P-30
Thermal Stress

COLD STRESS

The cold stress TLVs® are intended to protect workers from the severe effects of cold stress (hypothermia) and cold temperature injuries and to describe acceptable cold temperature working conditions where workers should not have any long term negative effects. The TLV® objective is to prevent the deep body temperature from falling below 36°C (96.8°F) and to prevent cold injury to body extremities (deep body temperature is the core temperature of the body determined by conventional methods for rectal temperature measurements). For a single, occasional exposure to a cold environment, a drop in core temperature to no lower than 35°C (95°F) should be permitted. In addition to provisions for total body protection, the TLV® objective is to protect all parts of the body with emphasis on hands, feet, and head from cold injury.

Introduction

Fatal exposures to cold temperatures among workers have almost always resulted from accidental exposures involving failure to escape from low environmental air temperatures or from immersion in low temperature water. The single most important aspect of life-threatening hypothermia is the fall in the deep core temperature of the body. The clinical presentations of victims of hypothermia are shown in table 1. Workers should be protected from exposure to cold temperatures so that the deep core temperature does not fall below 36°C (96.8°F); lower body temperatures will very likely result in reduced mental alertness, reduction in rational decision-making, or loss of consciousness with the threat of fatal consequences.

Pain in the extremities may be the first early warning of danger to cold stress. During exposure to cold, maximum severe shivering develops when the body temperature has fallen to 35°C (95°F) or below. This must be taken as a sign of danger to the workers and if worker's show signs of over exposure to cold temperature he/she should immediately be removed from that environment. Useful physical or mental work is limited when severe shivering occurs.

Since prolonged exposure to cold air or to immersion in cold water, at temperatures well above freezing can lead to dangerous hypothermia, whole body protection must be provided.

1. Adequate insulating dry clothing to maintain core temperatures above 36°C (96.8°F) must be provided to workers if work is performed in air temperatures below 4°C (39.2°F). Wind chill cooling rate and the cooling power of air are critical factors. [Wind chill cooling rate is defined as heat loss from a body expressed in watts per meter squared which is a function of the air temperature and wind velocity upon the exposed body.] 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 chart relating the actual dry bulb air temperature and the wind velocity is presented in Table 2. The equivalent chill temperature should be used when estimating the combined cooling effect of wind and low air temperatures on exposed skin or when determining clothing insulation requirements to maintain the deep core temperature.

TABLE1. Progressive Clinical Presentations of Hypothermia*

Core Temperature °C	°F	Clinical Signs
37.6	99.6	"Normal" rectal temperature
37	98.6	"Normal" oral temperature
36	96.8	Metabolic rate increases in an attempt to compensate for heat loss
35	95.0	Maximum shivering
34	93.2	Victim conscious and responsive, with normal blood pressure
33	91.4	Severe hypothermia below this temperature
32}	89.6}	Consciousness clouded; blood pressure becomes
31}	87.8}	difficult to obtain; pupils dilated but react to light; shivering ceases
30}	86.0}	Progressive loss of consciousness; muscular rigidity
29}	84.2}	increases; pulse and blood pressure difficult to obtain; respiratory rate decreases
28	82.4	Ventricular fibrillation possible with myocardial irritability
27	80.6	Voluntary motion ceases; pupils nonreactive to light; deep tendon and superficial reflexes absent
26	78.8	Victim seldom conscious
25	77.0	Ventricular fibrillation may occur spontaneously
24	75.2	Pulmonary edema
22}	71.6}	Maximum risk of ventricular fibrillation
21}	69.8}	
20	68.0	Cardiac standstill
18	64.4	Lowest accidental hypothermia victim to recover
17	62.6	Isoelectric electroencephalogram
9	48.2	Lowest artificially cooled hypothermia patient to recover

2. Unless there are unusual or extenuating circumstances, cold injury (other than hands, feet and head) is not likely to occur without the development of the initial signs of hypothermia. Older workers or workers with circulatory problems require special precautionary protection against cold injury. The use of extra insulating clothing and/or a reduction in the duration of the exposure period are among the special precautions which should be considered. The precautionary actions to be taken will depend upon the physical condition of the worker and should be determined with the advice of the physician with knowledge of the cold stress factors and the medical condition of the worker.

Evaluation and Control

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 tissue freezing will occur only at temperatures below -1°C (30.2°F) regardless of wind speed.

At air temperatures of 2°C (35.6°F) or less, it is imperative that workers who become immersed in water or whose clothing becomes wet be immediately provided a change of clothing and be treated for hypothermia.

