Working in Extreme Temperatures

Rodney Lofland, CSP
Hamilton County Risk Management
Session Objectives

You will be able to:

• Understand how hot conditions affect your body
• Recognize symptoms of heat illness
• Why the body’s cooling mechanisms fail
• Take precautions to reduce the risk of heat illness
Heat is the leading cause of weather-related deaths in the US
OSHA’s heat fatality map, 2008-2014

https://www.osha.gov/SLTC/heatillness/map.html
They were overwhelmingly male... 

Male 97%

Female 3%

(Jackson & Rosenberg, 2010)
Younger than you might expect…

Age in years

- <55
- 55+

(Jackson & Rosenberg, 2010)
Although no specific OSHA Standard...

Section 5(a)(1) of the OSH Act states: “Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."
The Body’s Response to Heat

The body tries to maintain a core temperature of 37°C or 98.6°F.

Homeostasis – the body trying to maintain internal stability

To rid excess heat:

- Increasing blood flow to skin surface
- Releasing sweat onto skin surface

http://www.behance.net/gallery/Active-Microclimate-Cooling-System/4833917
Body’s Cooling System

- Blood circulates closer to the skin so heat is lost
- Body sends sweat to the skin’s surface
- Sweat evaporates off the skin, cooling the body
- High heat prevents heat transfer out of the bloodstream
- High humidity prevents sweat from evaporating.
Heat Stress → Dehydration

During heavy work, a body can lose 1-2 liters of water per hour.

- Thirst is not stimulated until the body is already 1-2% dehydrated.
- Desire to drink fluids diminishes with increased core temperature.
- Involuntary Dehydration
Dehydration → HRI

A dehydrated person may experience:

- Headaches
- Loss of accuracy/dexterity
- Muscle fatigue and cramping
- Weakness
- Reduced Alertness
- Nausea
- Increased Heart Rate
Effects of Body’s Response

Reduced blood flow to brain
  • Reduced mental alertness and comprehension
Reduced blood flow to active muscles
  • Fatigue, loss of strength
Increased sweating
  • Slipperiness

Potential result of = a Higher rate of mistakes/injuries

too much heat
The Heat Equation

High Temperature
+ High Humidity
+ Physical Work
= Heat Illness
Two Primary Heat Sources

Two primary sources of heat for workers:

1. Environmental heat
2. Internal heat (metabolic)

Heat-related illnesses occur when the body is not able to lose enough heat to balance the heat generated by physical work and external heat sources.
Work-related Factors

Workload
• Type of work
• Level of physical activity
• Time spent working

Clothing
• Weight (heavy v. breathable)
• Color (dark v. light)
• Personal protective equipment and clothing
Additional Heat Stress Factors

- Radiant heat
- Air velocity
- Machinery and power tools can generate radiant heat
- Working on elevated or reflective surfaces
- Direct Sunlight
Personal Sensitivity To Heat

- Acclimatization (getting used to heat)
- Age
- Physical condition and overall health
- Metabolism – those who sweat more less susceptible to HRIs
- Use of alcohol
  - consuming too much alcohol after work contributes to dehydration and can affect the way a person’s body responds to working in hot conditions the next day.
Medical risk factors for HRI

- Diabetes
- Heart and lung diseases
- Prior heat stroke
- Drugs, alcohol
- Meds
Synergism – heat may magnify chemical exposures and vice versa
Table 3. Medications and Substances that Contribute to Heat-Related Illness

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Diuretics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha-adrenergic agonists</td>
<td>Ephedra-containing supplements</td>
</tr>
<tr>
<td>Amphetamines</td>
<td>Laxatives</td>
</tr>
<tr>
<td>Anticholinergics</td>
<td>Neuroleptics</td>
</tr>
<tr>
<td>Antihistamines</td>
<td>Phenothiazines</td>
</tr>
<tr>
<td>Benzodiazepines</td>
<td>Stimulants</td>
</tr>
<tr>
<td>Beta blockers</td>
<td>Thyroid receptor agonists</td>
</tr>
<tr>
<td>Calcium channel blockers</td>
<td>Tricyclic antidepressants</td>
</tr>
<tr>
<td>Cocaine</td>
<td></td>
</tr>
</tbody>
</table>

