangkok, Thailand
30.5% Energy Savings



IDeAs Z Squared Design Facility
San Jose, California
LEED Platinum / Net Zero

Western Science Center
Hemet, California
LEED Platinum

Cooper Union
New York, New York
LEED Platinum

NREL Research Support Facility
Golden, Colorado
LEED Platinum

David Brower Center
Berkeley, California
LEED Platinum

The Chartwell School
Seaside, California
LEED Platinum

Portola Valley Town Center
Portola, California
LEED Platinum

RADIANT COOLING

Performance

Sensible Cooling

A radiant cooling system can effectively manage a portion of building's sensible load

12 – 14 BTUH/SF

Direct Solar Loads

In areas with high direct solar loads, the systems capacity can significantly increase to

25 – 32 BTUH/SF

RADIANT COOLING

Typical Parameters

Tubing

Cross-linked polyethylene (PEX) barrier tubing
5/8” diameter
6” to 9” on center spacing
Maximum tubing length per loop – 350’

Operating Water Temperatures

55°F to 58°F
5°F to 8°F temperature differential

Surface Temperature

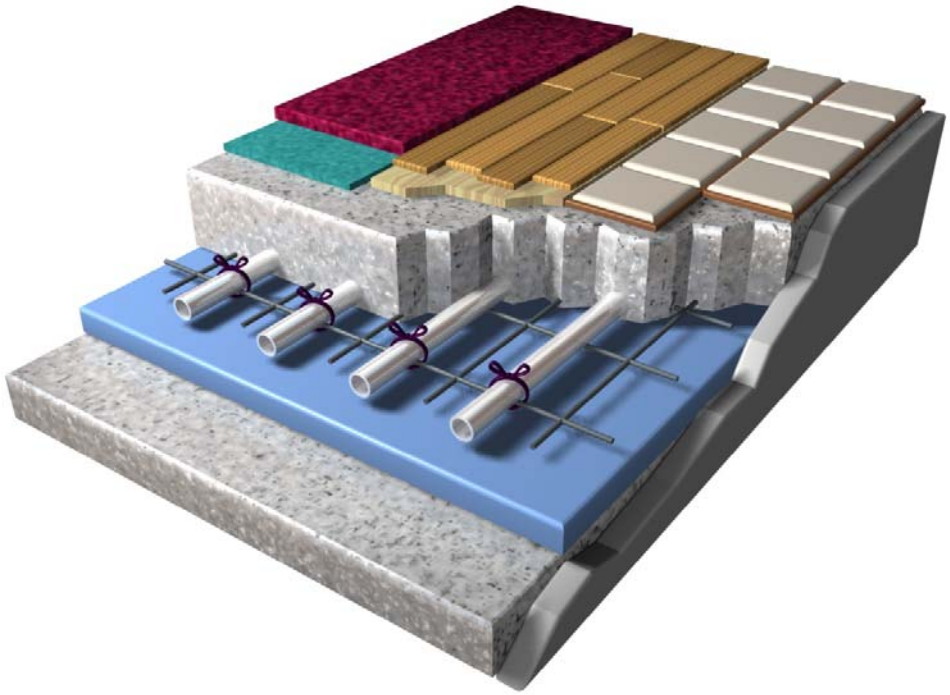
Minimum 66°F

RADIANT COOLING

Typical Construction

Slab on Grade

- Flooring
- Structural Slab
- PEX Tubing
- Wire Mesh / Rebar
- Insulation
- Compacted Grade

