Using Embedded Tube Radiant Cooling Systems to Maximize LEED Points

Devin Abellon, P.E. – Business Development Manager
Uponor

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# LEED v3
new construction

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RADIANT COOLING

High Mass

- Thermally Activated Building System (TABS)
- Overhead slab or floor slab
- Thermal mass
- Larger surface area
- Moderate temperatures (e.g., 65F)

Low Mass

- Suspended or surface-mount
- Faster response
- Typically less surface area
- Colder temperatures (e.g., 55F)
2nd LAW of thermodynamics

Clausius Statement:
Heat generally cannot flow spontaneously from a material at lower temperature to a material at higher temperature.
<table>
<thead>
<tr>
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<th>190 Btu/h</th>
<th>110 Btu/h</th>
<th>100 Btu/h</th>
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<tbody>
<tr>
<td>Radiant transfer</td>
<td>47.5%</td>
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<tr>
<td>Convective transfer</td>
<td></td>
<td>27.5%</td>
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<tr>
<td>Exhalation and other processes</td>
<td></td>
<td></td>
<td>27%</td>
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<tr>
<td>THERMALLY ACTIVE SURFACES</td>
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<tr>
<td>systems target radiant transfer</td>
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<tr>
<td>TYPICAL HVAC systems target convective transfer</td>
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</table>
HUMAN COMFORT
ASHRAE Standard 55

Six Factors:

- Air Movement
- Air Temp
- Humidity
- Clothing
- Radiant Temp
- Metabolism
RADIANT TEMPERATURE

**Average Uncontrolled Surface Temperature**
Area weighted average of the surface temperatures of all uncontrolled surface

**Mean Radiant Temperature**
Average of the AUST and the surface temperature of the controlled surface

**Operative Temperature**
Average of the Mean Radiant Temperature and the Air Temperature
Room Temp. = 78.0°F
AUST = 78.0°F
MRT = 72.0°F
Operative Temp. = 75.0°F
SOLAR GAIN
SOLAR GAIN
SOLAR GAIN

Incident Radiation (shortwave)

Reflected Radiation (longwave)

Absorbed Radiant Floor

\[ ts = 19^\circ C \]
Radiant cooling capacity averages 12-14 Btu/hr-ft². When used in areas with high solar gain potential, it is especially effective increasing to 25-32 Btu/hr-ft².
RADIANT COOLING
System Advantages

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

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

ADOPTER architecture 2030 CHALLENGE
ENERGY EFFICIENCY

Case Studies

- Suvarnabhumi Bangkok Airport
  Bangkok, Thailand
  30.5% Energy Savings

- California Academy of Sciences
  San Francisco, California
  LEED Platinum

- 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

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<tr>
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<tr>
<td>Topping Slab</td>
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<tr>
<td>PEX Tubing</td>
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<tr>
<td>Wire Mesh</td>
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<tr>
<td>Insulation</td>
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<tr>
<td>Structural Slab</td>
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</table>
RADIANT COOLING
Typical Construction

Wood Deck

- Flooring
- Topping Slab
- PEX Tubing
- Wood Deck
- Insulation
RADIANT COOLING
Manifolds
RADIANT COOLING
Piping Diagrams

Mixing with Heating/Cooling Switchover
RADIANT COOLING
Piping Diagrams

Primary/Secondary Piping
CONTROL POINTS

Control Points

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

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
CONTROL S
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
COST

Typical Cost Factors

No Cost
• Structural Slab already part of the construction budget
• Chilled water source typically already part of the budget

Additional Cost
• Cost of tubing, manifolds, fittings, circulators
• Insulation
• Increased Labor

Reduced Cost
• Smaller air handling units, ductwork, diffusers, etc.
• Reduced ceiling space requirements may allow for reduced floor to floor heights
• Potential to reduce electrical service size

Reduced Maintenance Cost
• Less airside equipment to maintain
COST

Typical Cost Factors

Pacific Northwest National Laboratory Study

- Average cost of the radiant system, including central plant
  - $9.31/ SF (7-8 year payback)

2010 R.S. Means Cost Data

- Average cost of materials & labor (excluding chilled water source)
  - $4.25 - $5.43/ SF

Innovations for Reduced Cost

- Big Box Retailer
- 2-1/2 year payback
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

Important Considerations

• Controls
• Installation Methods
• Installation and Life-Cycle Costs
Questions?