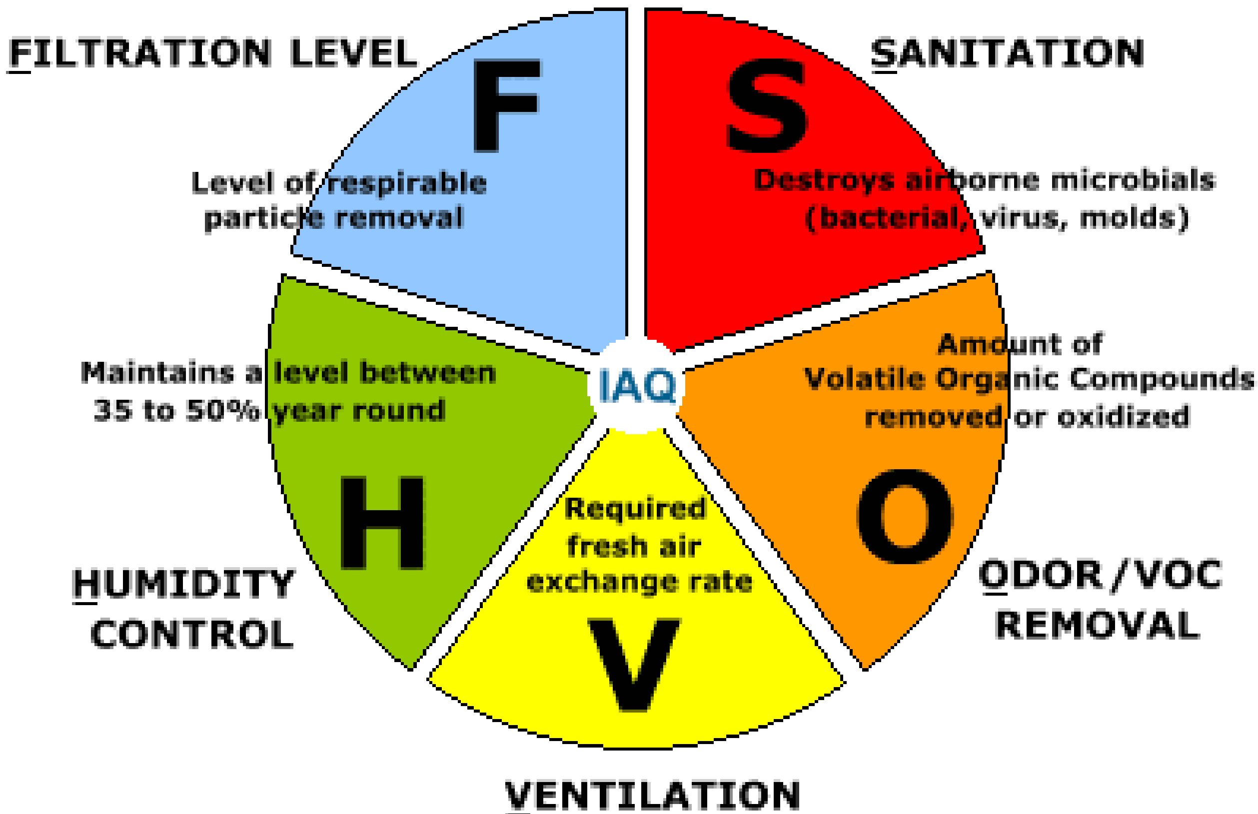

FILTRATION LEVEL
F
Level of respirable particle removal
SANITATION
S
Destroys airborne microbials (bacterial, virus, molds)
IAQ
Maintains a level between 35 to 50% year round
H
HUMIDITY CONTROL
Amount of Volatile Organic Compounds removed or oxidized
O
ODOR / VOC REMOVAL
Required fresh air exchange rate
V
VENTILATION

This Week's Presentation

> Review: Worksheets #3a & 3b;

> **MEEB:** *Comfort and Design Strategies;*
...> Worksheet #4a;

> This Week's Media Material: *From Gray to Green;*

> **MEEB:** *Indoor Air Quality;*
...> Worksheet #4b;

> **C+C:** *Waste Equals Food*

So On With The Show!