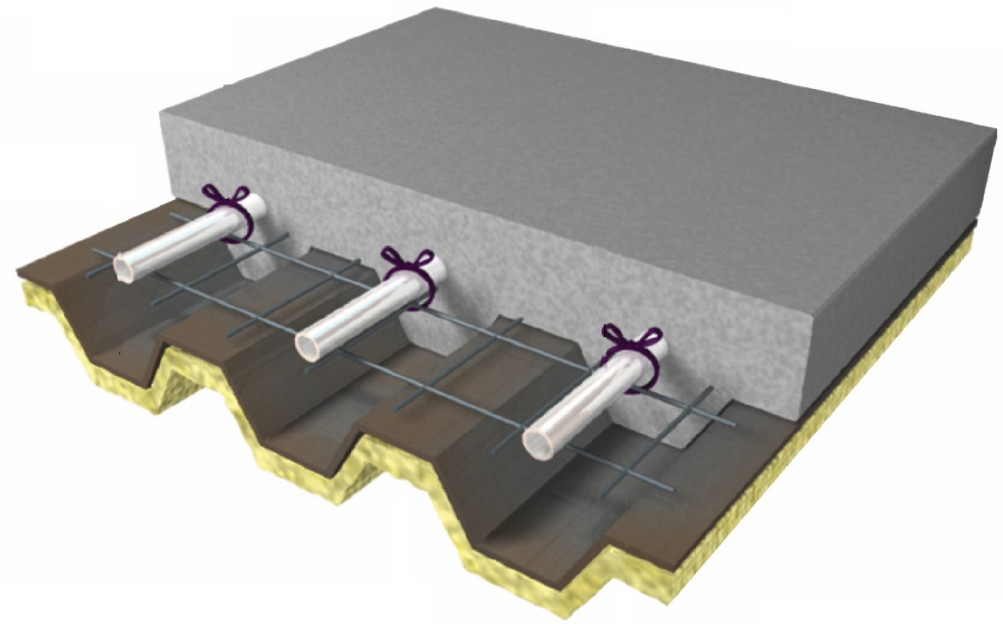


RADIANT COOLING

Typical Construction

Suspended Slab

- Structural Slab
- PEX Tubing
- Wire Mesh / Rebar
- Metal Deck
- Insulation



RADIANT COOLING

Typical Construction

