The path to Net Zero travels right through Hydronicsville
Who is this guy and what does he do?

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Author (Contractor Magazine, P&M Magazine, numerous other trade magazines)
Instructor (RPA)
Has been doing hydronics and radiant for nearly 40 years.
Former expert witness.
Former adjunct college professor.
Learning Objectives

Upon completion of this program, attendees will be better able to:

• Describe how hydronic based radiant systems work and operate.
• List the benefits of utilizing non floor radiant systems for heating and cooling.
• Identify the major components of a hydronic based radiant heating or cooling system.
• Identify the appropriate materials and components to be used in the system.
• Ensure hydronic radiant systems are designed correctly and efficiently to achieve a net zero capability.
What is Radiant Heating?

• A process by which energy leaves the surface of an object or body and travels omni-directionally to the surface of another cooler object or body in Mother Natures efforts to balance out all things thermal.
We’ve all experienced radiant heating...
We’ve all experienced radiant heating…

• Standing next to a dark brick wall in the evening that had been exposed to sunshine.
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• Sitting in front of a camp fire on a clear starlit night.
We’ve all experienced radiant heating…

• Standing next to a dark brick wall in the evening that had been exposed to sunshine.
• Sitting in front of a camp fire on a clear starlit night.
• Walking into a radiantly heated home out of the cold.
What dictates human comfort?

- Mean (average) radiant temperature
- Ambient air temperature
- Relative humidity
- Noise
Mean Radiant Temperature
What dictates human comfort?

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What dictates human comfort?

- Mean (average) radiant temperature
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A definition of comfort…

• You are not too hot.
• You are not too cold.
• You are not over humidified.
• You are not under humidified.
• You are not hearing the delivery system in the background.
• Simply stated, if all of the above conditions are TRUE, then you are comfortable.
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• Simply stated, if all of the above conditions are **TRUE**, then you are comfortable.
What is radiant cooling?

- A process by which energy leaves the surface of a warm body and travels to the surface of another cooler object, again in Mother Natures effort to balance out all things thermal.
We’ve all experienced radiant cooling…

Image courtesy Messanna Cooling Solutions
We’ve all experienced radiant cooling…

• Sitting outside on summer night with high ambient air temperatures, but clear cloudless sky.

• Walking down the frozen produce isle at the local grocery store and feeling the coolness coming from the glass reach in freezers

• Walking into a hockey arena when air temperature is 70 degrees F.
We’ve all experienced radiant cooling…

• Sitting outside on summer night with high ambient air temperatures, but clear cloudless sky.

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• Walking into a hockey arena when air temperature is 70 degrees F.
Parasitic Energy Consumption

3,000 watts/hour

500 to 650 watts/hour

25 watts (average)
## Thermal Energy Capacity for Common Fluids

<table>
<thead>
<tr>
<th></th>
<th>Air</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.018 BTU’s/cubic foot per degree F difference</td>
<td>62.4 BTU’s/cubic foot per degree F difference</td>
</tr>
</tbody>
</table>

Result: Water carries **3,400 times** as much energy as air does for the same volume and temperature differential…
Typical VRF distribution

Variable refrigerant flow systems can deliver cooling to some zones and heating to others, with no reheat needed (an air-source system is shown here).
How compatible is hydronics with alternative energy?

- Solar Thermal
How compatible is hydronics with alternative energy?

- Solar PV/Thermal
How compatible is hydronics with alternative energy?

• Ground Source Heat Pump
How compatible is hydronics with alternative energy?

• Thermal Battery Storage systems.
How compatible is hydronics with alternative energy?

• Simply stated, hydronics is completely compatible with every alternative energy known to mankind, including those that haven’t been invented yet…
How long has hydronics and radiant been around?
History of Radiant Panel Heating

- Roman bath houses
- 1907 - first use of iron pipe in England
- Frank Lloyd Wright - radiant pioneer
- 1940’s - copper and steel pipe systems
- 1960’s - PEX developed in Europe
- 2015 – Saw a 10% increase in the sales of PEX tubing over 2014, and still climbing…
Advantages of Radiant Panel Heating

• Improves comfort by increasing average surface temperature
• Allows comfort at lower (or higher) air temperatures
• Provides an almost ideal match to human thermal comfort requirements
• Reduces room temperature stratification and mechanically induced exfiltration
Advantages of Radiant Panel Heating

• Many systems are out of sight
• Easily zoned
• Creates gentle room air circulation
• Easily routed through buildings
• Systems with high thermal mass can respond quickly to increased loads when necessary
Advantages of Radiant Panel Heating

• Systems with low thermal mass release heat almost instantly
• Heated floors dry quickly
• Resistant to physical damage
• Can operate with virtually no noise
• Adaptable to almost any heat source and fuel
• Reduces energy consumption
Case Study Slab-On-Grade House

