

## **Some Additional Information on Thermal Stress**

Requirements associated with thermal stress have been issued based on much scientific data behind the human body's response to hot and cold conditions. This document/appendix provides some of the data behind these requirements as well as specific health conditions associated with overexposures to heat and cold.

- Thermal stress is a broad definition that covers personnel working in temperature extremes that can be hazardous to human health from excessive heat and cold conditions. It describes the physical and physiological reactions of the human body to temperatures that exceeds the human body's thermal threshold. While the framework to manage heat or cold stress is similar in scope, specific actions differ by temperature extreme.
- While thermal stress in outdoor occupations and activities is mostly weather and climate dependent, thermal stress inside buildings and structures is usually not. It is possible to have cold stress conditions inside a facility even on hot summer days. Conversely, it is also likely to have heat stress conditions inside certain areas even when it is cold and wintry outside.
- The overarching intent of the Thermal Stress Program is to ensure a core body temperature of individuals as close to normal (typically within 1-2° Fahrenheit) while they are working in conditions that contribute to heat or cold exposures and stressors. The program functions by limiting the amount of work time an individual is exposed to extreme temperatures while completing specific types of work load (low, medium, high). Key elements of the program involve identifying sources of thermal stress and planning measures to reduce or eliminate heat load/cold exposures where possible.

## **Heat Stress Safety Information**

- Thermal heat stress includes injuries or illnesses caused when a person is working in, or exposed to elevated temperature conditions directly affecting an individual's ability to function in a normal manner. Additionally, operations that require the use of PPE – especially those that necessitate the use of semipermeable or impermeable clothing – are likely to cause heat stress among exposed workers, even if ambient temperatures indicate that heat stress shouldn't be a concern.
- An individual's age; weight; degree of physical fitness; metabolism; how well he or she is acclimatized; the use of alcohol or drugs; and a variety of medical conditions (e.g. hypertension) all affect that person's sensitivity to heat. Prior heat injury predisposes an individual to subsequent sensitivity to heat injury. It is difficult to predict who will be affected and when, because individual susceptibility varies. As such, environmental factors are not only limited to ambient air temperatures. Radiant heat, air movement, heat conduction, relative humidity all affect a person's response to heat.
- Studies have shown that thirst cannot be relied upon as a guide to the need for water. The sensation of thirst lags behind fluid depletion. Usually, once one recognizes that he or she is thirsty, that individual is already dehydrated. When in hot environments, breaking the hourly intake into 15-20 minute intervals will easier, physiologically, on the body than drinking the whole amount at once. The best hydrating fluid is water. Caffeinated or sugary beverages stress the body in and of themselves and should be avoided in hot environments. Electrolyte beverages such as Gatorade® or PowerAde® contain excessive amounts of sugar. Individuals

who prefer these types of beverages are strongly encouraged to dilute them at least by half. Under extreme conditions such as a full day of heavy labor, or working in heavy protective gear, a loss of sodium may occur. In these cases, drinking undiluted commercially available carbohydrate-electrolyte replacement fluids is effective in minimizing physiological disturbances during recovery.

