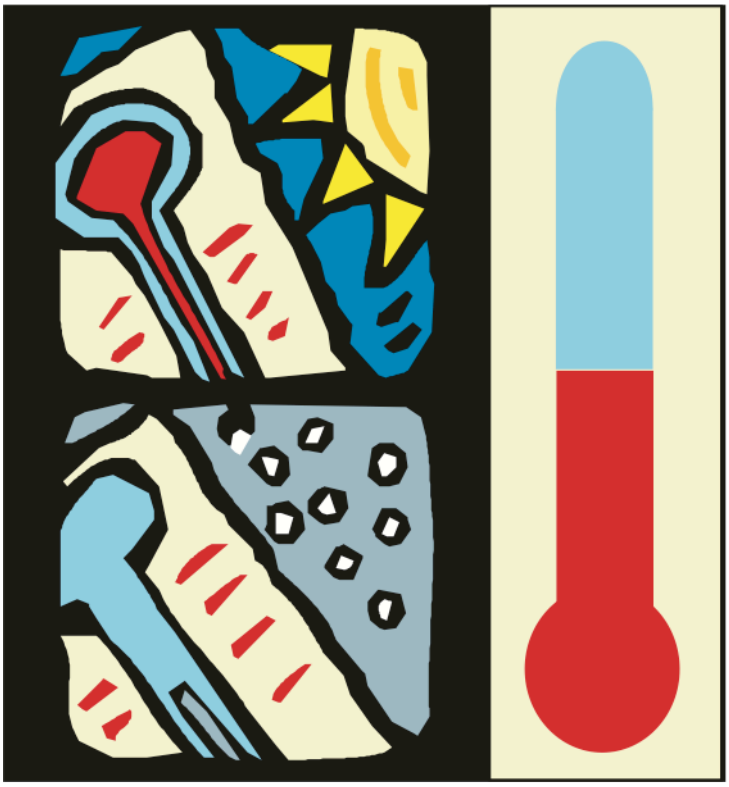
Thermal Stress Awareness

Self-Study #18649



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Introduction

Course Overview

Thermal stresses can expose individuals to a variety of health hazards at work, at home, and at play. Every year thermal stresses cause severe injuries and death to a range of people, from elderly people in cities during summer heat waves to young people engaged in winter mountaineering. Awareness is the key to preventing the health hazards associated with thermal stresses. This course is designed for personnel at Los Alamos National Laboratory (LANL). It addresses both heat and cold stresses and discusses their factors, signs and symptoms, treatments, and controls.

Course Objectives

After completing this course, you will be able to

- define heat stress and cold stress;
- identify health effects of thermal stresses;
- recognize the signs, symptoms, and treatment of thermal stresses;
- identify engineering and administrative controls for thermal stresses;
- list ways to prevent thermal stresses; and
- identify whom to contact for thermal stress information or a workplace evaluation.

About This Self-Study Course

Thermal Stress Awareness Self-Study (#18649) consists of an introduction, two modules, and a quiz. To receive credit in UTrain for completing this course, you must score 80% or better on the 10-question quiz. Directions for initiating the quiz are appended to the end of this training manual.

This course contains several links to LANL websites. UTrain does not support active links, so please copy and paste these links into the address line in your browser.

Module 1: Heat Stress

Module Overview

From 1979 to 1995, 6,615 occupational- and non-occupational-related deaths in the United States were attributed to excessive heat exposure. Left untreated, heat stress can be potentially fatal. By becoming familiar with the signs and symptoms of heat stress and the treatment and response actions for heat-related illnesses, you can help reduce the risk of heat stress.

Module Objectives

After completing this module, you will be able to

- define heat stress;
- identify sources of heat and factors that contribute to heat stress;
- identify the signs, symptoms, and treatments of five types of heat-related illnesses;
- describe four ways to monitor for heat stress;
- identify controls used to prevent the occurrence of heat-related illnesses; and
- identify whom to contact for workplace evaluation of heat stress.

Heat Stress Defined

Heat stress is defined as the net heat load on the body from metabolic heat production, environmental factors, and clothing.

Sources of Heat

The primary sources of heat that contribute to heat stress are radiant heat, convective heat, and metabolic heat.

Radiant Heat

Radiant heat is transferred primarily in the form of infrared radiation (IR) from objects or bodies with hotter surfaces to objects or bodies with cooler surfaces. Sources of radiant heat can be artificial, such as the heat radiated from a boiler, or natural, such as radiation from the sun. Radiant heat from the sun causes the outside air to heat up, creating the ambient environmental temperature. The rate of heat transferred by radiant heat is dependent on skin temperature, clothing, and the temperature of surrounding surfaces.

Convective Heat

Convective heat is the exchange of heat between the skin and the surrounding air. If the temperature of the air is higher than the temperature of the skin, heat will flow from the air to the skin. If the air is cooler than the skin, heat will flow from the body. The rate of heat transferred by convection depends on how much the air temperature differs from the skin temperature, along with the type of clothing worn and the amount of airflow to the skin.