Last Week: Environmental Resources (Chapter 2)

Worksheet #3a

... 1. The relationship between global population growth and energy resources is best described as follows:

(a) as population has grown over the past 200 years, use of renewable energy resources has become the norm

(b) as population has grown over the past 200 years, use of renewable resources has given way to use of non-renewable resources

(c) there is no relationship between population and prevalent energy/resource type

Last Week: Environmental Resources (Chapter 2)

Worksheet #3a

... 2. Entropy is best described as:

(a) a tendency for all energy forms to move toward increasing order (quality);

(b) a tendency for all energy forms to move toward increasing disorder (un-usability);

(c) the ability for matter and energy to be interchanged under extreme circumstances;

(d) another term for the energy used to manufacture building materials

Last Week: Environmental Resources (Chapter 2)

Worksheet #3a

... 3. The typical efficiency of generation and delivery of electricity in North America is around:

(a) 95%

(b) 75%

(c) 50%

(d) 35%

Last Week: Environmental Resources (Chapter 2)

Worksheet #3a

… 4. "Embodied" energy is best described as:

(a) the heat output from building occupants

(b) the energy required to produce and deliver a building material

(c) the energy lost through the use of inefficient building systems

(d) the collective energy that has been used by the human race up to this time

Last Week: Environmental Resources (Chapter 2)

Worksheet #3a

… 5. Which of the following best describes the state of the world's water resources:

(a) since water is fully recyclable, there is no likelihood of water shortages;

(b) water consumption is increasing, but global/local resource are more than adequate;

(c) increasing population is placing increasing demands on water supplies;

(d) no one has seriously looked at the state of the world's water resources

Last Week: Environmental Resources (Chapter 2)

Worksheet #3a

... 6. Why is building material reuse noted as being preferable to material recycling:

(a) reuse is much more socially acceptable than recycling;

(b) recycling a material actually results in the loss of all embodied energy;

(c) reuse is much more commonly required by building codes;

(d) reuse retains more of the embodied energy and material resources than recycling.

Last Week: Environmental Resources (Chapter 2)

Worksheet #3a

… 7. An ecological (or environmental) footprint is best described as:

(a) the productive territory required to support a given society (city, county, country);

(b) the impact that a society has on its own environmental quality;

(c) the history of environmental decisions and impacts left by a society;

(d) the area of a specific government entity that is devoted to ecological preservation.

Last Week: Sites and Resources (Chapter 3)

Worksheet #3b

… 1. A "microclimate" is best described as:

(a) the thermal conditions on a localized area of a building material;

(b) climate conditions that briefly occur and then quickly dissipate

(c) climate conditions in a relatively small area, such as directly surrounding a building;

(d) a summary of climate conditions that is based upon only 1-2 years of actual data.

Last Week: Sites and Resources (Chapter 3)

Worksheet #3b

... 2. The "urban heat island" effect would predict which of the following:

(a) temperatures in urban areas are lower than those in surrounding rural areas;
(b) temperatures in urban areas are higher than those in surrounding rural areas;
(c) there is a thermal "moat" or barrier separating most urban and rural areas;
(d) an urban area will act as a heat sink, pulling heat away from rural areas

Last Week: Sites and Resources (Chapter 3)

Worksheet #3b

... 3. Considering “layers” in the site analysis process involves:

(a) evaluating climate conditions below, at, and above the ground surface;

(b) evaluating climate conditions outside, internal to, and within the building envelope;

(c) considering each element of the prevailing climate as connected to all other elements;

(d) using a CAD (computer) system to plot overlays of the site elements

Last Week: Sites and Resources (Chapter 3)

Worksheet #3b

... 4. The “Solar Hemicycle” is:

(a) a useful set of sunpath diagrams;

(b) a solar radiation calculator (or nomograph);

(c) a house designed by Frank Lloyd Wright;

(d) the title of an important book by Ian McHarg.

Last Week: Sites and Resources (Chapter 3)

Worksheet #3b

... 5. Shading by vegetation often proves more effective than shading by overhangs and fins:

(a) because vegetation is renewable and other devices are not;

(b) because vegetation is easily replaced if damaged;

(c) because vegetation looks more sustainable than overhangs and the like;

(d) because vegetation growth better matches seasonal needs for shading.

Last Week: Sites and Resources (Chapter 3)

Worksheet #3b

… 6. The "band of sun" analysis technique involves:

(a) mapping the path of the sun on the Earth's globe for each month;

(b) graphically showing how the sun's position interacts with a building section at noon on the summer and winter solstices and the equinox;

(c) drawing an elevation of a building on a sunpath diagram;

(d) splitting incoming solar radiation into its spectral components.

Last Week: Sites and Resources (Chapter 3)

Worksheet #3b

... 7. "Noise" is:

(a) any sound that is not heard within a building;

(b) any sound that is not wanted;

(c) any sound that exceeds 50 db(A) in loudness;

This week... Comfort, Design, and Indoor Air Quality

Comfort & Design Strategies

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - The Body

Why do we build buildings...? Why do we need ***shelter****?*

One Answer: To pursue our lives in climates *other* than those in which we are suited, so that we might pursue *other* resources.