- Worker Acclimatization:
  - When workers are unexpectedly exposed to hot (especially hot and humid) work environments, they readily show signs of distress and discomfort (e.g., develop increased core temperatures and heart rates; complain of headache or nausea; and suffer other symptoms of heat-related illnesses). On repeated exposure to a hot environment, there is a marked adaptation in which the principal physiologic benefit appears to result from an increased sweating efficiency (earlier onset, greater sweat production, and lower electrolyte concentration) and a simultaneous stabilization of the circulation, such that, after daily heat exposure for 7-14 days, the individuals perform the work with a much lower core temperature and heart rate and a higher sweat rate (i.e., a reduced thermoregulatory strain) and with none of the distressing symptoms that were experienced.
  - Failure to replace the water lost in sweat will slow or even prevent the development of the physiologic adaptations described. It is important to understand that heat acclimatization increases the sweating rate, therefore workers will have an increased water requirement during this time.
  - Under heat stress conditions, gradually increase the work time over the first two weeks. (Individuals are most susceptible to heat stress during their initial two week period of work in hot and humid conditions).
- Physiological factors:
  - Employees (especially those new to working under heat stress conditions) should be aware of factors that can contribute to susceptibility to heat stress. Factors that must be considered before assigning an employee to work under heat stress conditions include:
    - Muscular activity and work capacity
    - Age and physical condition
  - Susceptibility to heat stress can be affected by:
    - Medical condition or Prescription Medication, inform supervisor or the OMS prior to beginning work under heat stress conditions.
    - Allergy medicine (prescription or non-prescription).
    - Sunburn – likely to reduce work capacity under heat stress conditions.
    - Prior heat stress episode or injury.
  - Individuals who believe that they require a medical evaluation concerning their work in elevated temperature conditions should make a request through their respective supervisor. All medical evaluations will be conducted by OMS. In the event of any accidents or incidents the user must undergo and immediate evaluation by OMS located on the sixth floor of building 10, Room 6C306. The phone number for OMS is (301) 496-4411.

#### **Heat-related disorders and health effects:**

- Minor conditions:

- Heat edema presents with swelling and discomfort of the hands and feet. Individuals may complain that their shoes feel tight or are ill fitting. The exact cause is unknown but generally involves dilation of the blood vessels and shifts in fluid within the body. The condition is self-limiting and symptoms typically resolve within a few days.
- *Miliaria rubra*, also known as “prickly heat” or heat rash occurs when sweat gland pores become blocked. This most often appears in areas of the body where clothing is restrictive. Sometimes a secondary infection may occur. Skin with *miliaria rubra* cannot sweat effectively. Therefore, the risk of heat illness is increased in proportion to the amount of skin involved. In most cases, the rashes will disappear when the affected individual returns to a cool environment.
- Sunburn can impair sweating and predispose an individual to heat injury from systemic effects, including fever, that influence thermoregulation. When sunburn occurs over 5% of the body surface area, the affected individual should be kept from significant heat strain until the burn has healed.
- Heat tetany may result when an individual hyperventilates after being exposed to heat stress. Symptoms include muscle spasms and numbness and tingling around the mouth. It generally occurs before heat acclimatization. Treatment involves removing the affected person from the heat and slowing down the breathing pattern.
- Syncope is a temporary circulatory failure due to pooling of the blood in the peripheral veins. Because of this, there is not enough oxygenated blood reaching the brain. This disorder usually occurs in individuals who are not acclimatized to the hot environment. It can manifest itself similarly to heat exhaustion, however the onset of collapse is often rapid and unpredictable and is not associated with other symptoms of heat exhaustion. Symptoms range from lightheadedness to loss of consciousness. Victims typically recover rapidly once they sit or lay supine. Syncope occurring more than five days after heat exposure may indicate dehydration or heat exhaustion.
- Heat cramps are brief, recurrent, often painful skeletal muscle cramps. They are usually associated with performing hard physical labor in a hot environment. The cramps are usually preceded by muscle fasciculation (“twitches”), which may be seen or felt on the muscle surface. Cramps produce a hard lump in the muscle. There are no systemic symptoms. These cramps are attributed to an electrolyte imbalance caused by excessive sweating. They can be caused by both too little as well as too much salt.
- Major conditions:
  - Heat Exhaustion is the most common heat-related cause of illness. It occurs when the heart cannot pump quickly enough to sustain the needs of the skin blood flow to maintain body temperature along with the metabolic needs of the body for muscle and vital organ activity. Dehydration, reduced blood volume and constricted blood vessels are all contributing factors. The signs and symptoms of heat exhaustion include:
    - Generalized weakness
    - Headache
    - Nausea
    - Fatigue
    - Dizziness
    - Increased heart rate and muscle cramps

- Sweating persists and may even be profuse, and the individual may become disoriented.

