Radiant Heating & Cooling for Commercial Buildings

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Radiant Heating & Cooling Systems
Hydronic Distribution & Plumbing
History of Radiant Systems

- First used by Chinese, Koreans & Romans
- 1937 in-floor heating developed by American architect Frank Lloyd Wright
- 1968 PEX-a developed by Dr. Thomas Engel
- 1980’s PEX is introduced in N.A.

- ASHRAE Journal (Jan-Feb 2010)
What is PEX?

- Degrees of crosslinking by method:
  1. PEX-a (Engel)
  2. PEX-b (Silane)
  3. PEX-c (Radiation)
Not All PEX is Created Equal

PEX-a Sectional View
80%+ Uniform Crosslinking

PEX-b Sectional View
65-70% Crosslinking

PEX-c Sectional View
70-75% Crosslinking
Radiant Heating / Cooling Options

- Radiant Floor
  - Slab
  - Gypsum
  - Plywood Track
  - Joist – No plates
  - Aluminum Joist Track

- Radiant Wall

- Radiant Ceiling
System Strategies

- **Active systems** are systems that run during the occupied time
- They provide a nearly steady set-point
- **Passive systems** (TABS) operate most often during the unoccupied time
- Occupants may experience a slight drift in set point temperature across the day
High Mass Installations

- On-grade with expansion joint
- Concrete on metal decking
- Slab-on-slab over high density insulation
- Concrete on pre-stressed decking
Low Mass Installations

- Poured-floor underlaymment
- Quik Trak® panels over wood subfloor
- Radiant ceiling with Uponor aluminum heat emission plates
- Quik Trak® panels wall application
Forced Air Heating Curve vs. Radiant Floor
Thermal Comfort...ASHRAE Standard 55

Ref. : ASHRAE Standard 55-2004
Air System Reduction

- Conventional air systems use 4-5 times as much air for ventilation
- Radiant + DOAS Ventilation system can reduce airflow by 70-80+%
Radiant Cooling capacity averages **12-14 Btu/h/ft²**.

When used in areas with high solar gain potential, it is especially effective, Increasing to **25-32 Btu/h/ft²**.
Sensible Load - Cooling

- Typical office building as modeled by US DOE (1998)
- The inclusion of radiant allows for smaller HVAC fan sizes.
- 42.3% energy savings
- Radiant cooling, on average, saves 30%
- Energy savings of 17% in cold, moist climates, 42% in warmer, dry climates
Net Zero and ASHRAE 90.1

• Results with Radiant Systems and Dedicated Outdoor Air Systems

• Achieved over 50% on-site energy savings for all of the 16 climate locations

• Average approx. 81% heating energy savings and 46% cooling energy savings

• Nearly 84% fan energy reduction mainly from the use of radiant thermal systems and DOAS

• Payback estimated at 7.6 years
TABS – Sandwich Approach

Thermo Active Building Systems

- Began in early 1990s in Switzerland
- Over 1000 installs across Europe since 1997

Peak shaving
## Additional Benefits

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Impact</th>
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<tbody>
<tr>
<td>Higher Return Temps (71-75F)</td>
<td>Increases efficiency of chiller</td>
</tr>
<tr>
<td>Lower Supply Temps (64-68F)</td>
<td>Works well with HPs (geothermal)</td>
</tr>
<tr>
<td>Increased ceiling height</td>
<td>More architectural freedom</td>
</tr>
<tr>
<td>Combine with night time free cooling</td>
<td>Additional Savings</td>
</tr>
<tr>
<td>Tighter control strategies</td>
<td>Higher Occupant Comfort</td>
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<tr>
<td>Little to no maintenance</td>
<td>Low operational cost</td>
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Pier 15 – San Francisco Exploratorium

“Net Zero Energy & Net Zero Carbon”

San Francisco Bay is heat sink/source for radiant heating & cooling system.
San Francisco Exploratorium

Combined DOAS with radiant heating/cooling

- 57% - more efficient than ASHRAE 90.1
- 30% - exceeds minimum ventilation requirement in ASHRAE 62.1
- 50% - reduction in ductwork sizing
- 60% - reduction in water consumption (rainwater)
- Free waterside economizer - bypassing heat pumps

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ASHRAE 90.1 BASELINE</th>
<th>EXPLORATORIUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lights - Interior</td>
<td>853,143</td>
<td>375,300</td>
</tr>
<tr>
<td>Lights – Exterior</td>
<td>49,100</td>
<td>49,100</td>
</tr>
<tr>
<td>Space Heating</td>
<td>782,934</td>
<td>352,800</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>422,555</td>
<td>25,000</td>
</tr>
<tr>
<td>Pumps</td>
<td>292,687</td>
<td>77,500</td>
</tr>
<tr>
<td>Ventilation Fans</td>
<td>287,374</td>
<td>155,800</td>
</tr>
</tbody>
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The Road To Net Zero

“ZEB” – Zero Energy Buildings
— 21 ZEB Buildings across the US

“ZEC” – Zero Energy Capable
— 39 ZEC buildings across the US

When HVAC required, approximately 50% utilize radiant heating and cooling, often with GSHP.

Between 0-10% premiums (much lower than modeled estimates)
Common Radiant Applications

- Museums
- Institutional, educational and recreational facilities
- High-rise hotels / offices
- Manufacturing & retail spaces
- Hospitals/health care and assisted living facilities

The Copenhagen Opera House, Denmark
Turf Conditioning
Normand Maurice (PWGSC) Montreal, QC

- 169,000 ft² Building Space
- Radiant Heating / Cooling
- 50% Energy Savings/yr
- LEED Gold
Normand Maurice (PWGSC) Montreal, QC

- 60 Wells instead of original 100
- Thermal Storage in Sand Bed
- $200,000/yr in Energy Savings
Bangkok International Airport

- Outdoor temperature at 25-35°C (77-95°F) and year round high RH
- Solar radiation of 318 btu/ft²
- 1.6 million ft² Radiant Cooling
- Supply/Return Water Temp is 13°C (55°F)/19°C (66°F)
- 40% of the total Airport Load is handled by the radiant cooling
- Total cooling load energy savings = 30.5%
Radiant Heating / Cooling Summary

Optimal human comfort

**HEATING**
30 to 50 Btu/h/ft² (heating)

**COOLING**
12 to 14 Btu/h/ft² (sensible)
25 to 32 Btu/h/ft² (solar ads.)

Stay 2-3° above dew point

Crucial part of the road to net zero

Low-temp Heating / High-temp Cooling
HVAC Hydronic Distribution Piping
PEX for Distribution Piping Applications:

- Baseboards
- Radiators
- Fan coils units
- Chilled beams
- VAV reheat terminal units
- Radiant manifolds
- And more...
Installation Examples
Installation Examples
Getting Water to You Faster

- Traditional Copper Systems:
  - Cold Line: 8 feet/s
  - Hot Line: 5 feet/s (cavitation based erosion at high flow, high temp)

- Uponor Logic Systems:
  - Cold Line: 10-12 feet/s
  - Hot Line: 10-12 feet/s

- Results in equal or smaller pipe diameters than traditional systems
Fire Ratings and Listings

- **CAN/ULC-S102.2**
  - Meets FS/SD of 25/50 up to 2” without insulation
  - Up to 3” with ½ insulation

- **CAN/ULC-S101**
  - Listings for up to 2-hour rated floor/ceiling and wall assemblies

- **CAN/ULC-S115**
  - Listings for up to 3-hour rated floor/ceiling and wall penetrations
  - ½" to 3" Uponor PEX-a pipe
Questions?

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