Introduction:

Occupational Heat Stress
Occupational Heat Stress
Learning Objectives

- Reduce risk of heat disorders and stroke.
- Reduce accidents and injuries.
- Reduce risk of human error.
- Maintain performance.
- Reduce cost of absenteeism.
Course Outline

- Heat Stress Defined
- Contributors to Heat Stress
- The Body’s Response
- Monitoring for Heat Stress
- Heat Stress Controls
- The Management of Heat Stress
Where the Heat Comes From

- Metabolic Heat from Converting Food to Energy and Using It to Do Work
- Heat may be Added by the Environment
- Heat may Be Taken Away by the Environment
- Clothing Can Trap the Heat
Loss of Thermoregulation Balance

Heat In

Heat Out
Heat Stress: Definition

Net Heat Load on the Body from the Combined Contributions of Metabolic Heat Production and External Environmental Factors.
Heat Strain: Definition

The Net Physiological Load Resulting from Heat Stress (the body’s response)
Environmental Factors

- Temperature
- Evaporative Potential
- Air Movement
- Radiant Heat
Our Body

Hypothalamus - the Body’s Temperature Control Center

Our body eliminates excess heat through
- Perspiration
- Blood Flow
Internal Factors

- Fluid Balance
  - Is there sufficient hydration?

- Metabolism (work load)
  - How much heat is generated?

- Perspiration
  - Ability to remove the heat
Complicating Factors

- Age, weight
- Diet
- Alcohol / Drugs
- Health
  - Medication
- Acclimatization / conditioning
Assessments Likely to Fail

- **Thirst**
  - lagging indication – possibly already dehydrated

- **Self Appraisal**
  - self awareness is important but under heat strain, judgment is impaired
Self Regulation

Conditions can often work against self regulation and safety

- Pay Incentives
  - High work rate to make more money
- Macho Phenomenon
  - I can handle it
- Emergencies
  - High psychological and physical stress
Heat Stress Symptoms

- Sweat Cessation
  - Skin may be hot and dry
- Skin Color Change
  - Rash
- Shivering
- Irritability
- Disorientation
Heat Stress Consequences

- Fatigue, Tired Feeling
- Reduced Productivity
- Increased Errors, Accidents
- Risk of Heat Related Disorders
When Responses Fail, Reactions Occur

- Rash
- Cramping
- Exhaustion
- Syncope (fainting)
- Stroke
- Death
Signs of Exhaustion and Dehydration

- Thirst
- Weakness
- Headache / Dizziness
- Loss of Coordination

Proper Response
- Cool Down / Rest
- Hydrate (drink)
- Seek Medical Attention
Syncope

Pooling of blood in extremities resulting in blurred vision, dizziness, and fainting

Proper Response

- Lay down
- Hydrate
- Seek Medical Attention
Stroke

Medical Emergency

- Hot Skin, Elevated Body Temperature, Fast Pulse
- Possible Convulsions, Delirium, Unconsciousness

Proper Response

- Immediate Cooling
- Emergency Medical Care (911)
First Aid

- Awareness training
- Look for signs in coworkers
- Drink Fluids
- Lie down, remove heavy gear and clothing
- Provide emergency cooling methods
- Emergency transportation or call 911
Industrial Hygiene Model

- Identify
- Monitor
- Control
  - Eliminate
  - Minimize
- Protect
  - Work / Rest
  - PPE
  - Training
Two Areas for Assessment

- **Environmental**
  - Evaluate the Ambient Environment and Its Affects on the Person

- **Individual**
  - Evaluate the Heat Being Generated Within the Person and/or other Physiological Affects
Possible Approaches

Environmental

The most commonly used measurements:

- Heat Index
- WBGT

Individual

- Core Temperature
- Heart Rate
- Sweat Rate
- Urine Sodium Level
- Oxygen Consumption
Key Body Temperatures

The World Health Organization recommends workers should maintain their body temperature below 38°C or 38.5°C when closely monitored.