Fig. 2-1
Embedding Tubing in Concrete Slab

Fig. 2-2
Water Heater as Heat Source
Piping Schematic for Case Study # 1

Fig. 4-51
Case Study # 2 Radiant Wall application
Radiant walls prior to insulation
Radiant walls after insulation
Radiant walls (high mass)
Radiant walls (low mass)

Image courtesy Robert Bean
Radiant Ceiling applications
Radiant Ceiling applications
Radiant Ceiling applications
Radiant Ceiling applications
Radiant Ceiling applications

Image courtesy Ahhm Radiant
NOTE: Any piping components containing chilled water must be insulated and vapor sealed to prevent condensation.

Fig. 4-50
Case Study
Electric Cable Heated Foyer

Fig. 2-14
Foyer Tile Warmed by Electric Cable

Fig. 2-15
Electric Cable on Wood Subfloor

Fig. 2-16
Wiring Schematic

Fig. 2-17
Enclosure for Temperature Controllers and Contactors

Fig. 2-34
SAMPLE HYDRONIC RADIANT PANELS

Hydronic Radiant Panel Systems
Hydronic Radiant Floor Panels

Fig. 3-1
Hydronic Radiant Wall and Ceiling Panels

Ceiling: (plate system)

Ceiling: (embedded tube)

Wall: (plate system)

Wall: (embedded tube)

Panel Radiator (horizontal)

Panel Radiator (vertical)

Radiant Baseboard

Fig. 3-2
Slab-on-Grade System

Fig. 3-3

NOTE: Exterior foundation is also possible but must be properly detailed to resist damage.
Gypsum Thin-Slab

NOTE: If fiberglass batts are used for underside insulation loose fibers must be prevented from falling into the space below. Possible details include a faced batt, poly-wrapped batts, or a permanent ceiling below the joists.
Concrete Thin-Slab

Fig. 3-5

- Foil-faced insulation recessed below subflooring
- Tubing fasteners (approved by tubing manufacturer) (must not nick, compress, or chafe tubing)
- Finish flooring
- Tubing fastened to subflooring
- Polyethylene bond breaker (may be specified by tile installer)
- Underside insulation (fiberglass shown)
- Floor joists
- Reflective foil insulation (shown as an option)

NOTE: If fiberglass batts are used for underside insulation loose fibers must be prevented from falling into the space below. Possible details include a faced batt, poly-wrapped batts, or a permanent ceiling below the joists.
Above Floor Plate System

Fig. 3-7
Below Floor Plate System

Fig. 3-8
Engineered Subfloor

Fig. 3-11
Installation of an Engineered Subfloor System

Fig. 3-12
CAD Layout of an Engineered Subfloor System

Fig. 3-13
Modular Board System

Fig. 3-14
CAD Layout of Modular Board System

Fig. 3-15
Characteristics of Radiant Ceilings

- Can operate at higher temperatures than floors
- Not affected by floor coverings and furniture
- Most respond faster than floors
- Will warm the floor as well as objects in the room below
- Take up less vertical space
- Add very little weight
- Induce very little air circulation
Radiant Ceiling Plate System

Fig. 3-16
Ceiling Panels for T-Bar Ceilings

Fig. 3-17
Radiant Plate Wall System

Fig. 3-18
Heat Source Options

• Gas- and Oil-Fired Boilers
  – Condensing and non-condensing
• Hydronic heat pumps (air and ground source)
• Water heaters
• Combination water heaters
• Other sources
  – Solar, solid fuel, thermal storage, etc.
Gas- and Oil-Fired Boiler Options
Heat Pumps

Water to Water

Air to Water
Buffer Tank in Heat Pump System

NOTE: Any piping components containing chilled water must be insulated and vapor sealed to prevent condensation.

Fig. 4-50
Combination System with Heat Exchanger

Fig. 4-51
Ventilation and Cooling Options

- Exhaust fan
- Heat recovery ventilator
- Energy Recovery Ventilator
- DOAS units
- Evaporative coolers
- High-velocity systems
- Conventional air-conditioning
- Radiant cooling
- Hybrid solutions
Variable-Speed Fan
Heat or Energy Recovery Ventilator

Image courtesy Bryant Heating and Cooling Systems
High-Velocity Air-Conditioning System
Managing the consumers expectations

• Warm floor concept versus radiant comfort…
Toasty warm feet concept

Warm every foot in the house.