Topping Slab

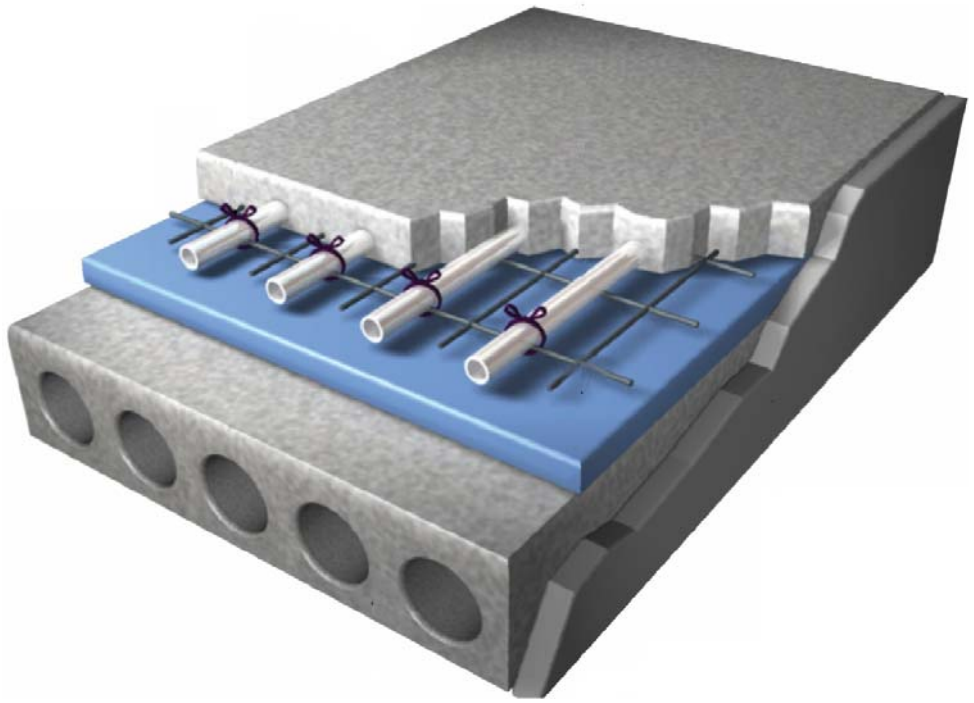
Topping Slab

PEX Tubing

Wire Mesh

Insulation

Structural Slab



RADIANT COOLING

Typical Construction

Wood Deck

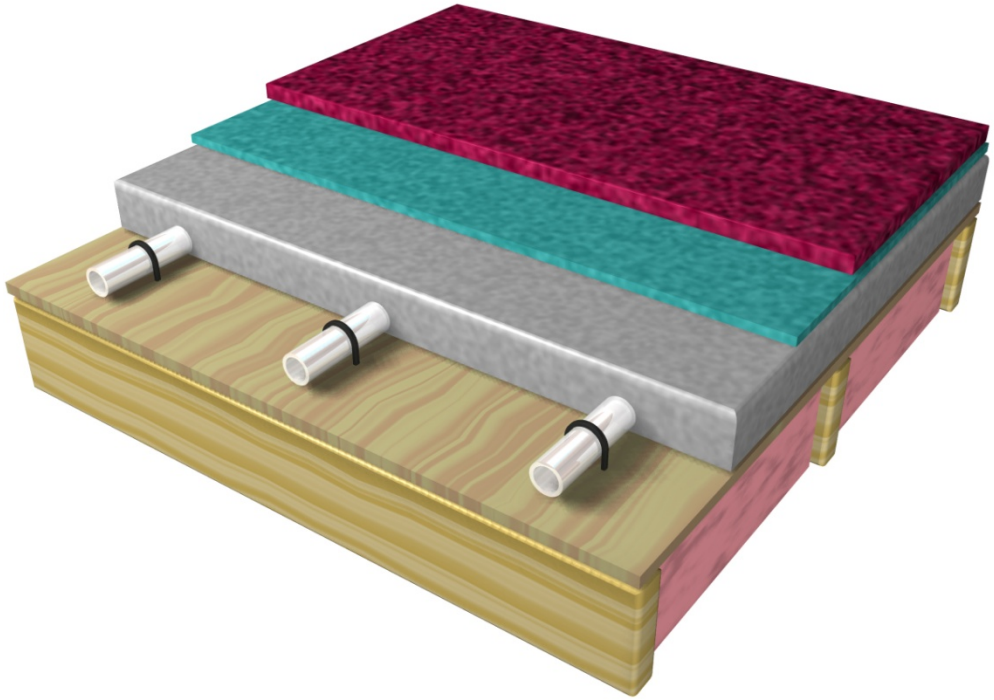