Metabolic Heat

Metabolic heat, a byproduct of your body’s metabolism, is the energy released as your body performs work. As stored chemical energy is converted into kinetic energy, metabolic heat is also produced. The amount of metabolic heat your body produces depends on the type of work you are doing. If you are shoveling dirt, the amount of heat generated by your metabolism will be much greater than if you are working at a desk.

Factors Affecting Heat Stress

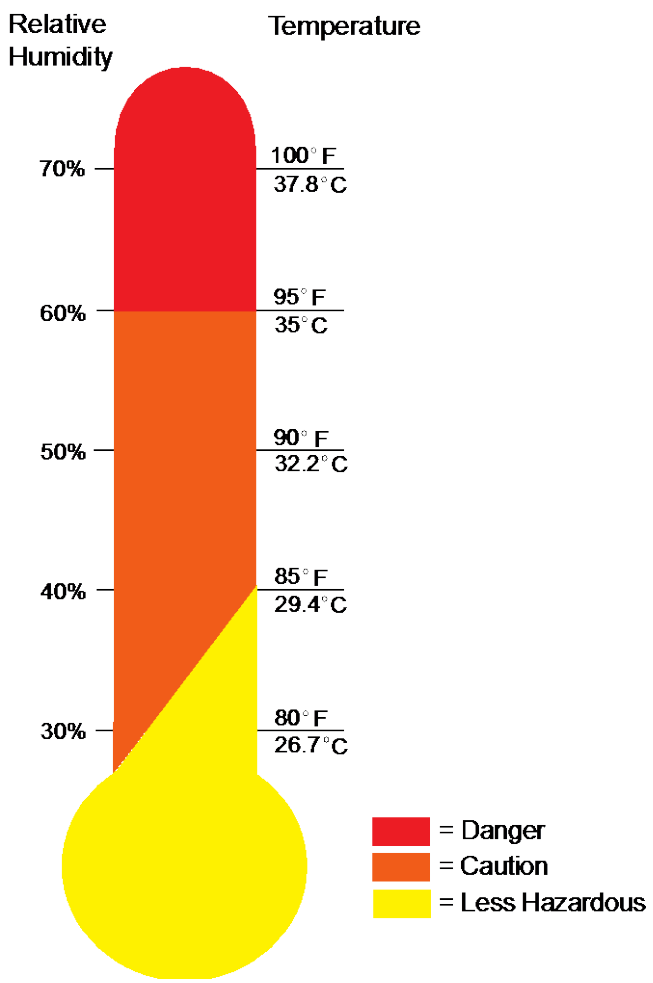
Heat stress is affected by a number of factors, including environmental conditions, acclimatization, individual variability, and personal protective equipment (PPE).

Environmental Conditions

Environmental conditions that affect the potential for heat stress include temperature, humidity, and airflow.

Temperature

Temperature is the simple measurement of heat in the air. Air temperature can play an important role in heat stress during the summer months, when it typically ranges between 70°F and 90°F in Los Alamos and White Rock.



Occupational Safety and Health Administration (OSHA) Heat Equation

Factors Affecting Heat Stress—continued

Relative Humidity

Relative humidity is the amount of moisture in the air relative to the maximum amount of moisture the air could hold at a given temperature. Relative humidity directly affects evaporation of moisture from the skin (also called evaporative heat loss), which is one of the ways the body cools itself. When high relative humidity is combined with high temperature, evaporation slows down and the body's ability to cool itself is reduced.

Note: *Relative humidity in the Los Alamos area is usually low.*

Airflow

Airflow is the movement of air within the environment. Airflow is produced naturally, as by wind, and can be artificially produced by fans. When the surrounding air is cooler than your skin, increasing the airflow will increase the amount of heat loss from your body. When the surrounding air is hotter than your skin, increasing the airflow can increase the heat gain to your body, depending on the rate of evaporative heat loss.

Acclimatization

Acclimatization consists of the physiological changes that occur in your body in response to a succession of days of exposure to heat stress. Over a period of time, these changes reduce the strain caused by heat stress. Changes include greater sweat production and increased sweating efficiency.

Most people become acclimated during the first or second week of exposure to hot environmental conditions. For acclimatization to take place, you must be performing work under the hot environmental conditions—you will not become fully acclimated just sitting around in the heat. The length of time required for you to become acclimated is influenced by your individual variability.

Individual Variability

Individual variability is determined by several factors that affect susceptibility to heat stress. These factors include physical fitness, drug and alcohol use, age, and stress. Most of these factors affect metabolism, a source of heat and a potential contributor to heat stress.

Factors Affecting Heat Stress—continued

Physical Fitness

In most cases, the more physically fit you are, the faster you will acclimate to high temperatures. Obesity predisposes individuals to heat disorders because a greater expenditure of energy is required to carry additional fat, causing an increased metabolic heat load. In addition, as the ratio of body surface (skin) to body weight decreases, the body becomes less effective at cooling itself.

