

Heat Stress

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Abstract

Exposing the body to extreme temperature conditions for an extended period may result in heat stress. Many occupations have opportunities for exposure to heat and it is the responsibility of the safety professional to monitor heat conditions and make recommendations to prevent heat related illnesses. This article introduces the heat index as a tool for the safety professional to evaluate hot conditions. Also discussed are symptoms of heat related illnesses, their first aid, level of severity and methods to mitigate hot conditions.

Keywords

Heat
Stress
Heat Index
Illness
Exhaustion

INTRODUCTION

The National Weather Service uses a heat index that alerts the public when combinations of heat and humidity could make hot weather hazardous. Although intended primarily for the public, it can be useful in evaluation of occupational exposures. What is the heat index and how is it be used to reduce heat-related illnesses? How are heat related illnesses prevented? The index, also referred to as "apparent temperature," is a measure of the contribution humidity makes with high temperature to reduce the body's ability to cool itself. For those with access to the World Wide Web a similar chart can be seen at Queen's University Environmental Health And Safety Guidelines for Working in the Heat, "<http://www.safety.queensu.ca/safety/summer/heat.htm>."

HEAT INDEX

Heat index approximates the influence of temperature and humidity on a typical person. It takes into account the effects of evaporation and radiation of heat between the body and the ambient atmosphere. The following equation is an example of one method to calculate the heat index given the temperature and relative humidity.^[1,2]

Heat index =

$$\begin{aligned} & 16.923 + 0.185212*t \\ & + 5.37941*rh \\ & - 0.100254*t*rh \\ & + (0.941695e-2)*t^2 \\ & + (0.728898e-2)*rh^2 \\ & + (0.345372e-3)*t^2*rh \\ & - (0.814971e-3)*t*rh^2 \\ & + (0.102102e-4)*t^2*rh^2 \\ & - (0.38646e-4)*t^3 \\ & + (0.291583e-4)*rh^3 \\ & + (0.142721e-5)*t^3*rh \\ & + (0.197483e-6)*t*rh^3 \\ & - (0.218429e-7)*t^3*rh^2 \\ & + (0.843296e-9)*t^2*rh^3 \\ & - (0.481975e-10)*t^3*rh^3 \end{aligned}$$

where:

t = temperature in degrees Fahrenheit

rh = relative humidity

$$t^2 = t * t$$

$$t^3 = t^2 * t$$

$$rh^2 = rh * rh$$

$$rh^3 = rh^2 * rh$$

Figure 1 gives typical values for the heat index which is also known as the apparent temperature.^[3] In lieu of using the above equation, it is often easier to use a commercially available Wet Bulb Globe Temperature thermometer to determine the heat index.

Figure 1. Temperature, humidity, and apparent temperature (°F)

Relative Humidity (%)											
Air Temp	0	10	20	30	40	50	60	70	80	90	100
°F	Apparent Temperature °F										
110	99	105	112	123	137	150					
105	95	100	105	113	123	135	149				
100	91	95	99	104	110	120	132	144			
95	87	90	93	96	101	107	114	124	136		
90	83	85	87	90	93	96	100	106	113	122	
85	78	80	82	84	86	88	90	93	97	102	106
80	73	75	77	78	79	81	82	85	86	88	91
75	69	70	72	73	74	75	76	77	78	79	80
70	64	65	66	67	68	69	70	70	71	71	72
	Extreme Danger			Danger			Extreme Caution			Caution	

HEAT ILLNESSES

Whenever weather conditions warrant, prevention of heat illnesses is of utmost importance, and appropriate steps to reduce the effects of heat and humidity are essential. Learning to identify heat stresses can sometimes mean the difference between life and death. Some of the heat illnesses, symptoms, dangers, and first aid are:^[4]

- **Heat rash**, also known as prickly heat, occurs during the constant exposure to hot and humid air, causing a rash that can substantially reduce the ability to sweat. Heat rash is not just a nuisance because of discomfort, but by reducing the ability to sweat, there is a corresponding reduction in the ability to tolerate heat.
First Aid: Cleanse the affected area thoroughly and dry completely. Calamine or other soothing lotion may help relieve the discomfort

- **Heat cramps** may occur after prolonged exposure to heat. They are the painful intermittent spasms of the abdomen and other voluntary muscles. Heat Cramps usually occur after heavy sweating and may begin towards the end of the workday.
First Aid: Rest, drink plenty of water or electrolyte drink.
- **Heat Exhaustion** may result from physical exertion in hot environments. Symptoms may include profuse sweating, weakness, pallor, rapid pulse, dizziness, nausea, headache, vomiting, and unconsciousness. The skin is cool and clammy with sweat. Body temperature may be normal or subnormal.
First Aid: Rest in the shade or cool place. Drink plenty of water or electrolyte drink.