Flooring

Topping Slab

PEX Tubing

Wood Deck

Insulation

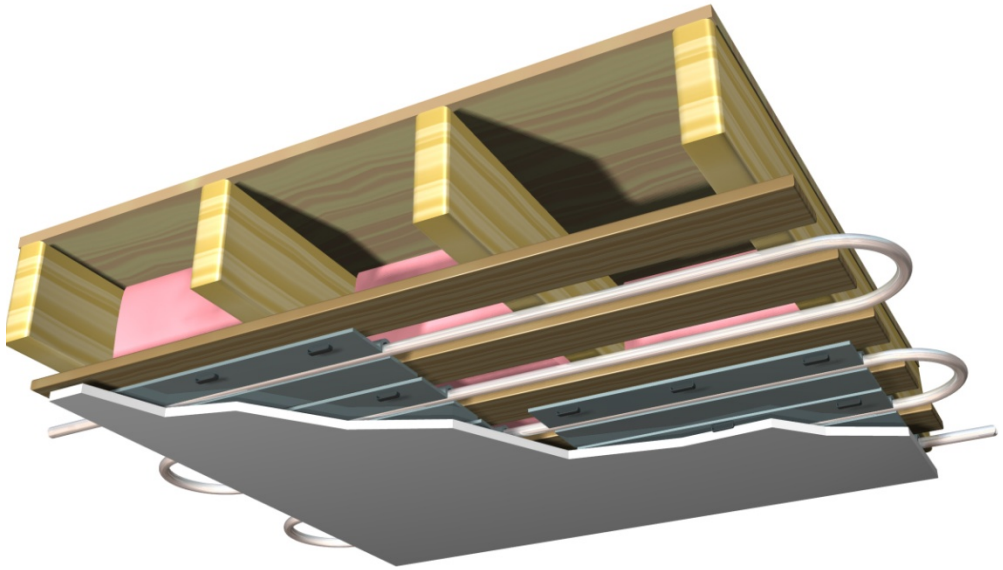


RADIANT COOLING

Typical Construction

Ceiling

- Wood Frame
- Insulation
- Aluminum Heat Transfer Plates