Age

As you get older, your sweat glands respond more sluggishly, resulting in less effective control of body temperature.

Drug and Alcohol Use

Drug or alcohol use can affect your rate of metabolism or it can cause you to become dehydrated. Some medications can also increase metabolism, creating more metabolic heat load.

Stress

Stress can also cause your metabolism to increase, creating more metabolic heat load.

Personal Protective Equipment

The type of PPE selected for other hazards may significantly increase your body's heat load. Fabrics and other materials that reduce the amount of moisture, heat, or air passing through them can minimize or eliminate evaporative cooling. Examples of PPE that can increase the effects of heat stress include polycoated Tyvek™ suits, impermeable chemical-resistant gloves, and full-face respirators. The potential for heat stress should be considered when selecting PPE for other hazards.

Signs, Symptoms, and Treatment of Heat-Related Illnesses

Adverse health effects of heat stress are known as heat-related illnesses. Heat-related illnesses range from heat rash, which is typically the mildest form of heat-related illness, to heat stroke, which is potentially life-threatening. Heat-related illnesses are outlined here, from least to most serious, along with a description of signs, symptoms, and treatment.

Heat Rash

Heat rash, also known as prickly heat, is caused by a constant exposure to hot and humid air, creating inflammation around the sweat ducts. The primary indication of heat rash is an eruption of red pimples accompanied by intense tingling and itching. Treatment for heat rash consists of cleansing the affected area thoroughly and allowing the area to dry completely. Applying calamine or similar lotions can help to relieve the discomfort and prevent the skin from becoming infected, the result of constant itching.

Heat Cramps

Heat cramps are painful, periodic contractions of the abdominal muscles or other fatigued muscles. Heat cramps are caused by excessive loss of body salts from prolonged sweating and may begin toward the end of the workday if a sufficient salt intake has not been maintained. Individuals suffering from heat cramps have a body temperature at or below normal. Treatment for heat cramps includes rest in a cool area and drinking lightly salted water (1 teaspoon per gallon) or an electrolytic drink such as Gatorade™ or Powerade™.

Heat Syncope

Heat syncope is characterized by fainting and is caused by the pooling of blood in the legs and skin. Heat syncope can be caused by maintaining a static posture such as standing for extended periods of time under elevated heat conditions. Signs and symptoms include blurred vision and fainting or almost fainting. Persons suffering from heat syncope typically have a normal body temperature. Treatment includes lying down in a cool atmosphere and drinking fluids.

Signs, Symptoms, and Treatment of Heat-Related Illnesses—continued

Heat Exhaustion

Heat exhaustion occurs when prolonged physical exertion in hot environments creates excessive thermal stress along with dehydration. Signs and symptoms of heat exhaustion are profuse sweating, rapid pulse, and pale skin and may also include dizziness, nausea, headache, and vomiting. The body temperature of a person suffering from heat exhaustion may vary from normal to slightly increased. Treatment for heat exhaustion is similar to treatment for heat cramps and includes rest in a cool area and drinking plenty of water or an electrolytic drink. If not addressed, heat exhaustion can lead to unconsciousness and heat stroke.

Heat Stroke

Heat stroke is a life-threatening form of heat stress in which prolonged exposure to high temperatures causes a failure of the body's thermoregulatory system. Sweating is usually diminished or absent, and the skin is often hot and dry. Other signs and symptoms may include chills, irritability, disorientation, and/or unconsciousness. Left untreated, heat stroke can result in convulsions, coma, and/or death. The body temperature is usually above 104°F.

Severe heat stress is a medical emergency*. If you feel you may be suffering from heat stress, stop work!* Find a cool area, drink some liquids, and tell your supervisor or a coworker. If necessary, have someone take you to get medical attention.

If you think a coworker is suffering from heat stroke, get the person to a shaded or a cool area as quickly as possible, remove all PPE that may add to the heat load, and douse the individual in a cool liquid or place the person in an ice bath. Do not place the individual inside a hot motor vehicle. *Call 911 immediately.*

Monitoring Heat Stress

Methods that can be used to monitor for heat stress include behavioral observation, along with measurement of environmental conditions, body temperature, and heart rate. Monitoring for heat stress is an important component in preventing heat-related illnesses or recognizing them before they become serious. If you think heat stress monitoring may be needed in your work area, contact your supervisor, your site health and safety professional, or the Industrial Hygiene and Safety Group (HSR-5) at 5-4427.

Behavioral Observation

Although behavior may be affected by many factors and can be difficult to measure, certain actions may indicate that an individual is suffering from heat stress. Such behaviors can include

- complaints of being hot;
- inappropriately adjusting clothing to cool off, such as cutting off shirt sleeves;
- taking shortcuts and more frequent breaks;
- making more mistakes; and
- irritability, absenteeism, and low morale.