> The key to Comfort remains our **Metabolism** and its use and control of **Heat**.

Heat Production: Metabolic (MET) Units

1 MET = 50 kcal/h m^2 = 18.4 Btu/hour ft^2

One MET is the energy produced per unit of surface area by a person, seated at rest.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - The Body

> **Metabolism**

"The more active we are, the more heat is produced, and our own (first) skin is the most important regulator of heat flow."

Table 4.1 (p. 84) Illustrates Metabolic Rates for Typical Tasks

Our skin sends signals to the *Hypothalamus* to regulate body heat. The hypothalamus varies the the flow of blood throughout our body.

Our body maintains implicit "Zones" among body elements, so that critical systems are afforded better temperature control than others.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - The Body

> Heat Flow

There are only a few ways by which heat may be transported by our skin: **Convection, Conduction, Radiation, & Evaporation**

Additional heat may be gained or lost by other organs: Evaporation via Lungs; Heat Exchange during Respiration; Heat Expelled during Excretion...

As temperatures rise to match our body temperature, evaporation becomes more significant; as temperatures fall, radiation/conduction/and convection become more significant.

This week... <u>Comfort, Design, and Indoor Air Quality</u>

MEEB: Comfort & Design Strategies - The Body

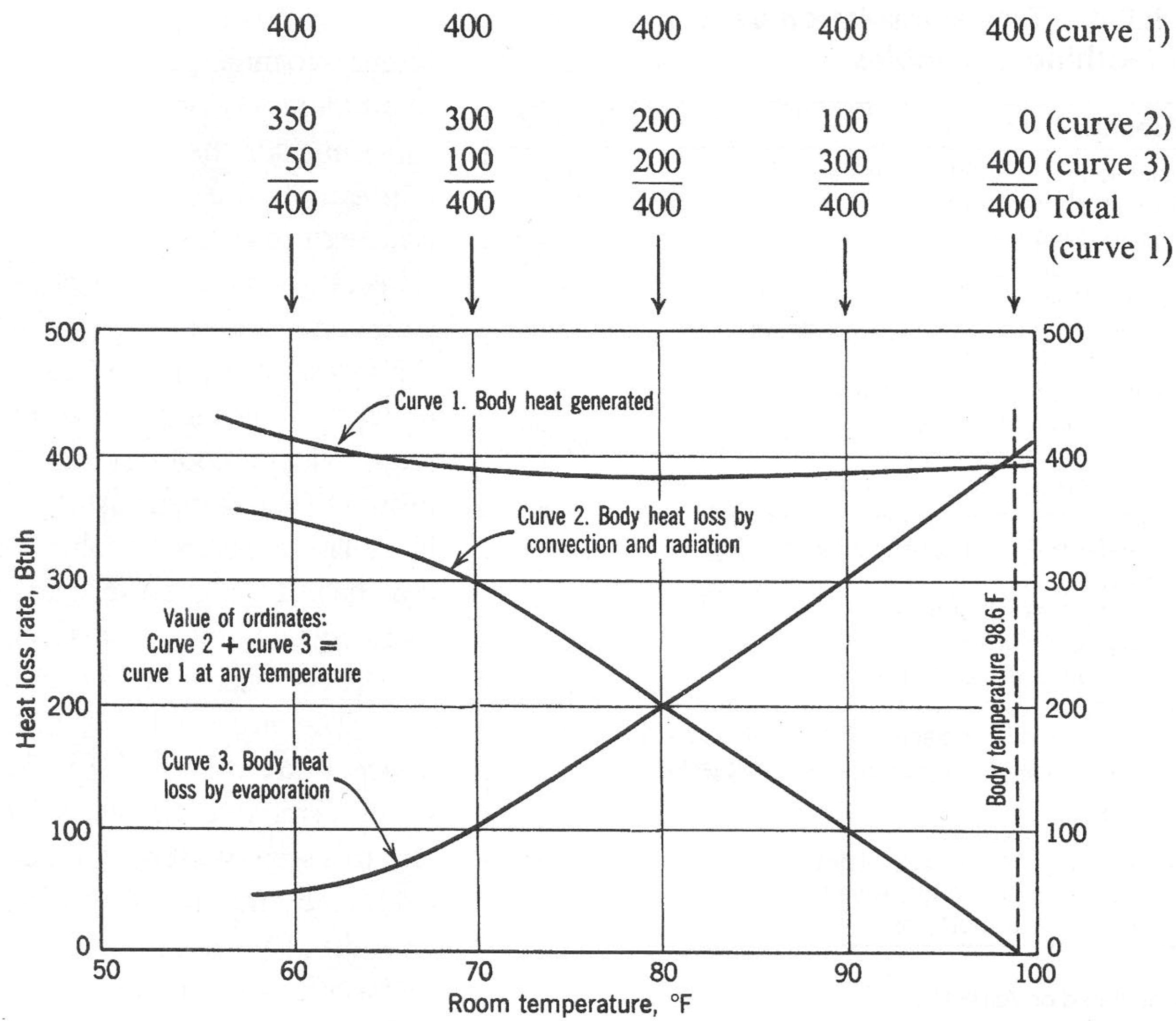


Fig. 4.1 *Heat generated and lost (approximate) by a person at rest (RH fixed at 45%).*

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - The Body