*Information from references 1, 3, 6, 14, and 15.*
When Cooling Mechanisms Fail

- High air temperature reduces effectiveness of the cooling system
- High humidity reduces evaporation rate of sweat
- Excess loss of sodium
- Dehydration
Dehydration

- **Cause:**
  - Excessive fluid loss

- **Signs & symptoms:**
  - Fatigue, weakness, cramps, dry mouth

- **Treatment:**
  - Fluids and salt replacement
Staying hydrated can help avoid having to pass one of these through your system.
Heat Cramps

• Cause:
  – Loss of salt and minerals

• Signs & Symptoms:
  – Painful spasms in arms, legs and abdomen
  – Hot, moist skin

• Treatment:
  – Drink water, rest, massage cramped areas
Heat Exhaustion

• **Cause:**
  – Too much loss of water & salt: sweating

• **Signs & Symptoms:**
  – Heavy sweating, intense thirst, skin is pale and cool, rapid pulse, fatigue or weakness, nausea & vomiting, headache, blurred vision, fainting

• **Treatment:**
  – Move to cool area, rest with legs elevated, loosen clothing, give fluids, cool with water & fan
Heat Syncope

- Sudden loss of consciousness
- Blood pressure drops, oxygenated blood supply to the brain is low
- The onset of syncope is rapid and unpredictable.

Credit: B. Miuula
Fainting (Heat Syncope)

Causes:

- Worker not used to hot environment
- Worker stands still in heat
- Blood pools in the legs, so less blood goes to the brain
- Quick recovery after lying down in cool place
- Prevent by moving around a little rather than standing still all the time
Heat Stroke

Cause:
- Total breakdown of body’s cooling system

Signs & Symptoms:
- High body temperature (>103)
- Sweating stops and skin is hot, red, and dry
- Headache, dizziness, weakness, rapid pulse, chills, difficulty breathing
- If untreated, delirium and unconsciousness
Heat Stroke - Treatment

• Treat as a medical emergency
  – May result in death, if not treated
  – 4,000 Americans die each year
• Move victim to cool area
• Give small cup of water (if not nauseous)
• Loosen and/or remove clothing
• Cool with water or massage with ice
• Fan vigorously to improve evaporation
Heat-Related Illness

• Any questions regarding what you have heard so far?
Prevention
Heat Related Illness Prevention Programs

Generally consist of:

- Worker Training/Awareness
- Provisions for acclimating workers to heat
- Reduction of physical demands
- Provide water breaks in cool rest areas
- Worker and environmental monitoring
- Work/Rest schedules
- Avoidance through alternative work schedules
Medical Surveillance

- Periodic medical evaluation
- Determining risk of heat-related illness
- Removing high-risk employees from hot working environments
HRIs happen early on the job among new workers

OSHA investigated HRI cases from 2005

- 46% on day 1
- 80% on days 1-4

https://www.osha.gov/SLTC/heatillness/heat_index/pdfs/all_in_one.pdf
Acclimatization

Initially, 20% exposure for the first day, followed by 20% per day increase in exposure over the next four days.
Heat Index


https://www.osha.gov/SLTC/heatillness/heat_index/index.html
4 Steps to using the Heat Index to protect workers

1. Develop a prevention plan for outdoor work based on the heat index;
2. Train worker to recognize and prevent HRIs
3. Track the worksite heat index daily and communicate the required precautions to workers
4. Implement your plan; review and revise it throughout the summer
# Four Risk Levels