If you observe such behaviors in a coworker, you may be witnessing a potential heat stress problem. When such behavior is observed under conditions of potential heat stress, notify your supervisor or the site health and safety professional.

Environmental Conditions

A wet-bulb globe-temperature (WBGT) monitor can be used to measure environmental conditions in the immediate work area. A WBGT measures

- dry-bulb temperature—a direct measurement of ambient air temperature;
- natural wet-bulb temperature—a measure of evaporative cooling; and
- globe temperature—a measure of the radiant heat.

Monitoring Heat Stress—continued

Using a formula, these three temperatures are weighted and a single number is calculated, which is the WBGT reading. When the metabolic heat produced by a worker is factored in, the WBGT, along with guidelines published by the American Conference of Governmental Industrial Hygienists (ACGIH), can be used to determine work/rest schedules. Metabolic heat produced from work is ranked as light, moderate, or heavy, based on the estimated workload (the amount of energy it takes a worker to perform the work). This ranking and the WBGT reading are compared against a table (shown below) in the 1997 ACGIH Threshold Limit Values (TLVs) booklet that provides recommended work/rest regimens. For example, if the workload is determined to be moderate and the WBGT is 85°F, workers should work for 30 minutes and then rest for 30 minutes during each hour.

Note: *The TLVs for heat stress apply to physically fit, fully clothed workers with adequate water and salt intake. Higher heat exposures than indicated in the table below may be allowable if medical surveillance determines an individual is more tolerant than the average worker.*

Work/Rest Regimen (per hour)	Workload °C (°F)		
	Light	Moderate	Heavy
continuous work	30.0 (86)	26.7 (80)	25.0 (77)
75% work 25% rest	30.6 (87)	28.0 (82)	25.9 (78)
50% work 50% rest	31.4 (89)	29.4 (85)	27.9 (82)
25% work 75% rest	32.2 (90)	31.1 (88)	30.0 (86)

***As workload increases, the heat stress impact on an unacclimatized worker is exacerbated. For unacclimatized workers performing a moderate level of work, the permissible heat exposure should be reduced by approximately 2.5°C.*

Examples of Permissible Heat Exposure Threshold Limit Values

Monitoring Heat Stress—continued

Body Temperature

Body temperature can be measured to indicate any increase in core body temperature. The ACGIH recommends that workers not be allowed to continue work if their core body temperature exceeds 100.4°F. Several instruments for measuring core body temperature include

- an ear canal thermometer, which is quick and accurate;
- an oral thermometer, which is not as convenient because the temperature must be taken 15 minutes after eating or drinking; and
- a rectal thermometer, which provides accurate information but is typically not a popular method.

Heart Rate

Heart rate can be used to indicate the effects of metabolic and environmental heat on the body and to adjust work/rest rates accordingly. In one method, the monitoring frequency is based on the ambient temperature and the type of clothing worn, as shown in the table below. The base heart rate is measured before work begins. (For individuals with a base heart rate greater than 80 beats per minute [bpm], it may be necessary to use a different method of heat stress monitoring.)

Ambient Temperature (°F)	Normal Work Clothing* (min.)	Impermeable Work Clothing (min.)
70–80	N/A	90
80–85	120	60
85–90	90	30
>90	60	15

**Normal work clothing is cotton coveralls or other cotton clothing with long sleeves and pants.*

Frequency of Heart Rate Measurement for Heat Stress Monitoring

Monitoring Heat Stress—continued

When a rest break is taken, the initial heart rate is measured within the first minute, and after three minutes, the recovery heart rate is measured. If the initial heart rate is greater than 110 bpm *or* if the recovery heart rate is greater than 80 bpm, the work shift should be decreased by one-third. For example, if the first work period was 60 minutes, the new work period should be 40 minutes. If the initial heart rate is less than 110 bpm *and* the recovery heart rate is less than 80 bpm, the work period can be increased by one-third, as long as the ambient temperature remains constant. Generally, individuals who are physically fit will have lower heart rates than individuals who are not physically fit.

Controlling Heat Stress

Engineering controls, administrative controls, and PPE can be used to minimize the potential for heat-related illnesses.

Engineering Controls

Engineering controls are the preferred method of controlling hot environments. Although in some cases engineering controls may not be feasible, circumstances may exist in which these controls can be effectively implemented. Implementing engineering controls may involve any of the following actions:

- Install air conditioning. For example, evaporative coolers can be installed in enclosed work areas such as Permacon™ structures. (Although air conditioning can eliminate the potential for heat stress, in many situations it may not be economically feasible or even possible.)
- Increase air movement. Portable fans can be set up in work areas and/or rest areas to provide convective cooling (if the air is not too hot).
- Reduce relative humidity using dehumidifiers, which can allow greater evaporative cooling from individuals.
- Use reflective shielding to reduce radiant heat load by as much as 80%–85%. For example, construct a canopy from reflective material to allow individuals working outdoors to work and/or rest in the shade.
- Use equipment to allow remote operation and distance the individual from the source of heat. For example, use tongs to place material in and remove materials from furnaces.
- Use powered tools or equipment to reduce physical work demands and so reduce metabolic heat output. For example, use a backhoe to dig a trench instead of a pick and shovel.