> **Clothing:** Retards Convection, Radiation, & Conduction

(Cold-climate factors)

In hot climates, we depend more on evaporation and *protection* from radiation.

CLO: Insulating value of clothing

1 CLO = American Man's Business Suit, circa 1941.
Average clothes may be estimated at 0.15 CLO/lb.

(My vote for the Worlds Dumbest Thermal Unit!)

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Thermal Comfort

What is Comfort? "A feeling of well-being." Or...?

"That condition of mind which expresses satisfaction with the thermal environment." (ASHRAE 2004)

"Lack of discomfort -- thermally, of being unconscious of how you are losing heat to your environment." (MEEB, p.86)

Three factors affect comfort: Personal, (measurable) Environmental, and (unmeasurable?) Psychological.

Examples of each?

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Thermal Comfort

Our buildings are ultimately (though not exclusively) judged by their success in managing thermal comfort.

Heat loss mechanisms are controlled by the following environmental states:

Conduction	<>	Surface Temperature
Convection	<>	Air Temperature, Air Motion, Humidity
Radiation	<>	Surface Temperature, Body Orientation
Evaporation	<>	Humidity, Air Motion, Air Temperature

Cold Environments:	Conducted, Convective, and Radiative Heat Loss dominate;
Hot Environments:	Evaporative Heat Loss dominates.

ASHRAE Comfort Zone
MEEB: p. 87

"The basic comfort zone can be expanded by changing environmental variables and/or human behavior."

Our comfort is, roughly, shaped by four environmental parameters:

