**Climate**

Overview

1) Heat exchange process
2) Measuring conditions
3) Comfort
4) Heat stress
5) Cold stress

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**Five Components of Thermal Environment**

Air Temperature
- dry bulb temperature
Relative Humidity
- hydrometer
Wet Bulb Temperature
- psychrometer
Mean Radiant Temperature
- temperature in black copper sphere
Air Velocity
- anemometer

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1) Heat Exchange Process

A) Avenues of heat exchange
   - 82 - 86 degrees
   - hypothalamus
Conduction
Convection
Radiation
Evaporation

1) Heat Exchange Process

B) Heat exchange equation:

\[ \Delta s = (M - W) + R + C - E \]

where,
- \( \Delta s \) = change in heat stored,
- \( M \) = metabolism,
- \( W \) = work,
- \( R \) = radiant exchange,
- \( C \) = convective exchange,
- \( E \) = evaporative loss.

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1) Heat Exchange Process

C) Environmental factors
   complex interaction between:
   - Air temperature
   - Humidity
   - Air flow
   - Temperature of surrounding surfaces

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1) Heat Exchange Process

D) Clothing effect

Insulating effect, reducing heat loss to environment
Materials have an insulation value (the CLO unit)

over all CLO units =

\[ 0.8 \cdot E \text{ (individual items) } + 0.8 \cdot 16 \text{ degrees F} \]
- permeability of material to moisture
2) Measuring Thermal Conditions

Effective Temperature
(Figure 17-2)

Operative Temperature
- effects of radiation and
convection only

Oxford Index
(Wet-Dry index (WD))
- simple weighting of wet and
dry bulbs

\[ \text{WD} = 0.85 \text{WB} + 0.15 \text{DB} \]

Wet-Bulb Globe Temperature
- simple weighting of the natural
wet bulb, globe temperature
and dry bulb
- insensitive to high humidity and
low air velocity

Botsball
- special thermometer highly
correlated with WBGT
- as temperature, humidity,
wind speed, radiation

Composite Indices

3) Thermal Comfort

Draught Effect
most annoying factor in workplace
cooling by air movement
undesirable
most sensitive in the head / neck
area

Low Humidity Effect
drys skin, nose, throat, eyes, and
lips
eye irritation below 30% RH

4) Heat Stress

A) Physiological Effects
Q10 Effect -- 10% for 1 degree
Cardiovascular response
skin blood flow 5% to 20%
heart rate can increase 75%
Sweating
hypodration -- leads to core
temperature rise

B) Individual Differences
Physical fitness increases tolerance
oxygen to muscles
Age decreases tolerance
less effective sweat glands
less body weight
Gender - females more severe
effects
Body fat increases effect
Alcohol reduces tolerance

Heat Stress
Heat Illness
- heat rash, prickly heat
- heat cramps
- excessive loss of salt
- heat exhaustion
- muscular weakness, nausea,
vomiting, dizziness, fainting
- principally from dehydration
- heat stroke - acute
- failure of temperature
regulatory system

Page 2
4) Heat Stress

C) Acclimatization to Heat Stress (figure 17-7)
- repeated exposure results in adapted response to heat stress
- mostly occurs within 7 days, complete adaptation by 12 - 14 days
- increase sweating efficiency
- reduced heart rate
- lower core and skin temperatures

D) Indices of Heat Stress
- Heat stress index
  - comprehensive (ratio of metabolism, convection, and radiation to evaporation)
  - difficult to obtain and not in common use
- Heat index (page 569; figure 17-8)
  - U.S. National Weather Service
  - Shows the effects of temperature and humidity

E) Effect of Heat Stress on Performance
- Simple cognitive & perceptual - motor response
  - minimal effect
- Complex cognitive & perceptual - motor response (figure 17-11)
  - immediate
- Safety behavior
  - minimum at 63-73 degrees F

F) Recommended Heat Exposure Limits
- NIOSH recommended heat stress levels
  - based on metabolic heat, acclimatization, and work-rest cycle
  - Figure 17-12

G) Reducing Heat Stress
- environment
  - air conditioners
  - fans
  - dehumidifiers
- task
  - reduce energy expenditures
  - frequent breaks
  - provide cool water
- worker
  - training
  - acclimatization
  - physical fitness
  - protective equipment
  - figure 17-13

5) Cold Stress

A) Physiological Effects
- Vasoconstriction
- Shivering
  - increase metabolic rate 2-4 times
- Severe cold stress
  - frostbite - ice crystals in skin
  - hypothermia - body temperature below 95 degrees F
5) Cold Stress

B) Acclimatization to Cold Stress

very minimal
knowledge, experience, and physical fitness more important

C) Wind Chill Index (WCI)

WCI usually converted to equivalent wind chill temperature

5) Cold Stress

D) Effect of Cold Stress on Performance

Physical work
- decreased strength and endurance

Tactile sensitivity is decreased

Manual performance
(figure 17-14)
- related to tactile sensitivity
- unimpaired performance above 55 - 65 F hand-skin temperature

5) Cold Stress

Cold Stress

Tracking performance
- unimpaired performance above 39 - 65 F ambient temperature

Reaction time
- no clear effect on simple reaction time
- increases errors in choice reaction test and decreases time for those errors

Mental activities
- no clear effect

5) Cold Stress

E) Protection from Cold Stress

Proper clothing
Use of gloves
Use of auxiliary heaters
Rewarming rooms