Controlling Heat Stress—continued

Administrative Controls

When adhered to, administrative controls can be an effective method of reducing the potential for heat stress in the workplace. Implementing administrative controls may involve any of the following actions:

- Allow time for workers to acclimate to hot environmental conditions. This usually means reducing work under conditions of potential heat stress to several hours per day for the first week or two.

  Note: *After time off, reacclimatization must take place. Depending on the length of time away, the time for an individual to reacclimate may range from a few days to two weeks.*

- Ask workers if they have any history of heat-stress-related problems before they begin work and monitor for conditions of heat stress as necessary. This may require the assistance of the site health and safety professional or an industrial hygienist from HSR-5.
- Keep workers hydrated. An individual may lose as much as 2–3 gallons of sweat in a day. Failure to replenish fluids and salts increases the risk that an individual will suffer from heat stress. Certain fluids, such as normal water, lightly salted water (1 teaspoon of salt per gallon of water), and sports drinks (high in electrolytes such as sodium, potassium, and chlorine), are effective methods of rehydration. Other fluids such as alcohol and coffee should be avoided since they tend to dehydrate the body and may increase the potential for heat stress. During periods of potential heat stress, it is recommended that workers
  - have fluids available at or as near as possible to the site;
  - drink fluids before, during, and after work; and
  - drink small quantities of fluids as frequently as possible, not just when thirsty.

  Note: *The use of salt tablets is discouraged as they may cause stomach distress.*

- Schedule strenuous work during the cooler hours of the day, such as between 7:00 and 10:00 a.m., or consider adjusting the entire work shift earlier or later in the day.

Controlling Heat Stress—continued

- Have work performed in the shade as opposed to direct sunlight. For example, schedule work during a time when the work site will be in the shadow of a building.
- Use work/rest cycles as described in the monitoring section to allow workers to rest and rehydrate.
- Rotate individuals and teams in and out of the heat to give them time to rest and rehydrate. Have team members watch each other for the signs and symptoms of heat stress.
- Provide general awareness and site-specific heat stress training. Awareness training, such as this course, helps workers reduce their risk of developing a heat-related illness through early recognition of heat stress signs and symptoms in themselves and their coworkers. Awareness training also helps workers understand the effects of nonoccupational factors, such as individual variability, and what to do in the event of a heat stress emergency. Site-specific training may include information on the location of heat stress equipment, minimal requirements for work in hot environments, whom to contact for heat stress monitoring, and specific measures to follow in the event of a heat stress emergency.
- Stop work if signs or symptoms of heat stress are observed, or at the very least, remove the affected worker(s).
- Immediately provide appropriate treatment to workers displaying signs or symptoms of heat stress to prevent conditions from getting worse.

Controlling Heat Stress—continued

Personal Protective Equipment

While some types of PPE increase the effects of heat stress on the body, other types of PPE can reduce the effects. When selecting PPE for operations in which heat stress may be an issue, try to select the coolest PPE that still provides sufficient protection against the hazards of the operation. Overprotecting for other hazards can increase the risk of heat stress. Examples of PPE that can help reduce the potential effects of heat stress are described in the following table.

Type of Clothing	Description
water-cooled clothing	Uses a pump and ice container carried by the user to circulate ice-cooled water around all areas but the hands and feet.
air-cooled clothing	Uses an air line with a vortex (cooling) tube attached to the user. Compressed air supplied through an air hose is blown through the vortex tube and over the skin.
cooling vest	Holds ice or other cold materials against the body. Cooling vests can be effective for up to several hours, depending on the environmental conditions and metabolic heat production of the individual. It may be necessary to have replacement ice packs in accordance with the length of the operation.
cooling bandana	Contains crystals that when placed in cold water and then worn around the neck or head, provide relief for about 30 minutes.
long-sleeve shirt and long pants	Insulates and prevents transfer of heat from the air to the body when air temperature is sufficiently higher than skin temperature or when working near strong radiant heat sources such as furnaces.
wetted overgarments	As used by desert-dwelling peoples, this PPE enhances evaporation and so helps to dissipate heat.
light-colored clothing	Reflects radiant heat better than darker clothing, so individuals are subjected to a lesser radiant heat load.

Workplace Evaluation

Depending on workplace conditions and location and/or the PPE being worn, heat stress monitoring may be required, per Laboratory Implementation Requirement (LIR) 402-820-01, *Noise and Temperature Stresses*. To find out if monitoring is required, or if you are concerned about the potential for heat stress in your work area, talk to your supervisor and your site health and safety professional or call HSR-5 at 5-4427 for a workplace evaluation.

