

building comfort quality into your indoor environment.

# Healthy HEATING

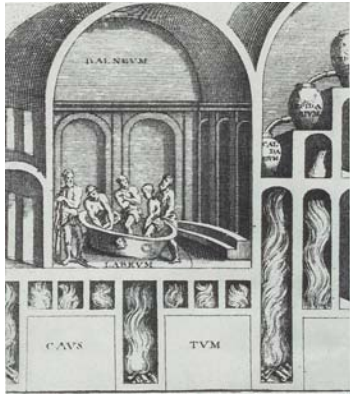
Comforting your mind, body and soul

environmental ergonomics

[info@healthyheating.com](mailto:info@healthyheating.com)

[www.healthyheating.com](http://www.healthyheating.com)

Radiant Fundamentals



Everything You Need to Know About Radiant You Learned Before Kindergarten

Radiant Fundamentals

- Radiant Principles
  - Thermography: Dr. Chapman (c/o Bob "Hot Rod" Rohr)

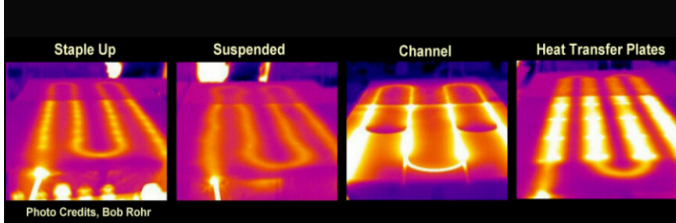



Photo Credits, Bob Rohr

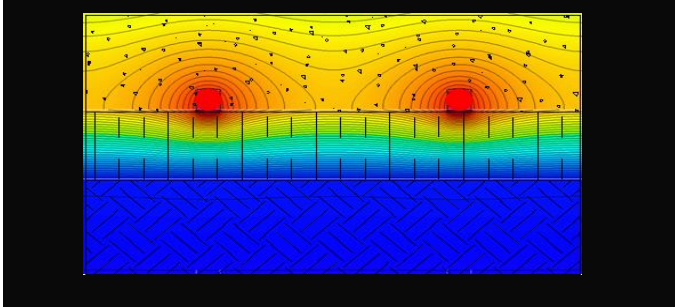
Radiant Fundamentals

- Radiant Principles
  - Schlieren and shadowgraph: Dr. Gary Settles



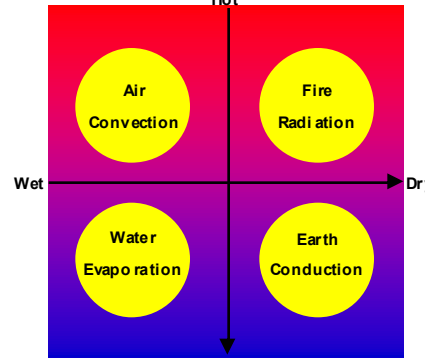
Radiant Fundamentals

- Radiant Principles
  - Software Modeling: Dr. deCarli



Radiant Fundamentals


- Radiant Principles
  - Heat & Moisture



Elementary Dear Watson!


Radiant Fundamentals

- Radiant Principles
  - Thermal Comfort
  - Dr. Fanger
- ANSI/ASHRAE
- Standard 55-1992
- 80% Satisfaction



Radiant Fundamentals

- Radiant Principles
  - Thermal Comfort
  - Five Factors To Consider
    - Activity
    - Clothing
    - "Operative" Temperature
    - Humidity
    - Air Speed



### Radiant Fundamentals

- Radiant Principles
  - Thermal Comfort
  - Operative Temperature
- Combined Air and All Surface Temperatures**

Unheated Surfaces  
Air  
Heated Surfaces

### Radiant Fundamentals

## The Role Radiant System Play In Thermal Comfort

### Radiant Fundamentals

- Radiant Principles
  - The Role Radiant System Play In Thermal Comfort

70°F  
75°F  
75°F - 85°F

### Radiant Fundamentals

- Radiant Principles
  - The Role Radiant System Play In Thermal Comfort

### Radiant Fundamentals

- Radiant Principles
  - The Role Air System Play In Thermal Comfort

### Radiant Fundamentals

- Radiant Principles
  - Demonstration of:
    - ASHRAE Thermal Comfort Program V.1.0, by C. Hui zenga, M.Sc., Berkley University, Dr. Fountain, Environmental Analytics
    - Thermal Comfort Calculator by Dr. Marsh, Welsh School of Architecture at Cardiff University