<table>
<thead>
<tr>
<th>Heat Index</th>
<th>Risk Level</th>
<th>Protective Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 91°F</td>
<td>Lower (Caution)</td>
<td>Basic heat safety and planning</td>
</tr>
<tr>
<td>91°F to 103°F</td>
<td>Moderate</td>
<td>Implement precautions and heighten awareness</td>
</tr>
<tr>
<td>103°F to 115°F</td>
<td>High</td>
<td>Additional precautions to protect workers</td>
</tr>
<tr>
<td>Greater than 115°F</td>
<td>Very High to Extreme</td>
<td>Triggers even more aggressive protective measures</td>
</tr>
</tbody>
</table>

Direct sunlight can increase heat index by 15°F
# Heat Index

<table>
<thead>
<tr>
<th>Heat Index</th>
<th>Risk Level</th>
<th>Protective Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;91°F</td>
<td>Lower (Caution)</td>
<td>• Provide drinking water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ensure available medical resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Plan ahead for higher heat indices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Encourage use of sunscreen</td>
</tr>
<tr>
<td>91°F to 103°F</td>
<td>Moderate</td>
<td>In addition to the steps listed above:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Remind workers to drink water often</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Review heat-related illness topics with workers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Schedule frequent breaks in cool, shaded area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Acclimatize workers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Set up buddy system/watch workers for signs of heat-related illness.</td>
</tr>
</tbody>
</table>
# Heat Index

<table>
<thead>
<tr>
<th>Heat Index</th>
<th>Risk Level</th>
<th>Protective Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>103°F to 115°F</td>
<td>High</td>
<td>In addition to the steps mentioned previously:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Alert workers of high risk conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Actively encourage workers to drink plenty of water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Limit physical exertion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Have person well-informed about heat related illnesses determine appropriate work rest schedule</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Establish and enforce work rest schedules</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Adjust work activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use cooling techniques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Watch/communicate with workers at all times</td>
</tr>
<tr>
<td>&gt;115°F</td>
<td>Very High to Extreme</td>
<td>• Reschedule work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If essential work must be performed:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Move work tasks to coolest part of the shift</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Conduct physiological monitoring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Develop and enforce protective work/rest schedules</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stop work if controls are not working</td>
</tr>
</tbody>
</table>
Electronic WBGT

- Ambient Temperature
- Relative Humidity
- Wind
- Radiant Heat (solar radiation from sun)

WBGT = 0.7T_w + 0.2T_g + 0.1T_d

- $T_w$ is the wet bulb temperature, which indicates humidity
- $T_g$ is the globe temperature, which indicates radiant heat
- $T_d$ is the ambient air (dry) temperature
Work Monitoring Programs

- Check heart rate at the beginning of a rest period
- Check pulse 2.5 minutes after break starts
Work Monitoring Programs (cont.)

- Take oral temperature at end of workday (should be <99.7F)
- Check for body water loss (weighing)
ELIMINATION
Design it out

SUBSTITUTION
Use something else

ENGINEERING CONTROLS
Isolation and guarding

ADMINISTRATIVE CONTROLS
Training and work scheduling

PERSONAL PROTECTIVE EQUIPMENT
Last resort

Control effectiveness

Business value
OSHA recommends the following engineering controls

- A/C (construction equipment cabs, e.g.)
- Increased general ventilation
- Cooling fans
- LEV @ points of heat or moisture production
- Reflective shields to redirect radiant heat
- Insulation of hot surfaces (furnace walls, e.g.)
- Elimination of steam leaks
Engineering Controls (cont.)

• Shielding from radiant heat sources
• Substituting machinery for manual labor
Engineering Controls

- General ventilation
- Spot cooling
Administrative controls are also critical for preventing HRI

- Emergency planning
- Acclimatization
- Access to water, shade, rest areas
- Work/rest scheduling
- Rotating workers to minimize overexertion
- Monitoring workers
- Buddy system
- Training & education
Administrative Controls

- Schedule heavy work for a cooler time of year or in the evening and early morning
- Allow more frequent breaks or longer rest periods
- Allow time for workers to become conditioned to heat
Administrative Controls (cont.)

- Reduce physical demand on workers
- Use relief workers
- Limit hours on hot work environments
- Pace the work
Scheduling work during cooler parts of the day or season

“Night work” courtesy DOT
PPE is a last resort in the hierarchy of controls but still important

Personal cooling systems
Reflective clothing
Ice vests
Wetted clothing
Water-cooled garments
Garments w/ circulating cooled air
Fluids!