Treatment should begin immediately in order to prevent progression to a more severe heat injury. The more severe assessment of heat stroke should be assumed in anyone who experiences a change in mental status such as disorientation.

Fortunately, this condition responds readily to prompt treatment; which includes immediately moving the victim to a cool environment, and having the victim lie down. Provide fluid replacement, and encourage the victim to get adequate rest. This individual should not return to the hot environment until all symptoms have dissipated. Upon return to a hot environment, the individual should be part of a “buddy system” where another can monitor the former victim’s response to the hot conditions. One important collateral hazard associated with heat exhaustion is if the victim is controlling an operation or operating machinery and loses consciousness, the victim, or others, may be injured when he or she faints.

- Heat Stroke occurs when the body’s system of thermoregulation fails and body core temperature rises to critical levels (>105° F). This causes dysfunction of the central nervous system resulting in delirium, convulsions or coma. Two types of heat stroke may occur, exertional and classical.
  - Exertional heat stroke occurs in physically active individuals who are producing substantial metabolic heat. It is the most common form in workers and athletes and can occur in both hot and temperate conditions.
  - Classical heat stroke occurs in vulnerable populations such as the young, the elderly and those without potable water. This type often presents as an epidemic during summer heat waves.
  - Regardless of the type, the primary signs and symptoms of heat stroke are:
    - ❖ Confusion
    - ❖ Irrational behavior
    - ❖ Loss of consciousness
    - ❖ Convulsions
    - ❖ Lack or sweating (usually)
    - ❖ Hot, dry skin
    - ❖ Abnormally high body temperature – if body temperature gets too high, death is likely to occur.
  - Heat Stroke is a medical emergency and professional medical treatment should be obtained immediately. Until medical response units arrive, place the victim in a shady area or into an otherwise cool environment. Remove outer clothing. The worker’s skin should be wetted down and air movement around the victim should be increased to improve evaporative cooling. The medical outcome of an episode depends on a number of factors including the victim’s physical fitness, and the timing and effectiveness of first aid treatment.
  - Regardless of a worker’s protests, no one who is suspected of being ill from heat stroke should be sent home or left unattended until and unless a physician has specifically approved such an order.

## Cold Stress Safety:

What constitutes cold, and its effects on the human physiology can vary across different areas of the country. In regions that are unused to winter's freezing conditions, near-freezing temperatures can be considered "extreme cold".

- Cold Stress Challenges
  - In outdoor environments, wind speed is a significant contributor to the physiological effects of cold. Wind chill is the temperature one feels when air temperature and wind speed are combined. In order to work safely, these challenges have to be counterbalanced to proper insulation (layered protective clothing), by physical activity and by controlled exposure to cold (work/rest scheduling).
  - Air temperature is measured using an ordinary thermometer that measures in degrees Celsius (°C) or Fahrenheit (°F).
  - Wind speed is either taken from posted weather data or measured directly using an anemometer. If accurate information is not available, Table 1 utilizes the following thumb rules for estimating wind speed.

**Table 1. Estimating Wind Speed**

5 mph	Light-weight flag moves
10 mph	Light-weight flag is fully extended
15 mph	Raises newspaper sheet off surface
20 mph	Causes blowing and drifting snow
25 mph	Large tree branches in motion
35 mph	Whole trees in motion
40 mph	Walking is impeded

- Water conducts heat away from the body 25 times faster than dry air. Therefore, wet conditions and clothing are significant contributors to cold stress injury risk. Even body sweat facilitates heat loss from the body. As such, anyone conducting strenuous work for extended periods of time in cold conditions should be aware of excessive sweating.
- Secondary hazards, such as simultaneous exposure to vibration and/or toxic substances can also reduce tolerances to cold; therefore exposures should be limited accordingly.
- Wind Chill
  - It is important for employers supervising employees working in cold outdoor environments to know and understand the concept of wind chill so that they can gauge workers' exposure risk better and plan how to safely do the work. It is also important to monitor workers' physical condition during tasks, especially new employees who may not working in the cold, or workers returning after spending some time away from work.
  - At any temperature, one feels colder as the wind speed increases. The combined effect of cold air and wind speed is expressed as "wind chill". It is essentially the equivalent air temperature that would feel the same on exposed human flesh as the given combination of air temperature and wind speed. It can be used as a good general guideline for deciding clothing requirements and the possible health effects of cold.
  - The National Oceanic and Atmospheric Administration (NOAA) provides information when wind chill conditions reach critical thresholds. A Wind Chill Advisory is issued