- PEX Tubing
- Drywall

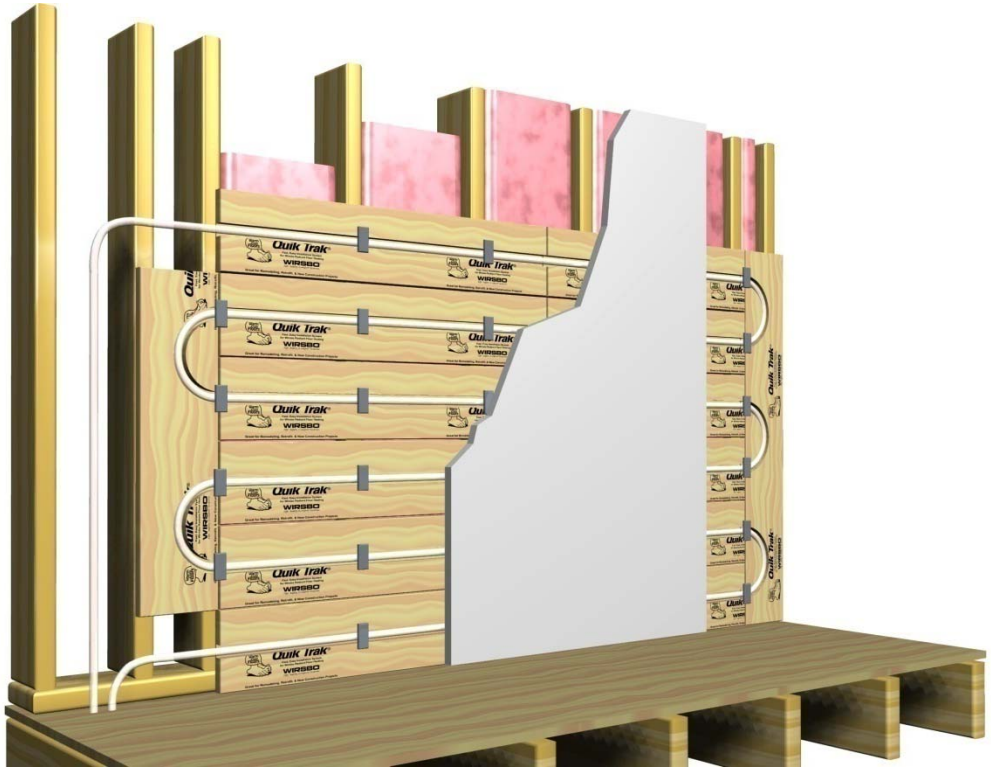


RADIANT COOLING

Typical Construction

Stud Wall

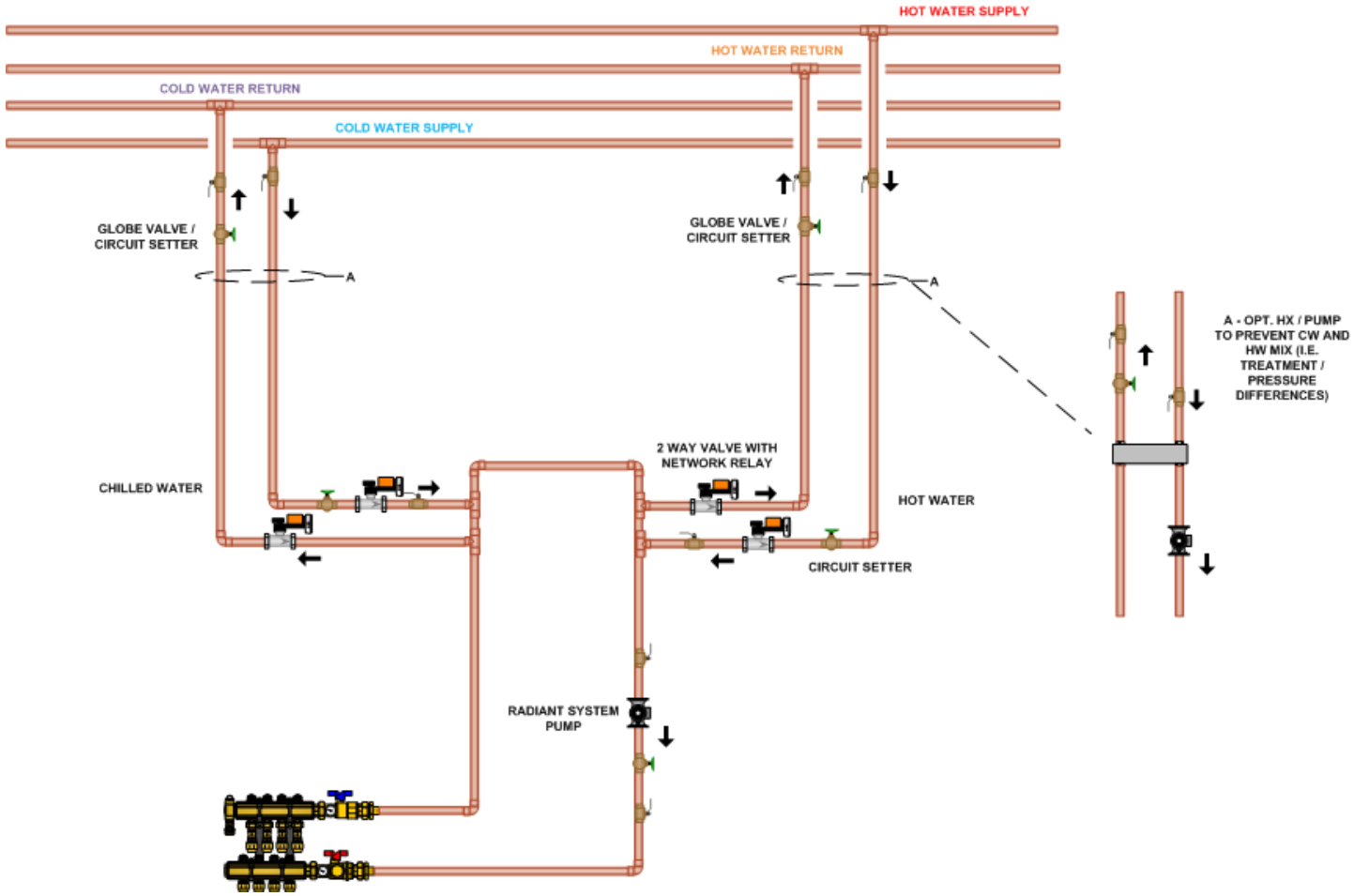
Wall Framing
Insulation
Quik Track
PEX Tubing
Drywall