Lessons Learned

Compaction and repackaging work was being conducted within a Permacon™ enclosure at the Mound Plant in Ohio in June 1998. The work was being monitored by the site foreman and two radiation control technicians (RCTs). Two workers and one additional RCT were just finishing the job and exiting the enclosure when one of the workers lost consciousness and began to fall. The other worker and the RCT caught the falling worker and removed the unconscious worker from the enclosure. Immediate actions included stopping work, removing the victim's PPE, placing a cold vest under the victim's head, and calling emergency services. The victim was taken to a local hospital emergency room, treated for heat exhaustion, and released about four-and-a-half hours later.

Lessons learned from this incident emphasize the following:

1. Clear communication is essential so that the proper information is given to the workers. All involved organizations must be directly involved in pre-job planning and work implementation. Use the Integrated Safety Management (ISM) process to address hazards such as thermal stress and implement controls during pre-job planning.

2. Jobs identified with stop-work levels for heat stress (WBGT limits) must be provided with real time monitoring. Stop-work levels must reflect actual working conditions and must be adhered to.

3. Heat stress procedures must be followed closely to avoid physical stress on workers. Work regimens must be adjusted as necessary to allow workers to become acclimatized.

Module 2: Cold Stress

Module Overview

Cold stress can result from low temperatures and wet or windy conditions. Personnel exposed to severe cold stress may experience frostbite or hypothermia. The following information will help you to recognize the signs and symptoms of frostbite and hypothermia and the treatment for each. Early recognition is essential to prevent serious consequences.

Module Objectives

After completing this section, you will be able to

- define cold stress;
- recognize factors that contribute to cold stress;
- identify the signs, symptoms, and treatment for frostbite;
- identify the signs, symptoms, and treatment for hypothermia;
- identify controls used to minimize or prevent cold stress; and
- identify whom to contact for workplace evaluation of cold stress.

Factors Affecting Cold Stress

Factors that may contribute to cold stress include temperature, air speed, conduction, metabolism, and vibration.

Temperature

Temperature is the measurement of the heat (or, in this case, the lack of heat) in the air. The colder the air, the more rapidly your body will lose heat.

Factors Affecting Cold Stress—continued

Air Speed

Air speed is the velocity of the air, usually measured in miles per hour (mph). As air speed increases, heat is drawn from your body much faster than in environments where the air is still. The equivalent chill temperature (ECT) Table, also known as the wind-chill index, relates the cooling power of both air speed and temperature to the cooling power of still air temperature. For example, as shown in the table below, at a temperature of 10°F with an air speed of 10 mph, the ECT is –9°F. Sufficiently low temperatures combined with sufficiently high air speeds can cause exposed flesh to freeze in less than 30 seconds.

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Chill Temperature (°F)											
calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(Wind speeds greater than 40 mph have little additional effect.)	LITTLE DANGER In <hr with dry skin. Maximum danger of false sense of security				INCREASING DANGER Danger from freezing of exposed flesh within one minute			GREAT DANGER Flesh may freeze within 30 seconds				
	Trench foot and immersion foot may occur at any point on this chart.											

*Developed by the U.S. Army Research Institute of Environmental Medicine, Natick, MA.

Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36°C (96.8°F) per cold stress TLV

Equivalent Chill Temperature Table

Factors Affecting Cold Stress—continued

Conduction

Conduction is a form of heat transfer that occurs when two objects are in contact. When cold metal, stone, or water is in contact with the skin, heat is drawn from the body. Submersion of body parts in cold water will draw heat from the body much faster than exposure to cold air, because the thermal conductivity of water is much greater than that of air. Conduction can occur from holding the un-insulated metal handle of a cold tool without using gloves, sitting in metal chair seats for extended periods of time, or wearing metal earrings or wet clothing. Clothing may become wet externally, as from falling into a river or being sprayed by a broken water pipe, or clothing may become wet internally from sweat.

Metabolism

Metabolism—the energy your body uses to perform work—generates heat as a byproduct. The more strenuous the work, the more heat that is generated. Sitting or standing still does not cause your body to generate much heat, while shoveling snow can generate large amounts of metabolic heat. Metabolism can be affected by depressants, such as alcohol and some medications, and by some toxic substances in the workplace.

Vibration

Vibration in combination with cold environments can cause Raynaud’s syndrome, a type of cumulative trauma disorder in which the arteries become compressed, especially around the hand area. Over time, the use of vibrating equipment such as chainsaws or jackhammers in cold environments may induce Raynaud’s syndrome. If you are working with vibrating tools in cold environments and have questions about how they may be contributing to cold stress, ask your site health and safety professional or talk to an HSR-5 industrial hygienist at 5-4427.