Thermal Comfort Test Facilities  
Circa 1970, Lingby, Denmark  
Danish Technical University

### Radiant Fundamentals

- Radiant Principles
  - Demonstration of ASHRAE Comfort Software – Example 1

Environmental Conditions	Results
Air Temperature: 70.0 °F	ET*: 65.3 °F (Too Dry)
MRT: 62.5 °F	SET*: 63.6 °F
Air Velocity: 19.7 fpm	TSENS: 0.6
Relative Humidity: 28 %	DISC: 0.6 (Slightly Uncomfortable)
Activity: ASHRAE Standard 55	PMV: -2.50 (Too Cold)
Metabolic Rate: 1.0 met	PPD: 93 %
Clothing: Knee-length skirt, blouse, panty hose, sandal	PD: 14 %
Clothing level: 0.54 clo	PS: 100 %
	TS: 1.1
	Tneutral (Humphreys): 71.5
	Tneutral (Aulicicms): 70.6

### Radiant Fundamentals

- Radiant Principles
  - Demonstration of ASHRAE Comfort Software – Example 2

Environmental Conditions	Results
Air Temperature: 69.2 °F	ET*: 72.4 °F (Too Warm)
MRT: 74.8 °F	SET*: 75.5 °F
Air Velocity: 19.7 fpm	TSENS: 0.1
Relative Humidity: 49 %	DISC: 0.1 (Comfortable)
Activity: ASHRAE Standard 55	PMV: 0.49
Metabolic Rate: 1.0 met	PPD: 10 %
Clothing: ASHRAE Standard 55 Winter	PD: 15 %
Clothing level: 0.90 clo	PS: 71 %
	TS: 1.1
	Tneutral (Humphreys): 71.5
	Tneutral (Aulicicms): 70.2

### Radiant Fundamentals


- Radiant Principles
  - Demonstration of Thermal Comfort Calculator: Dr. Marsh

Environmental Conditions	Results
Air Temperature (°C): 20	ET*: 72.4 °F (Too Warm)
Relative Humidity (RH): 49	SET*: 75.5 °F
Air Velocity (m/s): 0.5	TSENS: 0.1
Activity Level: 1	DISC: 0.1 (Comfortable)
Clothing Level (clo): 0.9	PMV: 0.49
	PPD: 10 %
	PD: 15 %
	PS: 71 %
	TS: 1.1
	Tneutral (Humphreys): 71.5
	Tneutral (Aulicicms): 70.2

Predicted Mean Vote: 0.9 Percentage People Dissatisfied: 22.1%

### Radiant Fundamentals

- Radiant Principles
  - Thermal Comfort – Evaporation, Conduction, Convection, Radiation



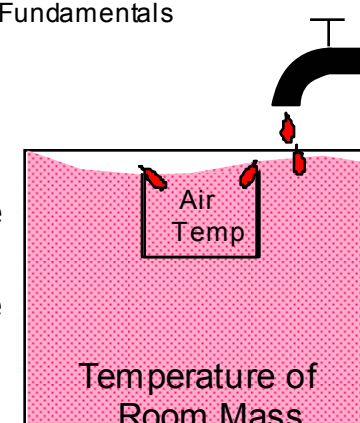
### Radiant Fundamentals

- Radiant Principles
  - Radiant System Performance
  - Discussion
    - What happens from start up to steady state?
    - What happens to thermal comfort performance when the architecture changes?
    - How much heat we can deliver from a floor?

### Radiant Fundamentals

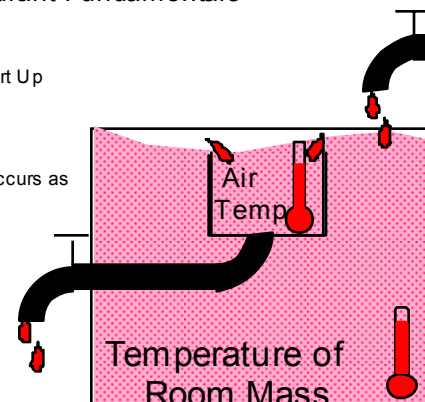
- Radiant Principles
  - Thermal Lag at Start Up

With Radiant Systems... the air is only warm because the surfaces are warm!