1) air temperature
2) relative humidity
3) radiant temperature
4) air speed

Two personal variables remain:
1) Clothing; 2) Metabolism

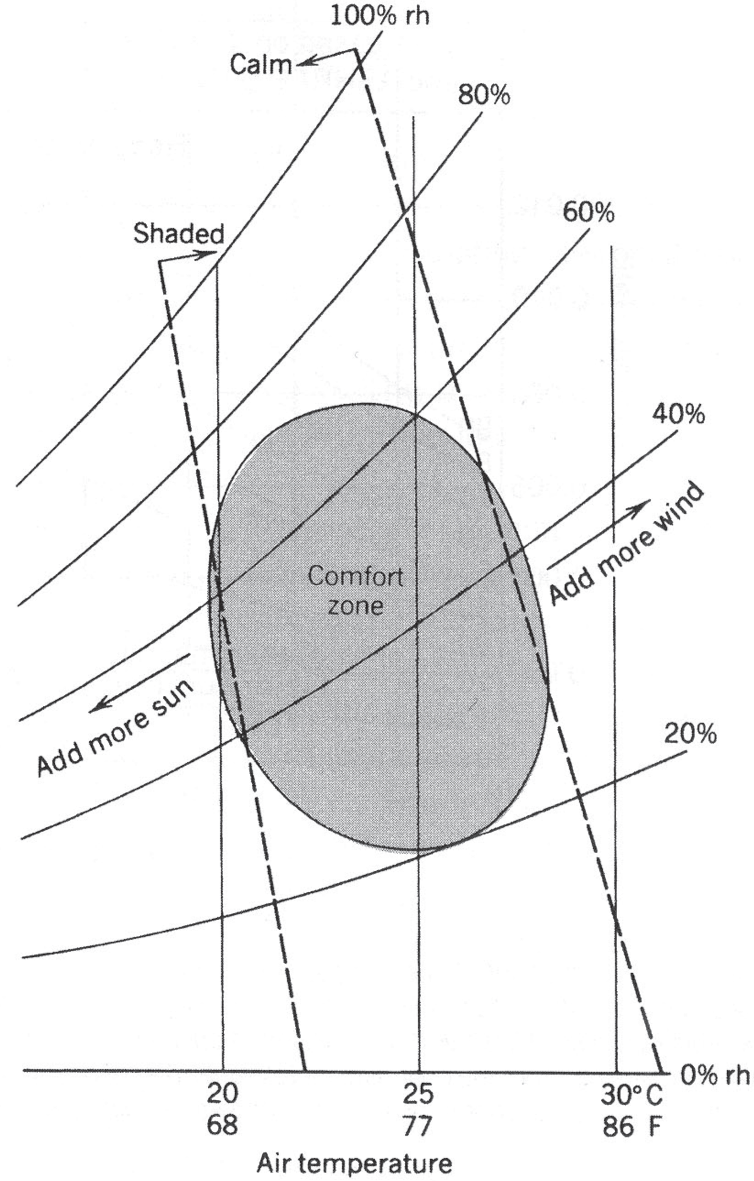


Fig. 4.4 *Comfort zone defined by relative humidity and air temperature.*

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Thermal Comfort

Some Additional Nitty Gritty:

> Dry Bulb Temperature (DB)
> Operative Temperature (OT = Average of DBT and MRT)
> Wet Bulb Temperature (WB)
> Relative Humidity (Actual $H_2$0 Density/Max $H_2$0 Density for a given temperature)
> Mean Radiant Temperature

The uniform temperature of an imaginary surrounding enclosure in which radiant transfer from the human body would equal the radiant heat transfer in the actual non-uniform enclosure.

This week... Comfort, Design, and Indoor Air Quality

Mean Radiant Temperature: http://www.meanradianttemperature.com/

*The **mean radiant temperature** of a space is the single most important criteria in determining thermal comfort of a person within that space (assuming that humidity, air movement and air infiltration are within normal ranges).*

The **mean radiant temperature** of a space is really the measure of the combined effects of temperatures of surfaces within that space. The larger the surface area and the closer one is to it, the more effect the surface temperature of that surface has on the individual. The MRT is the measure of all these surface areas and temperatures acting on a person's location in the room.

As one moves in the room, so does the value of MRT change with the new location. The closer one is to a large warm or cold surface, the more effect that surface has and the greater or smaller the MRT measure is at that point. In theory with a change in MRT, there is a corresponding air temperature that is required to provide comfort. This depends on several other factors but in general for every 1 degree F that the MRT drops, you must raise the air temperature about 1.4 degrees F to achieve comfort conditions. It must be stated that not all humans react to climatic and temperature conditions the same and this is even more evident since not all humans dress alike for warmth.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Thermal Comfort

> How does "acclimatization" affect the feeling of comfort?

Adaptive Model of Comfort: Integrates the effects of acclimatization and personal action upon comfort and, consequently, design for comfort.

> How do standards set upper and lower limits on humidity?

The lower limit seeks to avoid physiological complications and technical problems caused by dry air; the higher limit to avoid the growth of mildew and to lessen skin wettedness.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Thermal Comfort

> Passive Building Comfort Standards

Environmental systems based on "passive" mechanisms need a different set of comfort standards. Why?

Wider range of comfort conditions, more tolerance for summer air motion than, for instance, ASHRAE 1995. Results marked graphically are those "Bioclimactic" charts which we saw last week. These integrate better the interrelation of climate and human comfort factors. (MEEB, pp. 94,95)

Arens, et al, propose HIGHER Activity Levels; LOWER "CLO" levels, to correlate with increased solar radiation levels.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Thermal Comfort

> Passive Building Comfort Standards

Compared to ASHRAE, Arens, et al, propose
HIGHER Activity Levels and LOWER "CLO" levels,
to correlate with increased solar radiation levels.

DB Temperature rather than Operative Temperature is used.
Radiant heat factors accomodate necessary adjustments.

Additional Air Motion Factors:	Outdoors,	600 fpm limit
	Indoors,	300 fpm limit

Limits on Relative Humidity still imposed, for the same reasons.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Thermal Comfort

> Passive Building Comfort Standards

ERF: Effective Radiant Field = A measure of the net radiant heat flux to the body from all surfaces at temperatures other than room temperature.

*Total Solar Radiation (**Insolation**) on a horizontal surface =* I_{TH}

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Thermal Comfort

> Localized Comfort: *How to assure the comfort of specific locations within a complex building?*

Our own body sensations are also highly localized and specialized -- *not that there's anything* ***wrong*** *with that...*

Heat Sensitivity: Fingertips, nose, elbows;
Cold Sensitivity: Upper lip, nose, chin, chest, fingers.