- **Heat stroke** is a serious medical condition that urgently requires medical attention. Diminished or absent sweating is a primary symptom, which makes the skin hot and dry. Body temperature is very high (106 degrees Fahrenheit and rising) and if uncontrolled may lead to delirium, convulsions, a coma, and even death.
This is a Medical Emergency! Brain damage and death are possible. Douse the body continuously with a cool liquid and summon medical aid immediately

PREVENTION

The following six factors can lead to heat stress:

1. Temperature
2. Humidity
3. Movement of air
4. Radiant temperature of surroundings
5. Amount and type of clothing
6. Physical activity

Methods to prevent heat-related illnesses include; acclimatization, conditioning, hydration, air movement many conditions, and the wearing of proper clothing.

Acclimatization means becoming adjusted to work in heat and is essential if working in hot environments. In a heat-stressful situation, acclimatized persons will have lower heart rates, lower body temperatures, and higher sweat rates that consist of a more dilute sweat (with less salt) than persons who are not acclimatized. Maximum sweat rates vary from 0.6 liters per hour in the unacclimatized person to more than 1.5 liters per hour for a fully acclimatized person.

Evaporation of sweat from skin surfaces helps provide cooling. Fans may help cool a person in many situations, however fans won't cool a person at temperatures greater than 90° F when humidity is greater than 35%. Fans have been associated with increased heat stress when the ambient temperature exceeds approximately 100° F. Air movement when the air temperature is greater than body temperature may increase heat stress.

New employees and employees who have been away from work for a few days must be given adequate time to acclimate to the heat. Edwin L. Alpaugh writes in *Fundamentals of Industrial Hygiene* that "both work and heat stress are required to initiate the body changes that result in acclimatization. Working in the heat for about two hours per day for

a week or two will result in essentially complete acclimatization to that work-stress combination. Working more than two hours per day in the heat will not speed acclimatization, nor hinder it".^[5]

Workers in good condition can safely tolerate higher work rates than people not so fit. The more fit a person is, the lower the heart rate and the body temperature, and the more efficient their sweating mechanism as compared to a less-fit individual. Obese and stocky individuals are not able to tolerate heat as well as leaner people. Extremely obese individuals are six times more likely to suffer heat stroke than thin people.

Hydration, or having enough body water, is also an essential factor in working safely in elevated temperatures. In order to help prevent dehydration, which is excessive loss of body water, consume adequate fluids before, during, and after the job. Thirst may not be an adequate warning of dehydration, and workers should not be afraid of drinking too much water, since the body eliminates any excess the urine. Drink at set intervals, rather than only when you feel thirsty.

Physicians recommend against taking salt tablets, since they may cause stomach distress. Salt tablets also take fluid to digest, which means that fluid will be diverted from the blood, which it needs to help cool the body.

Recent research has shown that water is an adequate fluid replacement drink for low intensity and short duration activities in low heat environments. During prolonged heat exposure or a greater intensity workload, a carbohydrate-electrolyte beverage offers a variety of benefits according to Steven Gregg, Ph.D., including:^[6]

- Blood glucose falls and electrolytes are lost in sweat. Electrolytes (sodium, potassium and chloride) are critical elements in maintaining the body's fluid

balance and promoting fluid absorption in the small intestine. Sodium helps maintain blood volume, which is important for counter-acting the effects of dehydration and responding to heat stress.

- Working muscles need the energy found in carbohydrates to avoid fatigue and maintain work levels. In addition, proper amounts of carbohydrates help stimulate fluid absorption in the small intestine.
- Drinks should be non-alcoholic and non-caffeinated because both alcohol and caffeine increase urine output, which leads to dehydration.
- Proper clothing is essential because up to 70 percent of the cooling effect of your body's sweat evaporation may be lost by improper clothing. Light colored clothing reflects the sun's radiant heat, whereas dark colors absorb it. Simply putting on a shirt and trousers interferes with the cooling of your body due to heat loss from sweat evaporation. Changing from wet to dry clothing as needed helps reduce heat stress exposure. The use of respirators and other personal protective equipment (PPE) is a major contributor to heat stress. For example, when workers are wearing PPE such as plastic or chemical suits it is necessary to take into account the temperatures inside the suits when determining the potential for heat related illnesses.^[7]

CONCLUSION

Safety professionals must have a working knowledge of heat stress and heat related illnesses in order to protect workers health and safety. The debilitating effects of heat stress not only impair worker safety but also the worker's efficiency and effectiveness. Heat index is a valuable tool used to mitigate the effects of heat stress and heat related illnesses. This article has presented a brief overview of the heat related illnesses that may affect workers and methodologies to mitigate those effects.

Editor's Note: Richard Dresser became interested in heat stress as it affects the need for water, while preparing for his 2nd week long backpacking trip into the Grand Canyon, having to pack in a 48-hour supply of water. He has used this knowledge to help him complete numerous triathlons since 1983.

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