FESHM 4250: Temperature Extremes

Revision History

Author	Description of Change	Revision No. & Date
Jonathan Staffa	Guidance on general controls for heat stress and cold stress. Editorial changes made as needed.	June 2020
Jonathan Staffa & David Baird	Added FESHM Chapter format to document, adopted current TLVs and modified responsibilities.	March 2015

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(Heat Stress Sections 1-4; Cold Stress Sections 5-8)

HEAT STRESS

1.0 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.

2.0 DEFINITIONS

Acclimatization – a gradual physiological adaption that improves an individual's ability to tolerate heat stress.

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)

3.0 RESPONSIBLILITIES

3.1 Managers and Supervisors

The Managers or supervisors shall notify their DSO prior to the start of work in hot environments.

3.2 Division Safety Officer (DSO)

The DSO shall assist in identifying work in the Division/Sections/Projects that may require an industrial hygiene exposure assessment.

3.3 Industrial Hygiene (IH) Group

- Provide and maintain heat stress monitoring equipment.

- Conduct heat stress assessments.
- Identify heat stress hazards that exceed the limit values of using Tables 1-3 (Section 4.2), provide employee training and recommend engineering and/or administrative controls.

4.0 PROCEDURES

Exposure to heat stress should be assessed by the IH Group whenever there is a concern about this hazard. An IH survey may be conducted to compare conditions to Occupational Exposure Limits (OELs). Wet Bulb Globe Temperature measurements, metabolic rates, and the effect of heat stress on the workers is considered.

4.1 Control Implementation

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

a. The workload should be initially reduced and gradually increased over the first week of exposure to allow the worker to acclimatize. This should include newly assigned workers; those recently returning from a serious illness, long vacation, or has been recently relocated from another geographical area where climates differ.
b. Individuals should not work alone. If a worker experiences heat illness, the other(s) present can arrange for help.
c. Encourage employees to report signs and symptoms of heat strain they may have to the supervisor
d. Stay hydrated by drinking a cup of cool water (or other acceptable fluid replacement drink) about every 20 minutes.
e. Consider modification of work activities, schedules and locations.
f. Workers should consider clothing layers that are loose, light weight, open weave, and have moisture wicking properties.
g. If flame resistant/arc rated garments are required, donning and doffing required PPE layers could expose the worker to additional hazards. The outermost layer must be FR/AR adequate to prevent break open and ignition of the flammable under layer.

4.2 Screening Criteria for Heat Stress Exposure[1]

4.2.1. Table 1. Clothing-Adjustment Factors for Some Clothing Ensembles

Clothing Type	Addition to WBGT °C
Work cloths (long sleeve shirt and pants)	0
Cloth (woven material) coveralls	0
Double-layer woven clothing	3
SMS polypropylene overalls	0.5
Polyolefin coveralls	1
Limited-use vapor-barrier coveralls	11

4.2.2. Table 2. Screening Criteria for TLV and Action Limit for Heat Stress Exposure

	TLV® (WBGT values in ˚C)				**Action Limit (WBGT values in ˚C)**			
Allocation of Work in a Cycle of Work and Recovery	**Light**	**Moderate**	**Heavy**	**Very Heavy**	**Light**	**Moderate**	**Heavy**	**Very Heavy**
75 to 100%	31.0	28.0	-	-	28.0	25.0	-	-
50 to 75%	31.0	29.0	27.5	-	28.5	26.0	24.0	-
25 to 50%	32.0	30.0	29.0	28.0	29.5	27.0	25.5	24.5
0 to 25%	32.5	31.5	30.5	30.0	30.0	29.0	28.0	27.0

4.2.3. Table 3. Metabolic Rate Categories and the Representative Metabolic Rate with Example Activities

A. Light Work: Sitting with light manual work with hands or arms and driving. Standing with some light arm work and occasional working.

B. Moderate Work: Sustained moderate hand and arm work, moderate arm and leg work, moderate arm and truck work, or light pushing and pulling. Normal walking.

C. Heavy Work: Intense arm and trunk work, carrying, shoveling, manual sawing; pushing and pulling heavy loads; and walking at a fast pace.

D. Very Heavy Work: Very intense activity at fast to maximum pace.

E. TLVs should be corrected for clothing as follows:

[1]Note: Detailed information on these tables and their application is available in the latest version of the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents & Biological Agents & Biological Exposure Indices.

COLD STRESS

5.0 INTRODUCTION

Cold stress standards are intended to prevent workers from most severe effects of cold stress (hypothermia and frostbite) 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.

6.0 DEFINITIONS

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

7.0 RESPONSIBLILITIES

7.1 Managers & Supervisors

The Managers or supervisors shall notify their DSO prior to the start of work in cold environments.

7.2 Division Safety Officer (DSO)

The DSO shall assist in identifying work in the Division/Sections/Projects that may require an industrial hygiene exposure assessment.

7.3 Industrial Hygiene (IH) Group

The IH Group is responsible for sampling and maintaining industrial hygiene equipment used to quantify cold hazards.

8.0 PROCEDURES

Upon starting work in a very cold environment, the supervisor shall notify the DSO, who shall decide if further consideration is necessary. The DSO may, with the help of the IH Group, perform industrial hygiene assessments to determine the ECT in the work area. At the discretion of the IH Group, local weather broadcasts may be used to determine ECT.

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 4.

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

8.1 Screening Criteria for Cold Stress Exposure[1]

8.1.1. Table 4. Work/Warm-Up Schedule for a 4-Hour Shift

Air Temp-Sunny Sky		No Noticeable Wind		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	Non-emergency work should cease	
-35° to -37°	-30° to - 34°	55 min.	3	40 min.	4	30 in.	5	Non-emergency work should cease			
-38° to -39°	-35° to -39°	40 min	4	30 min	5	Non-emergency work should cease					
-40° to -42°	-40° to -44°	30 min	5	Non-emergency work should cease							
-43° & below	-45° & below	Non-emergency work should cease									

Prevention of Cold Stress

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 4). "Wind chill factors" can also be heard on local weather broadcasts.

For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32°C (-25.6°F). Superficial or deep local freezing will occur only at temperatures below -1C (30.2F), regardless of wind speed.

The recommended limits for properly clothed workers for periods of work at temperatures below freezing are found in Table 5. Older workers or workers with circulatory problems require special protection against cold injury.

If flame resistant/arc rated garments are required, donning and doffing required PPE layers could expose the worker to additional hazards. The outermost layer must be FR/AR adequate to prevent break open and ignition of the flammable under layer(s).

8.1.2. Table 5. 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®.

[1]Note: Detailed information on these tables and their application is available in the latest version of the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents & Biological Agents & Biological Exposure Indices.