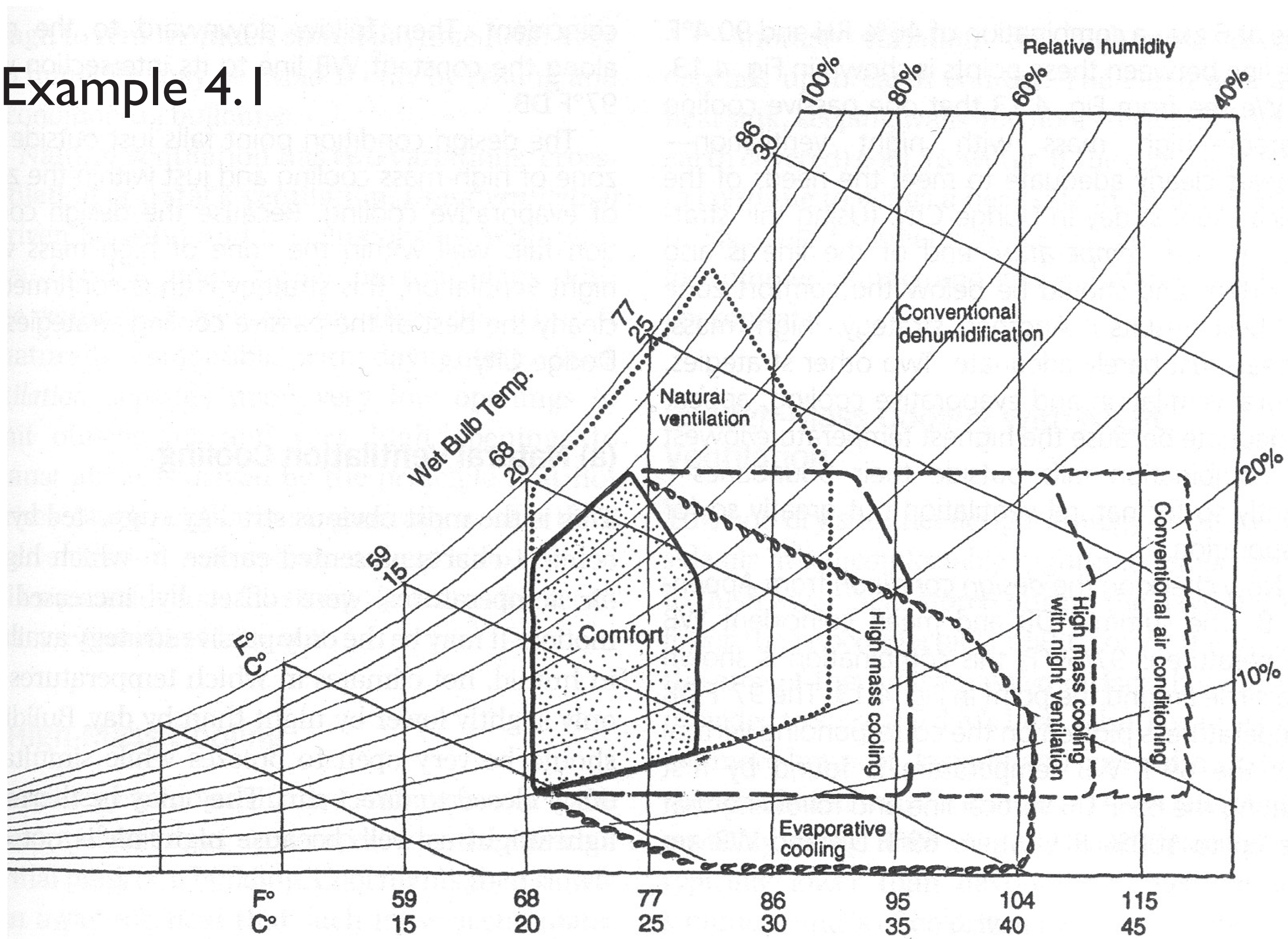
Fingertips: *Sensitive to the rate at which heat is being conducted.*

How might our designs accomodate Localized Comfort?

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Design for Cooling

p99, Example 4.1



This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Strategies for Cooling

> Natural Ventilation Cooling (Cross and Stack Ventilation)
> Examples?

> High-Mass Cooling (Requires a thermal sink)
> Examples?

> High-Mass with Night Ventilation
> (Day: Thermally Closed, Night: Thermally Open)

> Evaporative Cooling: Intensive air and water use.
> (Mechanical versions may affect sound and smell
> of interior environment.)

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Strategies for Heating

> Direct Gain: Typical use of solar energy.

> Indirect Gain: Anti-intuitive, but allows greater control of and protection from solar gain.