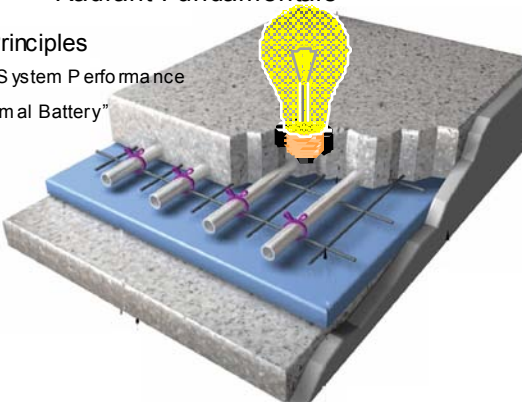
### Radiant Fundamentals

- Radiant Principles
  - Thermal Lag at Start Up
  - Recovery Is Fast!
  - Think "Light"
  - Radiant Transfer occurs as soon as there is a difference in temperatures.



### Radiant Fundamentals

- Radiant Principles
  - Radiant System Performance
    - "Thermal Battery"



### Radiant Fundamentals

- A Note on Slab Insulation

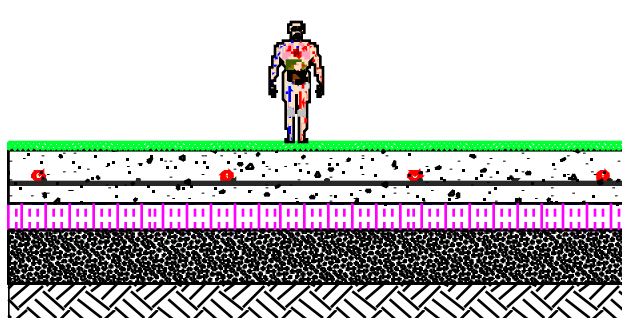
Soil Moisture Content (by mass)	Thermal Conductivity, Btu/h.ft.°F		
	Sand	Silt	Clay
Low, <4%	0.17	0.08	0.08
Medium, 4 to 20%	1.08	0.75	0.58
High, > 20%	1.25	1.25	1.25

Table 3, Soil Thermal Conductivities, 2000 ASHRAE Systems and Equipment, pg 11.9

When it comes to specifying insulation types, the obligations of a certified designer are based on liability exposures. "What is the standard of care expected from a design professional when specifying insulation?"

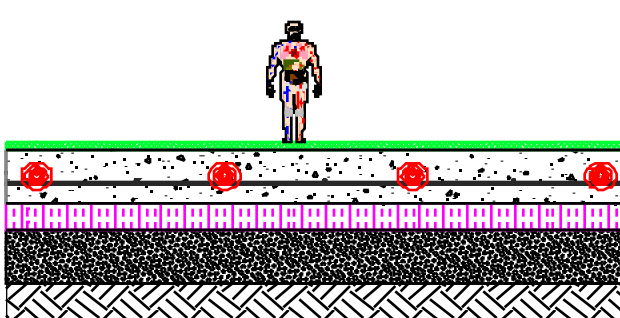
Are you below, at or above the benchmark in your decision?

### Radiant Fundamentals



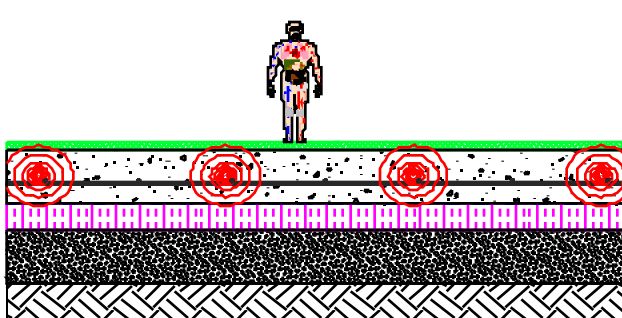
On start up the fluid in the pipes will be at or near the temperature of the concrete.

