Radiant Cooling & Heating
w/ Capillary Tubing
Chilly at Work? Office Formula Was Devised for Men
What Is The Function Of The HVAC System?
• Offset space heat loss/gain
• Maintain the space within thermal comfort zone
  • Heat generation at rest: 220-280 Btuh

Figure 1: Acceptable range of operative temperature and humidity (for spaces that meet criteria specified in Section 5.2.1).
What Is Mean Radiant Temperature (MRT)?

- The mean radiant temperature depends on one's position in the space. When the person moves nearer the warm window, the body's view angle of the warm window becomes larger, thus a higher MRT. Our body's surface temperature is about 90-92F and radiates heat to cooler surfaces and receives heat from warmer surfaces. For maximum comfort, the body prefers to be surrounded with air and surface temperatures that average 74F. When the air temperature and the MRT are equal, our body loses as much of its excess heat by radiation to surrounding cooler surfaces as it loses to the surrounding air by convection. To maintain the same comfort level when the surface temperatures rises (falls), the surrounding air must be cooler (warmer).
What if We Combine Air Temperature and Mean Radiant Temperature?

—The Operative Temperature

This is calculated by averaging the space's air temperature and its mean radiant temperature. The horizontal axis of the psychrometric chart is operative temperature, so the comfort envelope accounts for three comfort variables: air temperature, mean radiant temperature and relative humidity. The fourth environmental variable, air motion, shifts the envelope laterally. As the air motion increases, the envelope moves to the right, and vice-versa.
Human Comfort Zone:

- 50% radiation
- 30% convection
- 20% evaporation
- Temperature range: 68°F - 78°F
- Relative humidity: 30 - 60%
- Air velocity: 29 - 49 ft/min
- Surface to air temperature difference: 4°F

Human Biology:

- Humans overheat
- Heat in blood is brought to the skin's surface where:
  - If ambient is less than skin temperature
    » Heat converts to electromagnetic energy as infrared radiation, escaping in line of sight at the speed of light, in all directions, until it hits other objects and energy converts itself into temperature again
  - If ambient is greater than skin temperature
    » Heat escapes through perspiration and evaporation
- If no need to cool, or even to conserve heat, micro capillary veins will close partially or totally
Radiant Chilled Ceilings

The Biology of Capillary Radiant Heating and Cooling

• Heat transfer by radiation
  • Among all objects in a line of sight, in all directions, at the speed of light until a mean radiant temperature is accomplished
• The circulating regulated water temperature
  • If ceiling is cooler than skin temperature
    » Heat converts to electro magnetic energy as infrared radiation, escaping in line of sight at the speed of light, in all directions, until it hits the ceiling and energy converts itself into temperature again. The water then returns to the cooling system.
  • If ceiling is warmer than skin temperature
  • If no need to cool, or heat, control valves will close partially or totally
Radiant Cooling Design Considerations:

- Loads must be controlled by:
  - High performance envelope
    - Glass U values and SC values
    - Exterior shading devices
    - Building orientation, shape, and size
  - Efficient lighting and equipment load
  - Use of building mass
- Separate the latent load with DOAS
- Integrated design approach
- Coordination during Construction
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What Is Capillary Radiant Cooling?

- Chilled (61-65F) and hot (104-94F) water travels through capillary tubes imbedded into the ceiling system.
  - Walls and floors can also be integrated into the system if required.
- Heat is radiated to ceiling cooling system during the summer season.
- Heat is radiated from ceiling heating system during the winter season.
- No load – no heat transfer – no energy
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- Energy efficient
  - 1 ft³ of water contains same heat energy as 3,840 ft³ air
  - Water requires less transmission energy
- High indoor air quality
  - Dedicated Outside Air System
- Low Noise levels
  - NC 15?
- Minimal space requirement
  - 5/8” ceiling
  - Minimum ventilation ductwork
- Low Maintenance
What Does A Capillary Radiant Cooling System Consist Of?

- Capillary Tube Mats
- Chiller/Boiler, Geothermal or Solar
- Pumps
- Dedicated Outdoor Air System (DOAS)
- Dewpoint Control
- Temperature Control
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Capillary tube loop
Water connections can be customized

A = from ¾” to 1¼”
B & L = customized sizes

Connections
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Capillary Radiant Cooling & Heating System:
• Radiant floor cooling output of 12 BTU/Sq.ft
• Radiant wall & ceiling cooling output of 24 BTU/Sq.ft
• Radiant wall & ceiling heating output of 39 BTU/Sq.ft
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Radiant Cooling & DOAS Comparison:

• Capillary Radiant System = Quick Response
  • With quick response radiant system, use the air system as “steady state” temperature control (simple DOAS), use radiant system for transients.

• Big Pipe Radiant System (High Mass) = Slow Response
  • Typically used for heating applications only
  • Typical rule of thumb: 1” of slab = 1.5-2 hours response time
  • With slow response radiant system, use the air system for transient “trim” temperature control (more complicated DOAS), use radiant system for steady state.
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Thermographic picture of a capillary radiant ceiling
Capillary Radiant Cooling System:

- Summer Operation
Capillary Radiant Cooling System:

- Winter Operation

![Graph showing temperature variations over time](image)
Fusion welding

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Welding by Fusion

By fusion, becomes 1 piece, no joint.
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Capillary mats ready for installation
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Capillary mats being applied
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Custom fitting
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Plaster ceiling

BEKA cooling ceiling, shown as plaster
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T-bar ceiling and waved frieze with integrated capillary cooling mats in plastered ceiling
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Ceiling prepared for drywall

BEKA cooling ceiling for plaster board construction
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Drywall Ceiling

BEKA cooling ceiling, shown as prefabricated dry-build units.
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Ceiling & Floor Installation
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Floor Installation - Covering and sealing with a thin finishing mud
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Floor Installation – Below wood floor, within flooring set mortar
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Supply line connection from main to grid

BEKA supply lines with quick-action couplings.
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Metal ceiling grid
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29,000 Sq. Meter of Accessible Radiant Ceiling Panels - Vienna Twin Tower

Finished metal ceiling
Radiant Chilled Ceilings

Finished Metal Ceiling
Radiant Chilled Ceilings

Simplex Metal Ceilings
Radiant Chilled Ceilings

Armstrong Metal Ceilings
Radiant Chilled Ceilings

Installations:

- Phyllis Litoff Jazz Building, Oberlin College
- Illinois Institute of Technology, Chicago Ill.
- Durango project, Phoenix Az.
- Edwards Residence, Tempe Az.
- Shumway Project, Globe Az.
- Capella Lofts, New Haven Conn.
- Arizona State University, Carefree Project
  - $360 Cooling Energy Costs for 2005
  - In Excess of 20,000,000 Sq.Ft. in Europe
Thank You