Frostbite

Frostbite is the freezing of skin or tissue. It occurs when a body part loses heat to the environment faster than it can be replaced by circulating blood. As frostbite extends deeper into the tissue, the injury becomes more serious. Permanent damage can occur if the body part is not rewarmed. If a body part freezes solid, amputation may be necessary.

Frostbite Signs and Symptoms

The following are signs and symptoms of frostbite:

- numbness in the fingers, face, nose, ears, or other extremities;
- pain, if the temperature of an extremity falls rapidly, but possibly no pain if the temperature falls slowly;
- loss of feeling or a prickly type of discomfort;
- waxy or mottled skin that may turn grayish white, yellow, or blue;
- stiffness or decreased movement in the latter stages; and
- finger pads that may remain indented when pressed.
- Treatment of Frostbite

Take immediate action if any signs and symptoms of frostbite are observed, as follows:

1. Remove the person from the cold.
2. Gently remove clothing, shoes, or gloves from the affected parts. This helps to restore circulation.
3. Do not rub the affected area(s).
4. Cover the frostbitten part with warm hands or warmed clothes or soak the affected part in warm (less than 105°F) water until the affected part appears red and feels warm.
5. Do not break any blisters.
6. Transport the person to a medical facility.
7. If a part appears to be frozen deeper than the first layer of skin, or if a whole hand or foot is affected, *call 911 immediately*.

Hypothermia

Hypothermia is a life-threatening emergency. It occurs when your core body temperature drops and your body can no longer keep itself warm. It can occur in air temperatures up to 50°F. Once hypothermia progresses beyond the mild stage, it is difficult to reverse and has a high mortality rate. More severe forms of hypothermia may create a deadly cycle in which you lose the ability to think clearly and do not recognize your worsening condition.

Acute vs. Chronic Hypothermia

Acute hypothermia is the sudden drop in body temperature frequently associated with an incident such as getting wet. Acute hypothermia occurs rapidly. Acute hypothermia could occur if you fell into a river in winter.

Chronic hypothermia is the cooling of the body over a longer period of time. Chronic hypothermia may be hard to recognize because it develops slowly and is not usually associated with an incident. Potential causes of chronic hypothermia include not dressing properly for conditions, failure to eat well, other medical problems, or dampness from sweating.

Signs and Symptoms of Hypothermia

Early recognition of the signs and symptoms of hypothermia is the key to preventing a serious incident. Symptoms progress roughly in the order presented below and on the next page, though not all symptoms will be present every time and the order may vary.

Mild Hypothermia

Mild hypothermia (97°F–95°F body temperature) is characterized by mild to heavy shivering, a feeling of cold, numb hands, and/or goose bumps. You may begin to fumble with complex tasks.

Moderate Hypothermia

Moderate hypothermia (95°F–90°F body temperature) is characterized by confusion, loss of coordination, and noticeably slow movements. You may experience intense shivering, slurred speech, and fumbling fingers. You may not seem to care about the cold and may begin to become disoriented.

Hypothermia—continued

Severe Hypothermia

In the case of severe hypothermia (90°F–80°F body temperature), shivering ceases and walking becomes difficult if not impossible. You may exhibit irrational behavior, such as taking off coats or gloves. Your skin may become puffy or blue, your pulse and respiration slow, your pupils become dilated, and your muscles become rigid. You could become semiconscious.

Very Severe Hypothermia

If hypothermia is very severe (below 80°F body temperature), you become unconscious. Very severe hypothermia is characterized by an irregular heartbeat and irregular breathing. These symptoms can progress to no apparent pulse or breathing and subsequent cardiac arrest.

You are unlikely to experience severe forms of hypothermia while performing occupational activities at Los Alamos. However, if you work at remote sites or offsite, you could experience increased risk. Additionally, participation in nonoccupational winter activities such as winter backpacking, as well as summer hiking or camping at high altitudes without sufficient clothing, can result in severe hypothermia.

Treatment of Hypothermia

Consider the following actions if you observe any signs or symptoms of hypothermia in a coworker.

Normal Cold

Get the individual out of the cold and wind and into dry clothes. Add more clothing if necessary. Provide the individual with something warm to eat or drink if the person is conscious and alert. If the individual warms up quickly and feels better, the individual, if dressed properly and watched closely, can return to work in about an hour. If the individual does not warm up rapidly or gets worse, transport the person to a medical facility immediately.

Hypothermia—continued

Mild/Moderate Hypothermia

Gently warm and dry the victim and transport the individual immediately to a medical facility or call 911: *do not treat the victim at the job site!* Handle the victim very gently to avoid any chance of cardiac arrest. Do not rapidly rewarm the victim using heat lamps, electric blankets, or chemical heat because these heat sources can cause cold, external blood to return to the core too quickly. If the victim's core temperature stays above 90°F, chances for a complete recovery are good. If the individual's core temperature drops to 80°F–90°F, the individual may survive but have permanent damage.