> Isolated Gain: An un-integrated, but potentially rich approach.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies - Combining Strategies

> Daylighting

Sidelighting and Toplighting

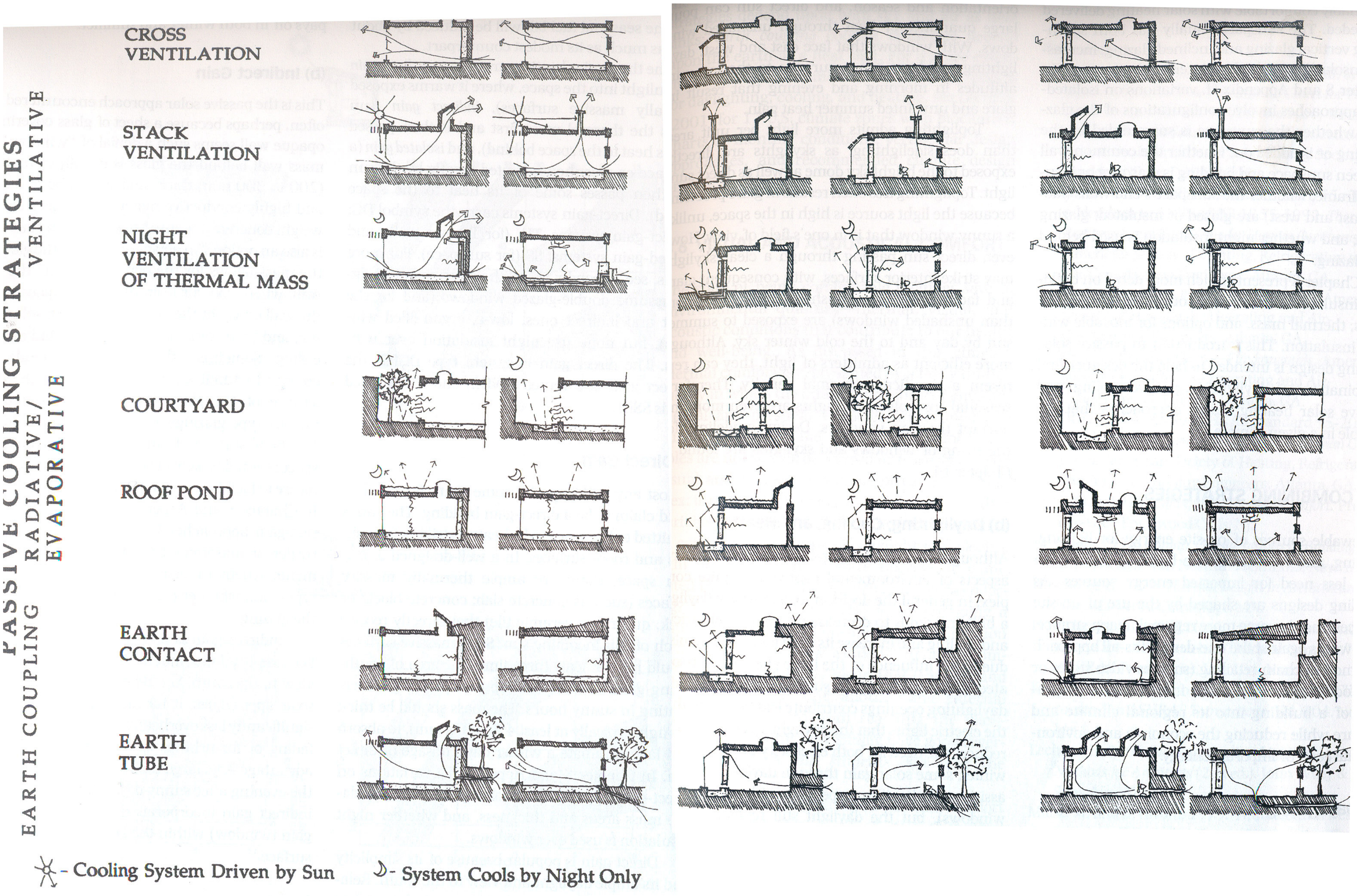
(Relative Advantages?)

> Daylighting, Cooling, and Heating

Ventilative Cooling:	Air as a heat sink.
Evaporative/Radiative Cooling:	Sky and Air as a heat sink
Earth Coupling:	Earth as a heat sink.

MEEB: Comfort & Design Strategies - Strategies for Heating Combinations

Direct Gain | Isolated Gain | Indirect Gain



This week... Comfort, Design, and Indoor Air Quality

MEEB: Comfort & Design Strategies -
Visual & Acoustical Comfort

> Visual Comfort: How Can we Categorize This?

What are examples and counter-examples?

