

APPENDIX D

HEAT/COLD STRESS MONITORING

- D-1. Heat Stress. Heat stress usually is a result of protective clothing decreasing natural body ventilation, although it may occur at any time work is being performed at elevated temperatures.
- a. Symptoms. If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur ranging from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to fatal. Because heat stress is one of the most common and potentially serious illnesses at hazardous waste sites, regular monitoring and other preventative measures are vital. Site workers must learn to recognize and treat the various forms of heat stress.
 - b. Treatment. The best approach is preventative heat stress management. In general:
 - (1) Urge workers to drink 0.5 liters (16 ounces) of water before beginning work, such as in the morning or after lunch. Provide disposable 120-ml (4-ounce) cups and water that is maintained at 10 degrees to 15 degrees C (50 degrees to 60 degrees F). Urge workers to drink 1 to 2 of these cups of water every 20 minutes, for a total of 3.5 to 7 liters (1 to 2 gallons) per day. Workers must wash hands and face prior to drinking. Provide a cool area for rest breaks.
 - (2) Acclimate workers to site work conditions by slowly increasing workloads, i.e., do not begin site work with extremely demanding activities.
 - (3) Provide cooling devices to aid natural body ventilation. These devices, however, add weight, and their use should be balanced against worker efficiency. An example of a cooling aid is long cotton underwear that acts as a wick to help absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing.
 - (4) Install mobile showers and/or hose-down facilities to reduce body temperature and to cool protective clothing.
 - (5) Conduct field activities in the early morning or evening in hot weather.

- (6) Ensure that adequate shelter is available to protect personnel against heat, cold, rain, or snow, etc., all of which can decrease physical efficiency and increase the probability of both heat and cold stress. If possible, set up the command post in the shade.
- (7) In hot weather, rotate shifts of workers wearing impervious clothing.
- (8) Good hygienic standards must be maintained by frequent changes of clothing and showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should immediately consult medical personnel and the site safety and health officer (SSHO).

D-2. Heat Stroke. Heat stroke is a medical emergency, with a high mortality rate. Heat stroke is an acute and dangerous reaction to heat stress caused by a failure of heat-regulating mechanisms of the body - the individual's temperature control system that causes sweating stops working correctly. Body temperature rises so high that brain damage and death will result if the person is not cooled quickly.

- a. Symptoms: Red, hot, dry skin, although person may have been sweating earlier; nausea; dizziness; confusion; extremely high body temperature; rapid respiratory and pulse rates; unconsciousness; or coma.
- b. Treatment: The most important objective in the treatment of heat stroke is the lowering of the victim's body temperature as rapidly as possible. Cool the victim quickly. If the body temperature is not brought down fast, permanent brain damage or death will result. Soak the victim in cool but not cold water, sponge the body with cool water, or pour water on the body to reduce the temperature to below 102 degrees F. Observe the victim and obtain medical help. Do not give coffee, tea, or alcoholic beverages.

D-3. Heat Exhaustion. Heat exhaustion is a state of very definite weakness or exhaustion caused by the loss of fluids from the body. This condition is much less dangerous than heat stroke, but it nonetheless must be treated.

- a. Symptoms: Pale, clammy, moist skin; profuse perspiration; and extreme weakness. Body temperature is normal, pulse is weak and rapid, breathing is shallow. The person may have a headache, may vomit, and may be dizzy.
- b. Treatment: Remove the person to a cool, air conditioned place; loosen clothing; place in a head-low position; and provide bed

rest. Consult physician, especially in severe cases. The normal thirst mechanism is not sensitive enough to ensure body fluid replacement. Have patient drink 1 to 2 cups of water immediately, and every 20 minutes thereafter, until symptoms subside. Total water consumption should be about 3.5 to 7 liters (1 to 2 gallons) per day.

- D-4. Heat Cramps. Heat cramps are caused by perspiration that is not balanced by adequate fluid intake. Heat cramps are often the first sign of a condition that can lead to heat stroke.
- a. Symptoms: Acute painful spasms of voluntary muscles (e.g., abdomen and extremities).
 - b. Treatment: Remove victim to a cool area and loosen clothing. Have patient drink 1 to 2 cups of water immediately, and every 20 minutes thereafter, until symptoms subside. Total water consumption should be 3.5 to 7 liters (1 to 2 gallons) per day. Consult with physician.
- D-5. Heat Rash. Heat rash is caused by continuous exposure to heat and humid air and aggravated by chafing clothes. The condition decreases ability to tolerate heat.
- a. Symptoms: Mild red rash, especially in areas of the body in contact with protective gear.
 - b. Treatment: Decrease amount of time in protective gear and provide powder to help absorb moisture and decrease chafing.
- D-6. Heat Stress Monitoring and Work Cycle Management. For strenuous field activities that are part of ongoing site work activities in hot weather, the following procedures should be used to monitor the body's physiological response to heat and to manage the work cycle, even if workers are not wearing impervious clothing. These procedures are to be instituted when the temperature exceeds 70 degrees F.
- a. Measure Heart Rate (HR). Take a rest period and measure heart rate by the radial pulse for 30 seconds as early as possible, in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute. If the HR is higher, shorten the next work period by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 110 beats/minute at the beginning of the next rest period, shorten the following work cycle by another 33 percent. The procedure is continued until the rate is maintained below 110 beats/minute.
 - b. Measure Body Temperature. Body temperature should be measured orally with a clinical thermometer as early as possible in the

resting period. Oral temperature (OT) at the beginning of the rest period should not exceed 99.40 degrees F; if it does, the worker will be prohibited from continuing work until the OT is maintained below 99.4 degrees F (37.4 degrees C).