Drink plenty of fluids
- Don’t rely on your thirst
- 5-7 oz. every 20 minutes

Acclimatization: adjust to the heat
- The body takes 3-5 days to get used to the heat
- Be careful when returning from a change in routine: (i.e. vacation)
Explore additional resources
OSHA has great material on their campaign website

https://www.osha.gov/SLTC/heatillness/
You may be particularly interested in OSHA’s smartphone app

- Use on iPhone & Android
- Calculate heat index
- Display risk level
- Specify protective measures at that risk level

https://www.osha.gov/SLTC/heatillness/heat_index/heat_app.html
CPWR’s Construction Solutions website is a practical tool

Solution: Heat Stress Program

A heat stress program outlines the steps to limit heat stress and reduce the risk of heat-related illnesses associated with working in high temperatures and humidity.

Risks Addressed:

Heat-related illnesses are caused by working in high temperatures, high humidity and/or direct sun for an extended period of time. Thousands of outdoor workers suffer from heat-related illnesses each year. In addition, many workers die from heat-induced illnesses each year. In 2010 alone, 30 workers died from heat stroke.

In hot environments, the body releases excess heat to maintain a stable internal temperature by circulating blood to the skin and through sweating. If the body cannot get rid of excess heat, it will store it and the body’s core temperature rises and the heart rate increases. When the body continues to store heat, the person begins to lose concentration and has difficulty focusing on a task, may become irritable or sick, and often loses the desire to drink water. Then, fainting, and even death, can occur if the person does not cool down (OSHA Fact Sheet).

Heat stress can lead to many different conditions, including, but not limited to, heat stroke, heat exhaustion, heat syncope, heat cramps, and/or heat rash. Prevention of heat stress in workers is important (CDC Heat Stress).

How Risks are Reduced:

The risk of heat-related illness and injury is reduced by increasing management and worker awareness of the hazards, and ensuring that water, shade and more frequent rest periods are provided.

In 2010, researchers at The Jikei University School of Medicine conducted a study to determine the effect of an oral rehydration solution versus a beverage of choice on fatigue for manual laborers on a hot day. The study included 153 cargo handlers at Tokyo International Airport during two summer days with a wet bulb temperature of 30°C Celsius. The study concluded...

Solution: Cooling Clothing and Personal Protective Equipment

Working in high temperatures and high humidity for an extended period can result in heat-related illnesses. Cooling vests, bandanas, hats and other personal protective equipment that reduce heat stress are available and can reduce the risk of heat-related illness.

Cooling vests are designed to maintain comfortable body temperature in high heat and humidity. Weighing 5 pounds or less, cooling vests come in various sizes and have adjustable straps to ensure a comfortable fit. Most products are made from nylon mesh filled with gel material that, once cooled, can be maintained between 59°F and 65°F for between 2.5 and 10 hours.

Cooling vests are cooled by submerging them in ice water for 1 to 20 minutes. Alternatively, some vests may be cooled by placing them in a refrigerator or freezer until the desired temperature is reached. The vests will not drop below approximately 59°F and therefore do not risk tissue damage, discomfort, or frostbite. When the vest has warmed up, ice water, a refrigerator, or a freezer are used to cool it down for reuse.

Submit Review

Rate Solution:

Name:

Email:

Job Description:

- Worker
- Contractor
- Vendor/Manufacturer
- Health & Safety Specialist
- Owner
- Architect/Designer

- Cost: $200 (verified 7/2012)
- Weight: 5 pounds
- Cooling Method: Cooling packs
- Cooling Time: 2.5 hours
- Recharge Time: 20 minutes in ice water
- Features: reflective material

http://www.cpwrconstructionsolutions.org/
The site provides info on heat stress solutions and evidence-based reviews

http://www.cpwrconstructionsolutions.org/
We made it! Thanks for listening.