- 37°C  98.6°F  Normal
- 38°C  100.4°F  Long Exposure
- 38.5°C  101.3°F
- 39°C  102.2°F  Short Exposure
- 41°C  105.8°F  Life Threatening
Heat Index

- Combination of Temperature & Humidity
- Gives “Feel Like” Temperature
- Used Primarily in the USA
- Assumes shade, radiant heat (Sun) is not accounted for
- Screening Tool: Not in Regulations
Wet Bulb Globe Temperature

- **Dry Bulb:** Shielded Thermometer
  - Air Temperature
- **Wet Bulb:** Wet Wick over Thermometer
  - Temperature, Humidity, and Airflow
- **Globe:** Black Copper Globe over Thermometer
  - Radiant Heat (sunlight)

WBGT Index provides work/rest guidelines intended to keep worker’s body temperature below 38°C
WBGT Index

Used to determine hourly work/recovery periods

- Measure WBGT
- Classify Type of Work Load
  - Resting, Light, Moderate, Heavy, Very Heavy
- Apply Correction Factors for Clothing if needed
- Determine work/recovery ratio
## Classification of Activities

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting</td>
<td>Sitting Quietly, Some Arm Movement</td>
</tr>
<tr>
<td>Light</td>
<td>Sitting, Standing, Some Arm/leg Movement, Small Hand Tool Use</td>
</tr>
<tr>
<td>Moderate</td>
<td>Walking, Carry Moderate Loads, Active Arm Work</td>
</tr>
<tr>
<td>Heavy</td>
<td>Some Heavy Lifting, Active Movement</td>
</tr>
<tr>
<td>Very Heavy</td>
<td>Lifting or Moving Heavy Objects with little or no break between movements</td>
</tr>
</tbody>
</table>
### WBGT Correction Factors for Clothing (in °C)

<table>
<thead>
<tr>
<th>Clothing Type</th>
<th>WBGT Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work clothes (long sleeve shirt and pants)</td>
<td>0°</td>
</tr>
<tr>
<td>Cloth (woven Material) Coveralls</td>
<td>0°</td>
</tr>
<tr>
<td>Double-layer woven clothing</td>
<td>+3°</td>
</tr>
<tr>
<td>SMS polypropylene coveralls</td>
<td>+0.5°</td>
</tr>
<tr>
<td>Polyolefin coveralls</td>
<td>+1°</td>
</tr>
<tr>
<td>Limited-use vapor-barrier coveralls</td>
<td>+11°</td>
</tr>
</tbody>
</table>
## Screening Criteria

### Heat Stress Exposure

**Threshold Limit Values (Action Limit)**

<table>
<thead>
<tr>
<th>Work Load</th>
<th>Light</th>
<th>Moderate</th>
<th>Heavy</th>
<th>Very Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work vs. Recovery (per Hour)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75% to 100%</td>
<td>31.0 (28.0)</td>
<td>28.0 (25.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% to 75%</td>
<td>31.0 (28.5)</td>
<td>29.0 (26.0)</td>
<td>27.5 (24.0)</td>
<td></td>
</tr>
<tr>
<td>25% to 50%</td>
<td>32.0 (29.5)</td>
<td>30.0 (27.0)</td>
<td>29.0 (25.5)</td>
<td>28.0 (24.5)</td>
</tr>
<tr>
<td>0% to 25%</td>
<td>32.5 (30.0)</td>
<td>31.5 (29.0)</td>
<td>30.5 (28.0)</td>
<td>30.0 (27.0)</td>
</tr>
</tbody>
</table>
# U.S. Army Flag System

<table>
<thead>
<tr>
<th>HEAT CATEGORY</th>
<th>WBGT INDEX, °F</th>
<th>EASY WORK</th>
<th>MODERATE WORK</th>
<th>HARD WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>WORK /REST</td>
<td>WATER INTAKE, QT/HR</td>
<td>WORK /REST</td>
</tr>
<tr>
<td>1</td>
<td>78-81.9</td>
<td>NL</td>
<td>1/2</td>
<td>NL</td>
</tr>
<tr>
<td>2 (Green)</td>
<td>82-84.9</td>
<td>NL</td>
<td>1/2</td>
<td>50/10 min.</td>
</tr>
<tr>
<td>3 (Yellow)</td>
<td>85-87.9</td>
<td>NL</td>
<td>3/4</td>
<td>40/20 min.</td>
</tr>
<tr>
<td>4 (Red)</td>
<td>88-89.9</td>
<td>NL</td>
<td>3/4</td>
<td>30/30 min.</td>
</tr>
<tr>
<td>5 (Black)</td>
<td>&gt; 90</td>
<td>50/10 min.</td>
<td>1</td>
<td>20/40 min.</td>
</tr>
</tbody>
</table>
WBGT Guidelines