RADIANT COOLING

Piping Diagrams

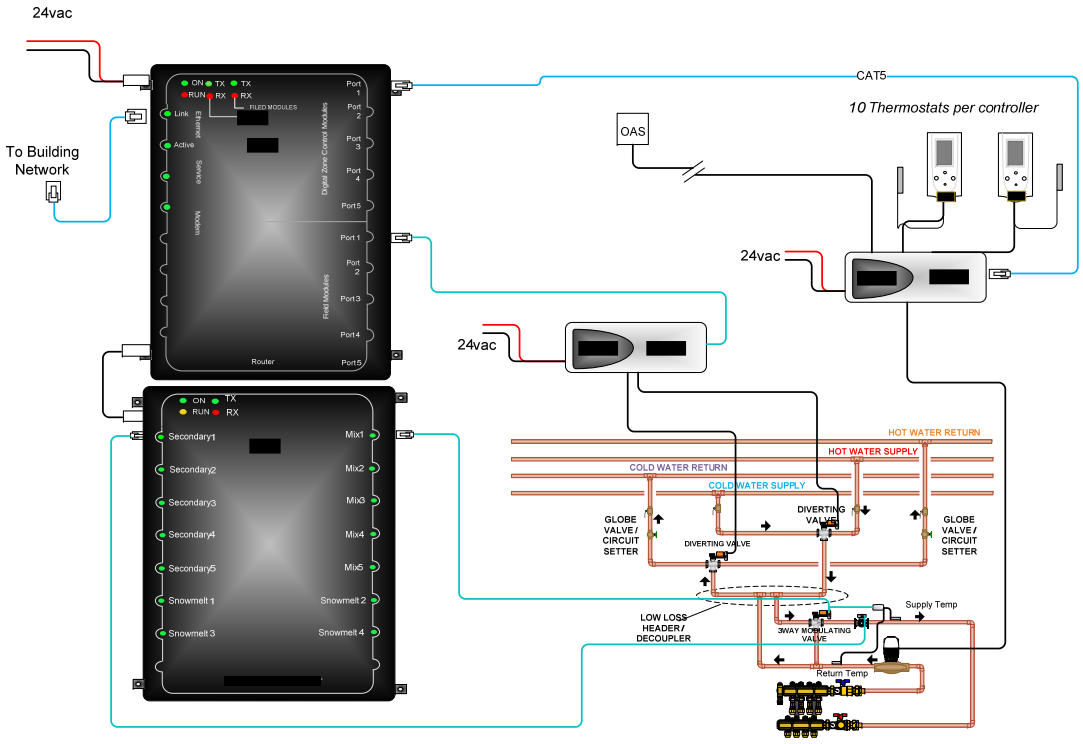
Local Secondary Injection



CONTROLS

Control Points

- Space Temperature
- Indoor Relative Humidity
- Operative Temperature
- Operating Water Temperatures
- Slab Temperature
- Control Valves
- Circulating Pumps
  Outdoor Temperature
- Outdoor Relative Humidity



CONTROLS

Control Strategies

- Base load with radiant cooling system and operate as a differential to air setpoint

- Utilize indoor adaptive rest strategy to optimize target water temperature for maximum effectiveness

- Continuously monitor indoor relative humidity for condensation control

RADIANT COOLING

Condensation Concerns

Condensation

Surface condensation will occur if the surface temperature drops below the dew point

Solution

Continuously monitor indoor relative humidity and maintain supply water temperature 2 degrees above dew point at all times

CONTROLS

Control Strategies

Responsiveness

- High thermal mass provides “inertia” against temperature fluctuations

- Heat transfer from the thermal mass to the space is instantaneous whenever there is a temperature difference

- Thermal mass evens out fluctuations in internal temperature

- Secondary system used to handle high load densities

RADIANT COOLING

Summary

Benefits

- Can be used to dramatically reduce overall building energy use
- Superior Human Comfort
- Improved architectural freedom

Performance

- 12-14 BTUH/SF Sensible, up to 25-32 BTUH/SF with direct solar for radiant floor installations

Important Considerations

- Controls
- Installation Methods
- Installation and Life-Cycle Costs

Questions?