- c. Manage Work/Rest Schedule. Use the following work/rest schedule as a guideline:

Adjusted Temperature (°F)	Active Work Time (min/hr) Using Level B/C Protective Gear
75 or less	50
80	40
85	30
90	20
95	10
100	0

- d. Measure the air temperature with a standard thermometer. Estimate fraction of sunshine by judging what percent of the sun is out:

- 100-percent sunshine = no cloud cover = 1.0
- 50-percent sunshine = 50-percent cloud cover = 0.5
- 0-percent sunshine = full cloud cover = 0.0

Calculate the adjusted temperature:

$$T (\text{adjusted}) = T (\text{actual}) + (13 \times \text{fraction sunshine})$$

- e. Reduce or increase the work cycle according to the guidelines under heart rate and body temperature.

D-7. Cold Stress.

- a. Persons working outdoors in low temperatures, especially at or below freezing are subject to cold stress. Exposure to extreme cold for a short time causes severe injury to the surface of the body or results in profound generalized cooling, causing death. Areas of the body that have high surface area-to-volume ratio such as fingers, toes, and ears are the most susceptible.
- b. Protective clothing. Personal protective clothing and equipment are essential in the prevention of cold stress and injury related to a cold environment. Clothing made of thin cotton fabric is ideal; it helps evaporate sweat by "picking it up" and bringing it

to the surface. Loosely fitted clothing also aids sweat evaporation. Tightly fitted clothing of synthetic fabric interferes with evaporation. Recommended clothing includes the following: cotton undershirt, cotton shorts/underpants, cotton and wool thermal underwear, cotton and wool socks, wool or thermal trousers (quilted or specially lined), waterproof insulated boots, wool shirt, wool sweater over cotton shirt, Anorak or arctic parka, wool knit cap, hard-hat liner, wool mittens, ski mask or scarf, and windproof and waterproof outer layer.

- c. Many factors influence the development of a cold injury: the type and duration of exposure, the ambient temperature, the humidity, and the velocity of the wind. Wind chill is used to describe the chilling effect of moving air in combination with low temperature.
- d. As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. Additionally, water conducts heat 240 times faster than air. Thus, the body cools suddenly when chemical-protective equipment is removed if the clothing underneath is perspiration soaked.

D-8. Frostbite Symptoms. Local injury resulting from cold is included in the generic term frostbite. Frostbite of the extremities can be categorized in three ways:

- Frost nip or incipient frostbite is characterized by sudden blanching or whitening of skin.
- Superficial frostbite is characterized by skin with a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.
- Deep frostbite is characterized by tissues that are cold, pale, and solid.

b. Treatment. To administer first aid for frostbite:

- (1) Take the victim indoors and rewarm the areas **quickly** in water that is between 39 degrees and 41 degrees C (102 degrees and 105 degrees F).
- (2) Give a warm drink—**not** coffee, tea, or alcohol. The victim must not smoke.
- (3) Keep the frozen parts in warm water or covered with warm clothes for 30 minutes, even though the tissue will be very painful as it thaws.

- (4) Elevate the injured area and protect it from injury.
 - (5) Do not allow blisters to be broken.
 - (6) Use sterile, soft, dry material to cover the injured areas.
 - (7) Keep victim warm and get immediate medical care.
- c. Precautions. After thawing, the victim should try to move the injured areas a little, but no more than can be done alone, without help.
- (1) Do *not* rub the frostbitten part (this may cause gangrene).
 - (2) Do *not* use ice, snow, gasoline, or anything cold on the frostbitten area.
 - (3) Do *not* use heat lamps or hot water bottles to rewarm the part.
 - (4) Do *not* place the part near a hot stove.
- D-9. Hypothermia. Systemic hypothermia is caused by exposure to freezing or rapidly dropping temperature.
- a. Symptoms. Its symptoms are usually exhibited in five stages:
- (1) Shivering.
 - (2) Apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95 degrees F.
 - (3) Unconsciousness, glassy stare, slow pulse, and slow respiratory rate.
 - (4) Freezing of the extremities.
 - (5) Death.
- b. Treatment. As a general rule, field activities must be curtailed if equivalent chill temperature (degrees F) as defined in Table D-1 is below zero (0 degrees F).

**TABLE D-1
COOLING POWER ON EXPOSED FLESH EXPRESSED AS AN
EQUIVALENT TEMPERATURE UNDER CALM CONDITIONS***

Actual Temperature Reading (°F)												
Estimated Wind Speed (in mph)	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 (1) minute.				GREAT DANGER Flesh may freeze within 30 seconds.			
Trenchfoot and immersion foot may occur at any point on this chart.												
*Developed by U.S. Army Research Institute of Environmental Medicine, Natick, MA SOURCE: ACGIH, Threshold Limit Values for Chemical Substances in the Work Environment for 1984-1985.												