Severe Hypothermia

Check the victim's breathing and pulse and perform CPR if necessary. *Call 911!* The individual must be immediately transported by advance life support ambulance or helicopter to a hospital. In this situation, the chance of cardiac arrest is high. Most victims whose body temperatures drop below 80°F do not survive.

Note: *If you are unsure how serious the condition of the victim is, take no chances. Call 911 or get the victim to a medical facility immediately!*

Monitoring Cold Stress

If you routinely work in temperatures lower than 39.2°F (4°C), you may be in danger of experiencing cold stress. LANL work practice requirements based on temperatures at or below 39.2°F (4°C) can be found in LIR402-820-01. Wind chill and humidity can be obtained from the LANL weather page at *http://www.weather.lanl.gov* .

For an evaluation of the potential for cold stress at your workplace, contact your site health and safety professional or call HSR-5 at 5-4427.

LIR402-820-01 recommends that workplace monitoring be conducted when temperatures drop below 61°F. Contact HSR-5 at 5-4427 for information on monitoring cold stress.

Controlling Cold Stress

Engineering controls, administrative controls, and PPE can be used to minimize the potential for cold stress. Some controls will not be applicable in certain situations. For assistance in the selection of suitable controls, contact your site health and safety professional or call HSR-5 at 5-4427.

Engineering Controls

Implementing engineering controls to minimize the potential for cold stress may include the following actions:

- Establish shelters out of the wind where workers can warm themselves with heaters.
- Provide hand warmers for workers to carry with them as they work or to use during breaks in established areas.
- Provide shielding or barriers to reduce exposure to drafts and wind or redirect ventilation so that it does not blow directly on workers.
- Provide workers with insulated gloves and tools and equipment that has insulated handles or hold points and padded or plastic chairs to minimize conductive heat transfer from their bodies to cold objects.

Controlling Cold Stress—continued

Administrative Controls

Administrative controls are an effective method of reducing the potential for cold stress if they are adhered to. Administrative controls include management controls as well as worker responsibility.

Management Controls

Management controls may involve the following actions:

- Schedule work during the warmer part of the day, if possible in areas where the sun is shining.
- Arrange work to avoid long periods of sitting or standing still.
- Use work rest cycles to rotate workers or teams in and out of potential cold stress conditions, allowing them to warm themselves during breaks.
- In temperatures below 10°F, allow new workers to acclimate to the cold and the protective clothing being used by reducing the length of their workday for the first few days.
- Provide warm soups or sweet drinks to prevent dehydration and give energy. Sugar is an instant energy source that can help to increase metabolism and so provide heat. Do not allow alcohol, which can slow the metabolism, or caffeine, which can increase dehydration.
- Provide general awareness training describing the signs, symptoms, and treatment for cold stress and site-specific training detailing what controls are in place to prevent cold stress, how they work, and what to do in an emergency.
- Maintain medical surveillance on workers who are exposed to cold stress situations.

Controlling Cold Stress—continued

Worker Responsibilities

Workers should do the following:

- Keep ears, toes, fingers, cheeks, and noses covered, especially when wind is present.
- Wear layers of warm clothing that can be removed or put back on as the individual heats up or cools down. Remove layers as necessary to minimize sweating, especially while performing physically demanding work,
- When physically demanding work ceases for extended periods of time (such as during lunchtime or periods of sedentary activity), do not wait to cool down before putting on additional clothing.
- Change clothing when it becomes wet.
- Use the buddy system, especially in remote or isolated areas. Know the signs and symptoms to watch for, conduct regular checks of your coworkers, and know what actions to take if you observe cold stress signs or symptoms. Stop work and warm up if symptoms of frostbite or hypothermia are suspected.

Controlling Cold Stress—continued

Personal Protective Equipment

To help prevent cold stress, follow these guidelines when choosing or wearing PPE:

- Use clothing that is tight enough to prevent exposure to drafts of cold air, but not so tight that it inhibits circulation. Clothing that is too tight may interfere with the blood flow, reducing the body's ability to keep extremities warm.
- Use clothing that retains insulating power even if it gets wet. (Wool and some types of polypropylene will still provide insulation against cold even after they are wet; cotton loses nearly all insulative properties once it is wet.)
- Use dry, thin liners to remove moisture (sweat) away from the body or wear breathable clothing to avoid a buildup of moisture beneath the clothes, which may cause rapid cooling once individual energy expenditure (metabolic heat) is reduced.
- Use waterproof clothing when working in wet areas. Gore-Tex™ is a good example of waterproof clothing that also allows sweat to evaporate, preventing the insulative layers beneath the Gore-Tex™ from becoming wet from sweat as quickly.

Workplace Evaluation

Depending on workplace conditions and location and/or the PPE being worn, cold stress monitoring may be required by LIR402-820-01. To find out if monitoring is required, or if you are concerned about the potential for cold stress in your work area, talk to your supervisor and your site health and safety professional or call HSR-5 at 5-4427 for a workplace evaluation.

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