### Radiant Fundamentals

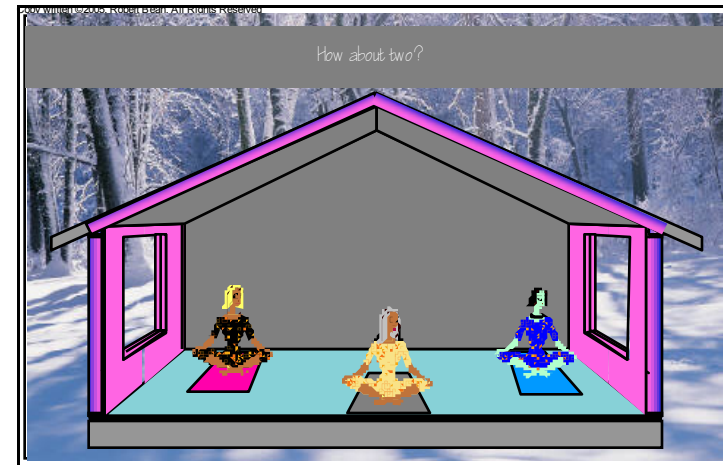
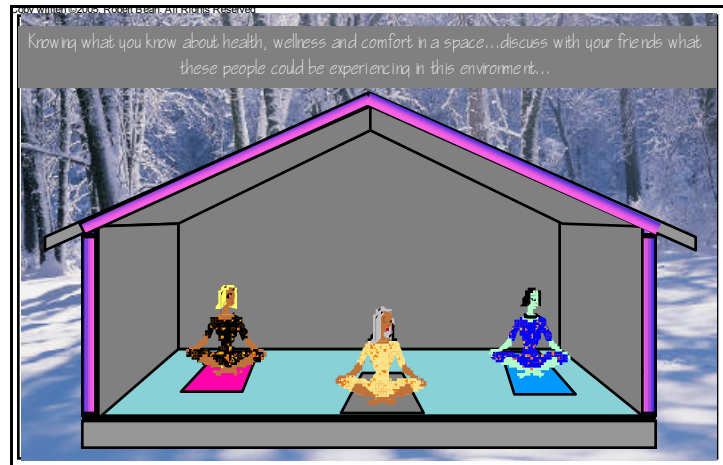
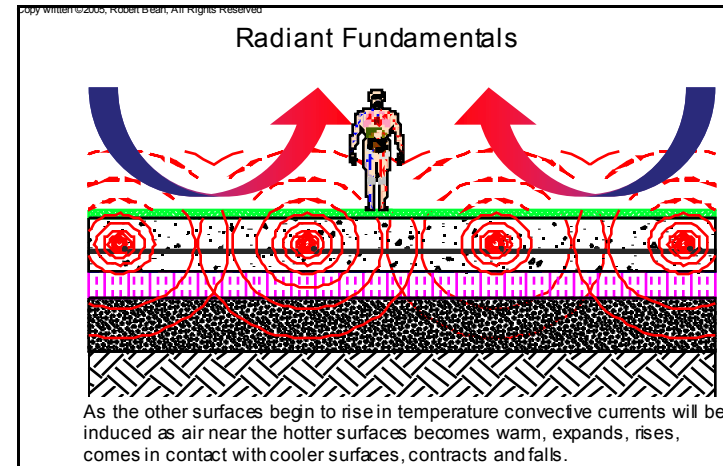
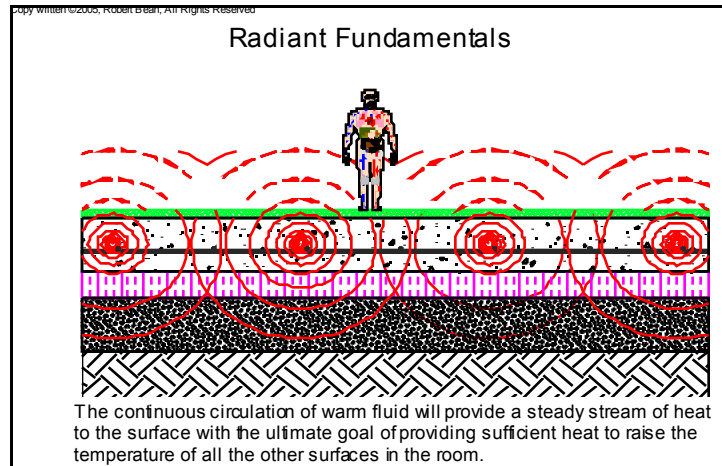
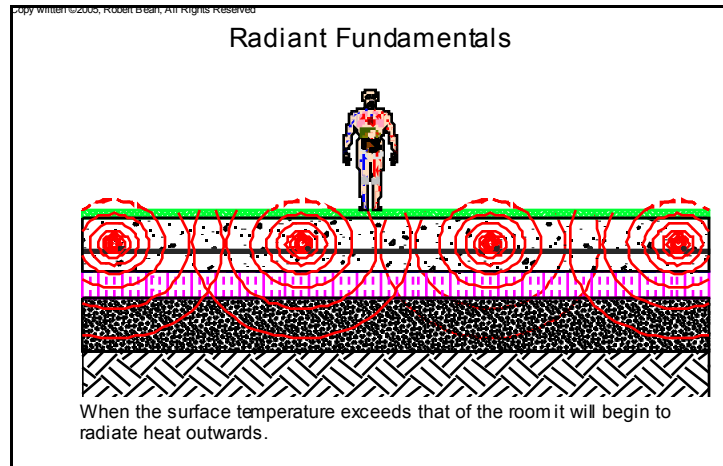