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Low Risk</th>
<th>Moderate Risk</th>
<th>High Risk</th>
<th>Extreme Risk</th>
<th>Dangerous!</th>
</tr>
</thead>
<tbody>
<tr>
<td>65°F</td>
<td>No Limits, But Watch For Heat Problems</td>
<td>Rest periods every 15 min.</td>
<td>Stop unacclimatized/ high risk, limit others</td>
<td>Cancel All Athletic Activities</td>
<td></td>
</tr>
<tr>
<td>70°F</td>
<td>Low Risk</td>
<td>Moderate Risk</td>
<td>High Risk</td>
<td>Extreme Risk</td>
<td>Dangerous!</td>
</tr>
<tr>
<td>75°F</td>
<td>Low Risk</td>
<td>Moderate Risk</td>
<td>High Risk</td>
<td>Extreme Risk</td>
<td>Dangerous!</td>
</tr>
<tr>
<td>80°F</td>
<td>Low Risk</td>
<td>Moderate Risk</td>
<td>High Risk</td>
<td>Extreme Risk</td>
<td>Dangerous!</td>
</tr>
<tr>
<td>85°F</td>
<td>Low Risk</td>
<td>Moderate Risk</td>
<td>High Risk</td>
<td>Extreme Risk</td>
<td>Dangerous!</td>
</tr>
<tr>
<td>90°F</td>
<td>Low Risk</td>
<td>Moderate Risk</td>
<td>High Risk</td>
<td>Extreme Risk</td>
<td>Dangerous!</td>
</tr>
<tr>
<td>95°F</td>
<td>Low Risk</td>
<td>Moderate Risk</td>
<td>High Risk</td>
<td>Extreme Risk</td>
<td>Dangerous!</td>
</tr>
</tbody>
</table>

Green Flag | Yellow Flag | Red Flag | Black Flag

Cancel 10000 m | Cancel 5000 m | Cancel 3000 m | Cancel 1500 m

Cancel 10000 m | Cancel 5000 m | Cancel 3000 m | Cancel 1500 m

3M Occupational Health & Environmental Safety Division

American College of Sports Medicine

American Academy of Pediatrics

US Marine Corps

NCAA (Safety) 1974-1993

NCAA (Performance) 1974-1993
Calculating Average from Multiple Exposures

\[ \frac{\text{WBGT}_1 \times t_1 + \text{WBGT}_2 \times t_2 + \ldots + \text{WBGT}_n \times t_n}{t_1 + t_2 + \ldots + t_n} \]
Heat Stress Program

- Work evaluation – where are workers exposed to potential heat stress
- Medical Screening
- Training
- Monitoring – WBGT or Individual
- Controls
  - Work/Rest
  - Fluids
  - Air flow – add fans if dry bulb is below 38°C
  - Personal Protective Equipment (PPE)
Medical Screening

- Pre-existing conditions
- Overweight
- Unacclimatized
- Conditioned
- Alcohol, Drugs
Training

- Management and Workers
  - Heat Stress & Heat Strain
  - Heat Disorders
  - Self and Coworker Awareness
  - Safe Practices
  - First Aid
Exposure Controls

- Rest/Work Scheduling
- Re-hydration
- Cooling Vests
- Ventilation
- Humidity Reduction
- Change Process or Procedure
- Clothing
Hydration

- Drink before, during and after physical labor
- Anticipate conditions: weather, gear, dress, workload
- Drink every 15-20 minutes
- Make fluids accessible
- Drink cool fluids
- Flavored drinks may increase use
- Replace Electrolytes in extreme conditions
Sources of Information

- ACGIH
- OSHA
- NIOSH
- ISO
- World Health Organization
- National Athletic Trainer’s Association
- National Weather Service
- Experienced Employers