* * *

> Acoustical Comfort: Can this be quantified?

What are some qualitative circumstances and effects?

This week... Comfort, Design, and Indoor Air Quality

Worksheet #4a:
Comfort and Design Strategies
(Chapter 4)

Micro and Macro

PBS Video Series: ***Design E^2***

This week's showing: Green Machine

This week... Comfort, Design, and Indoor Air Quality

MEEB: Indoor Air Quality

"Since the advent of Modern HVAC systems, ventilation has been addressed via heating and cooling system design efforts."

What made this possble...?

This week... Comfort, Design, and Indoor Air Quality

MEEB: Indoor Air Quality - IAQ and Building Design

IAQ has always been an issue. It's impact on our awareness has varied over time. Recent factors have combined to bring its importance to the fore: Increased time spent indoors, energy conservation techniques which limit fresh air, and proliferation of (possibly toxic) artificial materials.

> Litigation over allergies; trend towards non-smoking;

> Sick Building Syndrome

This week... Comfort, Design, and Indoor Air Quality

MEEB: **Indoor Air Quality -** IAQ and Building Design

Thermal Comfort and IAQ are NOT synonymous.

ASHRAE 2004: Acceptable IAQ is “air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people do not express dissatisfaction.”

Our role in providing acceptable IAQ involves:

- Limiting pollution at the source;
- Isolating unavoidable sources of pollution;
- Providing for an adequate supply and filtering of fresh air;
- Building and Equipment Maintenance.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Indoor Air Quality - Pollutant Sources and Impacts

What kind of IAQ problems might we have? (Table 5.1,p.114)

> Odors (... or CO_2 concentration.)

> Irritants (... cause *increasing* distress over time.)
-- VOCs (Volatile Organic Compounds)

> Toxic Particulate Substances (...*e.g.* asbestos)

> Biological Contaminants (Ick!)

> Radon and Soil Gases (... colorless, odorless,...)

This week... Comfort, Design, and Indoor Air Quality

MEEB: **Indoor Air Quality -** Predicting Indoor Air Quality

How best to remedy problems with IAQ and SBS?

1) Increase Ventilation Rate
   -- Units to Quantify IAQ:
   olf (1 *olf* = bioeffluent of an average person... ?) <> G
   decipol (perceived air quality) <> C_x

$$\text{Ventilation Rate } Q = 10 \frac{G}{C_i - C_o}$$

2) Testing to monitor and correct new or recurrent problems.

This week... Comfort, Design, and Indoor Air Quality

MEEB: **Indoor Air Quality -** Zoning for IAQ (Table 5.6, p. 120)

> Remove potential polutants from proximity with persons or other sensitive environments.
>
> -- Spatial segregation: *Sterile / Non-sterile*
>
> -- Mechanical Separation: *Differential Pressures*

> Task ventilate specific areas in which the above is not possible.

> Locate air intakes away from potential pollutants.
>
> -- Prevailing winds / Proximity with Exhaust

> Type of mechanical layout: Local versus Central Equipment.

This week... Comfort, Design, and Indoor Air Quality

MEEB: Indoor Air Quality - Passive and Low-Energy Approaches to Ventilation

> Windows

> Stack Effect

> Underslab Ventilation (Look out for Radon!)

> Preheating Ventilation Air (What about for Cooling?)

This week... Comfort, Design, and Indoor Air Quality

MEEB: Indoor Air Quality - Equipment for IAQ Control

> Exhaust Fans
-- Local (50 cfm, Toilets; 100 cfm, Kitchens; etc.)
-- Comprehensive (Principal Exhaust Fan: 50% capacity; Total 0.3 ACH -- Air Changes per Hour)

> Heating / Cooling of Makeup Air

> Heat Exchangers (extracts heat from Exhaust Air)
-- What are some considerations in their use?

> Desiccant Cooling
> Task Dehumidification and Humidification
> Filters (Particulate, Adsorption, Air Washers, Electronic Cleaners)

This week... Comfort, Design, and Indoor Air Quality

MEEB: Indoor Air Quality - Equipment for IAQ Control

> Locating Air-Cleaning Equipment
>
> -- Upstream filters or Downstream filters

> Ultraviolet Radiation (UV) ZAP!

> Individual Space Air Cleaning

> Controls for IAQ

This week... Comfort, Design, and Indoor Air Quality

MEEB: **Indoor Air Quality -** IAQ, Materials, and Health

> Multiple Chemical Sensitivity

> Materials and IAQ

> Green Design and IAQ

This week... Comfort, Design, and Indoor Air Quality

Worksheet #4b:
Indoor Air Quality
(Chapter 5)