TEMPERATURE EXTREMES

Heat Stress and Cold Stress

HEAT STRESS

Introduction

Heat stress depends on work rate as well as environmental heat load. When the body cannot cope with an excess heat load, three heat illnesses may occur. The most severe is heat stroke, which is characterized by dry skin, rapidly rising body temperature, collapse and death unless there is a prompt reduction in body temperature. Heat exhaustion is characterized by clammy moist skin, weakness, nausea, headache, low blood pressure and a weak pulse. Collapse will occur unless there is prompt rest and replenishment of lost electrolyte. Heat cramps are characterized by painful muscle spasms that disappear with rest and electrolyte replacement.

Definitions

Wet-Bulb Globe Temperature (WBGT) - an index used to quantify stress caused by radiant and convective heat, humidity, and wind. WBGT values are calculated using one of the following equations:

- With direct exposure to sunlight:

  $WBGT_{out} = 0.7\ T_{nwb} = 0.2\ T_g + 0.1\ T_{db}$

- Without direct exposure to the sun:

  $WBGT_{in} = 0.7\ T_{nwb} + 0.3\ T_g$

Where: T_{nwb} = natural wet bulb temperature (sometimes called NWB)
T_g = globe temperature (sometimes called GT)
T_{db} = dry bulb (air) temperature (sometimes called DB)

Responsibilities

The supervisor of work in hot environments shall notify their division/section ES&H group prior to the start of work.

The division/ section ES&H group shall perform all industrial hygiene testing needed to estimate the hazards of hot-weather work.

The ES&H Group or Section shall calibrate and maintain industrial hygiene equipment used to quantify heat stress potential.

Procedures

1. Exposure to heat stress should be evaluated by the division/ section safety personnel whenever there is a concern about this hazard. Assessment is based on Wet Bulb Globe Thermometer readings plus work levels and/ or the effect(s) heat stress is having on the workers.

2. If heat stress is found to be a problem, then the following controls should be implemented.

    a. The workload should be initially reduced and gradually increased over the first week of exposure. This should include newly assigned workers and those recently returning from a serious illness or long vacation.

    b. Individuals should not work alone. In the event that one experiences heat illness, the other(s) present can arrange for help.

    c. Individuals should drink a cup of cool water every 15-20 minutes.

    d. Consider modification of work activities, schedules and locations.

3. Table 1 below is for assessing and controlling heat exposures.

Table 1. Screening Criteria for Heat Stress Exposure (WBGT values in °C)

	Acclimatized				Unacclimatized			
Work Demands	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	29.5	27.5	26		27.5	25	22.5	
75% Work; 25% Rest	30.5	28.5	27.5		29	26.5	24.5	
50% Work; 50% Rest	31.5	29.5	28.5	27.5	30	28	26.5	25
25% Work; 75% Rest	32.5	31	30	29.5	31	29	28	26.5

A. Values are given in °C WBGT. As workload increases, the heat stress impact on unacclimatized worker is increased. For unacclimatized workers performing a moderate level of work, the permissible heat exposure TLV should be reduced approximately 2.5°C.

B. Light Work (up to 200 kcal/ hr or 800 Btu/ hr): e.g., sitting or standing to control machines, performing light hand or arm work,

C. Moderate Work (200-350 kcal/ hr or 800-1400 Btu/ hr): e.g., walking about with moderate lifting and pushing, or,

D. Heavy Work (350-500 kcal/ hr or 1400-2000 Btu/ hr): e.g., pick and shovel work.

E. Very Heavy Work (over 500 kcal/ hr or 2000 Btu/ hr): e.g., shoveling wet sand

F. TLVs should be corrected for clothing as follows:

Clothing Type	WBGT Additions
Summer work clothing	0
Cloth (woven material) overalls	+3.5
Double-cloth overalls	+5

COLD STRESS

Introduction

Cold stress standards are intended to prevent workers from the severest effects of cold stress (hypothermia) and cold injury, and to describe exposures to cold working conditions under which it is believed that nearly all workers can be repeatedly exposed without adverse health effects.

Fatal exposures to cold among workers have almost always resulted from accidental exposures involving failure to escape from low environmental air temperatures or immersion in low temperature water. Lower body temperatures often result in reduced mental alertness, reduction in rational decision-making, or loss of consciousness with the threat of fatal consequences.

Definitions

Equivalent Chill Temperature (ECT) - The perceived combined effect of cold and wind on exposed skin. Also known as *wind chill factor.*

Responsibilities

The supervisors of work in cold environments shall notify their division/section ES&H group prior to the start the work.

The division/ section ES&H group shall perform all industrial hygiene testing needed to estimate hazards of extended cold-weather work.

The ES&H Group or Section shall calibrate and maintain industrial hygiene equipment used to quantify cold hazards.

Procedures

1. Upon starting work in a very cold environment, the supervisor shall notify the division/ section ES&H group, who shall decide if further consideration is necessary. The division/ section ES&H group may, with the help of the ES&H Section, perform industrial hygiene sampling to determine the ECT in the work area. At the discretion of the ES&H Section, local weather broadcasts may be used to determine ECT.

2. For work in environments where the ECT is less than -25°F (-31.7°C), the supervisor shall impose the work/ rest regimens shown in Table 2.

3. Supervisors shall halt all extended cold-weather work in environments of <-75°F (< 59.4°C) ECT.

Table 2. Work/Warm-Up Schedule for Four-Hour Shift

Air Temp		Calm		5 mph wind		10 mph wind		15 mph wind		20 mph wind	
^{o}C	^{o}F	Max Work Period	Number of Breaks	Max Work Period	Number of Breaks	Max Work Period	Number of Breaks	Max Work Period	Number of Breaks	Max Work Period	Number of Breaks
-26° to -28°	-15° to -19°	Normal Breaks	1	Normal Breaks	1	75 min.	2	55 min	3	40 min	4
-29° to -31°	-20° to -24°	Normal Breaks	1	75 min.	2	55 min.	3	40 min.	4	30 min.	5
-32° to -34°	-25° to -29°	75 min.	2	55 min.	3	40 min.	4	30 min.	5	Cease non-emerg. work	
-35° to -37°	-30° to - 34°	55 min.	3	40 min.	4	30 in.	5	Cease non-emerg. work			
-38° to -39°	-35° to -39°	40 min	4	30 min	5	Cease non-emerg. work					
-40° to -42°	-40° to -44°	30 min	5	Cease non-emerg. work							
-43° & below	-45° & below	Cease non-emerg. work									

Prevention of Cold Stress

1. Adequate insulating of dry clothing to maintain core temperature above 36°C (96.8°F) must be provided to workers if it is performed at air temperatures below 4°C (40°F). The higher the wind speed and the lower the temperature in the work area, the greater the insulation value of the protective clothing required. An equivalent chill temperature can be computed using the air temperature and the wind velocity (see Table 3). "Wind chill factors" can also be heard on local weather broadcasts.

2. For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -3.2°C (25.6°F). Superficial or deep local freezing will occur only at temperatures below -1C (30.2F), regardless of wind speed.

3. The recommended limits for properly clothed workers for periods of work at temperatures below freezing are found in Table 2. Older workers or workers with circulatory problems require special protection against cold injury.

Table 3. Cooling Power of Wind on Exposed Flesh Expressed as Equivalent Temperature (under calm conditions)*

Estimated Wind Speed (in mph)	Actual Temperature (°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.			
	Trenchfoot and immersion foot may occur at any point on this chart.											

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

▭ Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36°C (98.6°F) per cold stress TLV®.