Every square foot. Every bare foot.
Managing the consumers expectations

• Beware of high efficiency homes and floor temperatures
Managing the consumers expectations

• Where are “warm floors” best utilized?
Bathroom floor warming. A MUST have
Managing the consumers expectations

- Can a radiant floor work better than a radiant wall/ceiling?
**Floor … Ceiling …. Or Wall?**

<table>
<thead>
<tr>
<th>SURFACE</th>
<th>CEILING</th>
<th>FLOOR</th>
<th>WALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact with people</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Response in <strong>less than 30 min.</strong></td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Response in <strong>more than 3 hours</strong></td>
<td>NO</td>
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<td>NO</td>
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<tr>
<td>Furniture limit</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>Heating</td>
<td>GOOD</td>
<td>EXCELLENT</td>
<td>GOOD</td>
</tr>
<tr>
<td>Cooling</td>
<td>EXCELLENT</td>
<td>POOR</td>
<td>GOOD</td>
</tr>
<tr>
<td>Certified performance</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

*Coupled with 5/8” drywall or metal panel*

Image courtesy Ahhm Radiant
Managing the consumers expectations

• What about the production of condensation?
Condensation requires **complete** environmental control
Managing the consumers expectations

• What about fresh air ventilation (open window policy)
OK, maybe not THAT drastic....
Speaking of windows…
Managing the consumers expectations

• Is radiant cooling a proven technology?
Suvarnabhumi International Airport (Bangkok, Thailand),
Hydronic Slab-on-Grade

Fig. 9-8
Hydronic Topping Slab

Fig. 9-9
Thin-Slab on Subfloor

Fig. 9-10
With Plates Below Subfloor

Fig. 9-12
Engineered Subfloor with Metal and Tubing Grooves

Fig. 9-13
Radiant Wall with Plates

Fig. 9-16
Modular Ceiling Radiant Heating and Cooling

Fig. 9-18
Embedded Electric Cable and Mat

Fig. 9-20
Thin Electric with Plastic Film

RADIANT CEILING HEAT

UNDER FLOOR SYSTEMS

Fig. 9-21
Non radiant (convective) hydronic systems
Non radiant (convective) hydronic systems

Image courtesy Modern Hydronic Heating v3.0
Non radiant (natural convective) hydronic systems

Valance Ceiling in heating mode

Valance Ceiling in cooling mode
Non radiant (natural convective) hydronic systems
Non radiant (natural and forced convective) hydronic systems
Non radiant (forced convective) hydronic systems
Handling the DHW needs.
Calculating DHW hourly needs for showering

• Total showers per hour (assume 4 people, 2 adults, 2 children)
Calculating DHW hourly needs for showering

• At 2 GPM flow rate, with 110 degree F draw, and an 8 minute shower duration per person, = 64 GPH at a 100 degree F rise = 53,312 btuH demand.
Calculating DHW hourly needs for showering

- Fire power needed = 53,312 divided by appliance efficiency (assume 92%) = 57,947 btuH input.
Calculating DHW hourly needs for showering

- Storage needed is based on estimated hourly demand, divided by .8 (assume 80% draw before dilution and mixing).
Calculating DHW hourly needs for showering

- 32 gallon base load divided by .8 = 40 gallons of storage required.
Calculating DHW hourly needs for showering

• If large soaking tub is present, take filled volume and divide by .8 to calculated required storage tank volume. i.e. 80 gallon soaking tub divided by .8 = 100 gallon tank. DO NOT compound unless there is zero diversity in loads.
Calculating DHW hourly needs for showering

- Bottom line, at 5 btuH per square foot, DHW heater is capable of carrying a substantial (53,000 divided by 5 = 10,600 square feet) space heating load.
Best way to provide remote hot water. (circ return)

• On demand.
Best way to provide remote hot water. (circ return)

- Push button, wired or wireless
Best way to provide remote hot water. (circ return)

- Motion detector, wired and wireless
Best way to provide remote hot water. (circ return)

- Remote circulator or located in mechanical room
Best way to provide remote hot water. (circ return)

- Dedicated circ return line versus using cold water line to return to source.
DHW circ return diagram

Image courtesy gothotwater.com
DHW Circulation Return Needs

- Code requirements
- Mechanical Methodologies
- Control logics
  - Circulators
  - Control valves
  - Control logics

Image Courtesy of Taco Comfort Solutions
DHW Circulation Return Needs

• Code requirements
• Methodologies
• Control logics
  – Circulators
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Image Courtesy of Taco Comfort Solutions
DHW Circulation Return Needs

• Code requirements
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• Control logics
  – Circulators
  – Control valves
  – Control logics

Image Courtesy of Taco Comfort Solutions
Waste Heat Recovery

• Drain/Waste Heat Recovery System
  – Types
    • Static

Image Courtesy of Swing Green, Inc
Thank You to EEBA for the opportunity to share information!
Got questions ???

Thank you EEBA and EEBA attendees
CONTACT INFORMATION

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