when wind chill temperatures are potentially hazardous. A Wind Chill Warning is issued when wind chill temperatures are expected to reach life threatening levels.

- NOAA’s National Weather Service (NWS) developed the Wind Chill Temperature (WCT) index that calculates the dangers from winter winds and freezing temperatures. This information can be expressed as in Table 2.

**Table 2. NWS WCT Index**

Wind Speed (mph)	Temperature °F																		
	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63	-69
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72	-78
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77	-83
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81	-87
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84	-90
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87	-93
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89	-95
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91	-97
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93	-99
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95	-101
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-96	-102
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98	-104

Frostbite Times  30 minutes  10 minutes  5 minutes

- As wind speed increases, it draws heat from the body, driving down skin temperature first and eventually the internal body temperature. As such, the wind can make it feel colder than it really is. The different colors within the table reflect the amount of time it takes for exposed skin to freeze given the temperature and wind speed. For example, if the temperature is 0°F and the wind is blowing at 15 mph, the wind chill is -19°F. At this wind chill temperature, exposed skin can freeze in 30 minutes.
- Cold Stress Illnesses and Injuries
  - **Frostbite:** an injury to the body that is caused by freezing. Frostbite causes a loss of feeling and color in the affected areas. It most often affects the nose, ears, cheeks, chin, fingers or toes. Frostbite can permanently damage body tissues, and severe cases can lead to amputation. In extremely cold temperatures, the risk of frostbite is increased in workers with reduced blood circulation, and among workers who are not dressed properly. The signs and symptoms of frostbite include:
    - Reddened skin develops gray/white patches. Sometimes the skin appears “waxy”.
    - Numbness in the affected part. This may be preceded by tingling or stinging.
    - The affected part feels firm/hard.
    - In severe cases, blisters may occur at the frostbite area.
    - First aid for frostbite involves warming the affected area as gently as possible.
      - ❖ Get victim into a warm area/room as soon as possible. Unless absolutely necessary, do not walk on frostbitten feet or toes; this can increase the damage.
      - ❖ Do not rub or massage the affected area to warm it because this action can cause more damage.
      - ❖ The affected area can be gently warmed through body heat. For example, the heat of an armpit can be used to warm frostbitten fingers.
      - ❖ You may immerse the affected area in warm (NOT hot) water (the water should be comfortable to the touch for unaffected parts of the body).
      - ❖ Do not use a heating pad, heat lamp, or the heat of a stove, fireplace, or radiator for warming. Affected areas are numb, and can be easily burned.