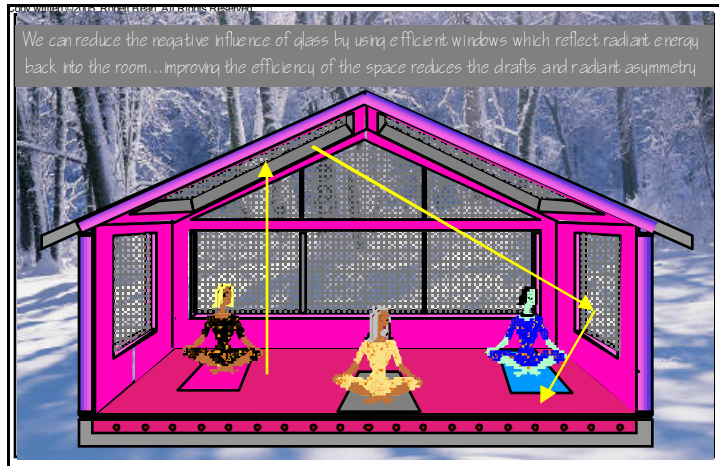
Once warm fluid begins to circulate heat will conduct outwards to the cooler concrete and begin to heat up the entire mass.

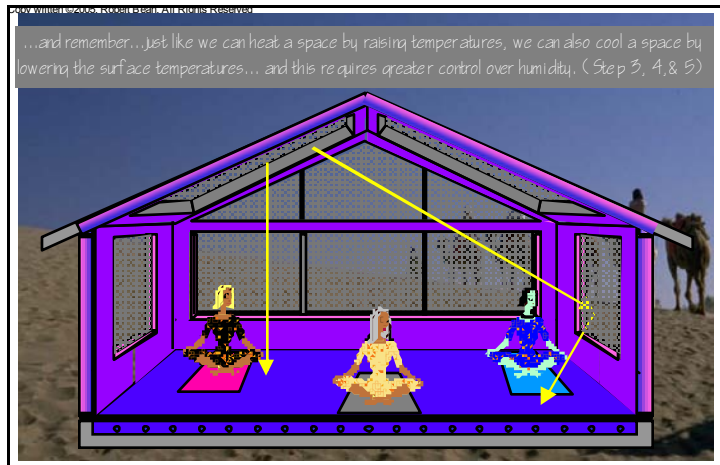
### Radiant Fundamentals



As warm fluid continues to circulate, the floor surface temperature will begin to warm above that of the room.