- ❖ Do not attempt to “pop” any blisters.
- ❖ Seek medical attention.
- **Immersion (Trench) Foot:** trench foot is an injury of the feet resulting from prolonged exposure to wet and cold conditions. Trench foot can occur at temperatures as high as 60°F if the feet are constantly wet. Injury occurs because wet feet lose heat much faster than dry feet. Therefore, to prevent heat loss, the body constricts blood vessels to shut down circulation in the feet. Skin tissue begins to die because of lack of oxygen and nutrients; and due to the buildup of toxic products in the tissue. Signs and symptoms of trench foot include:
  - Reddening of the skin. This may include the development of blisters and/or ulcers.
  - Numbness and swelling of the affected areas. This may be preceded by tingling pain.
  - Leg muscles may cramp.
  - In extreme cases, the foot may become gangrenous (the foot may turn dark purple, blue or gray).
  - Workers suffering from trench foot should:
    - ❖ Remove shoes/boots and wet socks.
    - ❖ Dry the feet.
    - ❖ Avoid walking on feet as this may cause tissue damage.
    - ❖ Seek medical assistance and evaluation.
- **Chilblains:** caused by the repeated exposure of skin to temperatures just above freezing to as high as 60°F. The cold exposure causes damage to the capillary beds (groups of small blood vessels) in the skin. This damage is likely permanent and the redness and itching will return with additional exposure. Chilblains typically occur on cheeks, ears, fingers and toes. Signs and symptoms include:
  - Redness and itching to the affected area.
  - Possible blistering.
  - Inflammation, and possible skin ulceration in severe cases.
  - First aid for chilblains:
    - ❖ Avoid scratching the affected area.
    - ❖ Slowly warm the skin; avoid vigorous rubbing and massage.
    - ❖ Use corticosteroid creams to relieve itching and swelling.
    - ❖ Keep blisters clean and covered. Do not attempt to break any blisters.
- **Hypothermia:** when exposed to cold temperatures, the body begins to lose heat faster than it can be produced. Prolonged exposure to cold will eventually use up the body’s stored energy. The result is hypothermia, or abnormally low body temperature (less than 95°F). A body core temperature that is too low affects the brain, making the victim unable to think clearly or to move well. This makes hypothermia especially dangerous because a person may not know it is happening and will not be able to do anything about it. Hypothermia is most likely at very cold temperatures, but it can occur even at cool temperatures (above 40°F) if a person becomes chilled from rain, sweat or submersion in cold water. The signs and symptoms of hypothermia include:
  - Mild symptoms:
    - ❖ An exposed worker is alert, however coordination may deteriorate.
    - ❖ He or she may begin to shiver and stomp the feet in order to generate heat.
  - Moderate to severe symptoms:
    - ❖ As the body temperature continues to fall, symptoms will worsen and shivering will stop.
    - ❖ The worker will continue to lose coordination and fumble with items in the hand.

- ❖ He or she will become confused and disoriented.
- ❖ Skin may take a “bluish” tinge (this can be seen even in darker skinned individuals).
- ❖ As hypothermia progresses, the worker may become unable to stand or walk, pupils will get dilated (large and black), pulse and breathing rates slow and eventually the victim will lose consciousness.
- ❖ If help is not received immediately at this point, the person will likely die.
- First aid for hypothermia. Take the following steps to treat a worker with hypothermia:
  - ❖ Alert supervisor and request medical assistance. In advanced hypothermia, activate the Emergency Medical System (call 911).
  - ❖ Move the person to a warm, dry area or room.
  - ❖ Remove any wet clothing and replace with dry clothes.
  - ❖ Cover the body (including head and neck) with layers of blankets; and with a vapor barrier (e.g. tarp or garbage bag). Do **NOT** cover the face.
  - ❖ If medical help is more than 30 minutes away, give warm, sweetened drinks (no alcohol) if the victim is alert. Never try to give a drink to, or force to drink, an unconscious person.
  - ❖ Place warm bottles or hot packs in armpits, sides of chest and groin area.
  - ❖ If a person is not breathing or has no pulse:
    - ✓ Call 911 for emergency assistance immediately!
    - ✓ Treat the worker per instructions, but be careful and do not try to give an unconscious person any fluids.
    - ✓ Check for signs of breathing and for a pulse. Check for 60 seconds. Sometimes pulse and breathing are very faint and “thready”. Ask for quiet if need be.
    - ✓ If after 60 seconds the affected worker is not breathing and does not have a pulse, workers trained in CPR may start rescue breaths for 3 minutes.
    - ✓ Recheck for breathing and pulse; check for a full 60 seconds.
    - ✓ If the worker is still not breathing and has no pulse, continue rescue breathing.
    - ✓ Only start chest compressions per the direction of the 911 operator or Emergency Medical Services (chest compressions are recommended only if the patient will not receive medical care within 3 hours).
    - ✓ Reassess the victim’s physical status periodically.