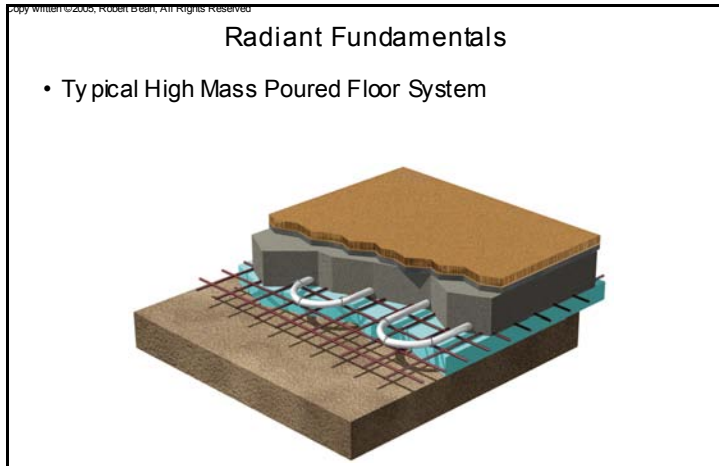
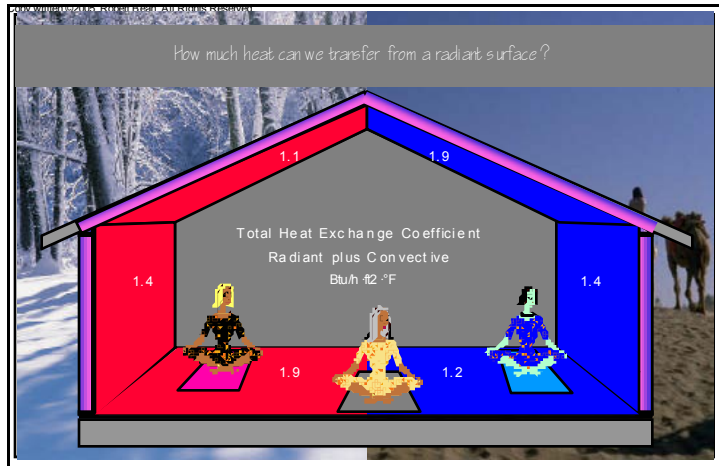
### Radiant Fundamentals

How much heat can we deliver from a radiant surface?

### Radiant Fundamentals

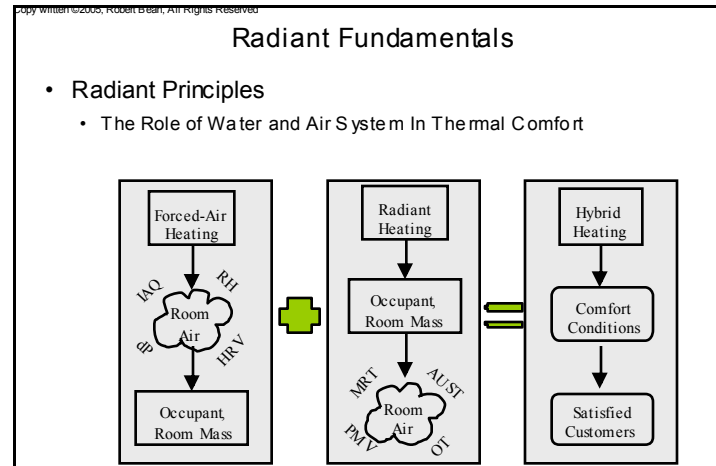
- Radiant Principles
  - Radiant Systems Performance
  - Output Examples - Typical

Mode	Total Heat Exchange Coefficient			
	Heating		Cooling	
Surface	Btu/h · ft <sup>2</sup> · °F	W/m <sup>2</sup> · °K	Btu/h · ft <sup>2</sup> · °F	W/m <sup>2</sup> · °K
Floor	1.9	11	1.2	7
Wall	1.4	8	1.4	8
Ceiling	1.1	6	1.9	11



**Radiant Fundamentals**

- Typical Low Mass Channel Floor System



**building comfort quality into your indoor environment.**

For the entire program [Download](#) your copy of the eBook and Drawing

**environmental ergonomics**

425288228 | 6474664494 Fax: 514, 514727-4288 514727-4288 | info@healthyheating.com | www.healthyheating.com

**building comfort quality into your indoor environment.**

Are you interested in seeing this live!

[info@healthyheating.com](mailto:info@healthyheating.com)

**environmental ergonomics**

425288228 | 6474664494 Fax: 514, 514727-4288 514727-4288 | info@healthyheating.com | www.healthyheating.com

**building comfort quality into your indoor environment.**

[www.healthyheating.com](http://www.healthyheating.com)

**environmental ergonomics**

425288228 | 6474664494 Fax: 514, 514727-4288 514727-4288 | info@healthyheating.com | www.healthyheating.com