TLVs® recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 3.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents:

1. If fine work is to be performed with bare hands for more than 10 to 20 minutes in an environment below 16°C (60.8°F), special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be utilized. Metal handles of tools and control bars should be covered by thermal insulating material at temperatures below -1°C (30.2°F).

2. If the air temperature falls below 16°C (60.8°F) for sedentary, 4°C (39.2°F) for light, -7°C (19.4°F) for moderate work, and fine manual dexterity is not required, than gloves should be used by the workers.

To prevent contact frostbite, the workers should wear anti-contact gloves.

1. When cold surfaces below -7°C (19.4°F) are within reach, a warning should be given to each worker to prevent inadvertent contact by bare skin.

2. If the air temperature is –17.5°C (0°F) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers should wear cold protective clothing appropriate for the level of cold and physical activity:

1. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing and easily removable windbreak garment.

2. If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of the clothing in use may be of a type impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outerwear should be changed as it becomes wetted. The outer garments should include provisions for easy ventilation in order to prevent wetting of inner layers by sweat. If work is done at normal temperatures or in a

hot environment before entering the cold area, the employee should make sure that clothing is not wet as a consequence of sweating. If clothing is wet, the employee should change into dry clothes before entering cold area. The workers should change socks and any removable felt insoles at regular daily intervals or use vapor barrier boots. The optimal frequency of change should be determined empirically and will vary individually and according to the type of shoe worn and how much the individual's feet sweat.

3. If exposed areas of the body cannot be protected sufficiently to prevent sensation of excessive cold or frostbite, protective items should be supplied in auxiliary heated versions.

4. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work should be modified or suspended until adequate clothing is made available or until weather conditions improve.

5. Workers handling evaporative liquid (gasoline, alcohol or cleaning fluids) at air temperatures below 4°C (39.2°F) should take special precautions to avoid soaking of clothing or gloves with the liquids because of the added danger of cold injury due to evaporative cooling. Special note should be taken of the particularly acute effects of splashes of "cryogenic fluids" or those liquids with a boiling point that is just above ambient temperature.

Work-Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) or below -7°C (19.4°F), heated warming shelters (tents, cabins, restrooms, etc.) should be made available nearby. The workers should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, minor frostbite (frost-nip), the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation or a change of dry work clothing provided. A change of dry work clothing should be provided as necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12°C (10.4°F) ECT, the following should apply:

1. The worker should be under constant protective observation (buddy system or supervision).

2. The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods should be taken in heated shelters and opportunity for changing into dry clothing should be provided.

3. New employees should not be required to work fulltime in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.

4. The weight and bulkiness of clothing should be included in estimating the required work performance and weights to be lifted by the worker.

5. The work should be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats should be used. The worker should be protected from drafts to the greatest extent possible.

6. The workers should be instructed in safety and health procedures. The training program should include as a minimum instruction in:

    a. Proper re-warming procedures and appropriate first aid treatment.

    b. Proper clothing practices.

    c. Proper eating and drinking habits.

    d. Recognition of impending frostbite.

    e. Recognition of signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.

    f. Safe work practices.

Special Workplace Recommendations

Special design requirements for refrigerator rooms include the following:

1. In refrigerator rooms, the air velocity should minimized as much as possible and should not exceed 1 meter/sec (200 fpm) at the job site. This can be achieved by properly designed air distribution systems.

2. Special wind protective clothing should be provided based upon existing air velocities to which workers are exposed.

Special caution should be exercised when working with toxic substances and when workers are exposed to vibration. Cold exposure may require reduced exposure limits.

Eye protection for workers employed out-of-doors in a snow and/or ice-covered terrain should be supplied. Special safety goggles to protect against ultraviolet light and glare (which can produce temporary conjunctivitis and/or temporary loss of vision) and blowing ice crystals should be required when there is an expanse of snow coverage causing a potential eye exposure hazard.

Workplace monitoring is required as follows:

1. Suitable thermometry should be arranged at any workplace where the environmental temperature is below 16°C (60.8°F) so that overall compliance with the requirements of the TLV® can be maintained.

2. Whenever the air temperature at a workplace falls below -1° (30.2°F), the dry bulb temperature should be measured and recorded at least every 4 hours.

3. In indoor workplaces, the wind speed should also be recorded at least every 4 hours whenever the rate of air movement exceeds 2 meters per second (5 mph).

4. In outdoor work situations, the wind speed should be measured and recorded together with the air temperature whenever the air temperature is below -1°C (30.2°F).

5. The equivalent chill temperature should be obtained from Table 2 in all cases where air movement measurements are required; it should be recorded with the other data whenever the equivalent chill temperature is below -7°C (19.4°F).

Employees should be excluded from work in cold at -1°C (30.2°F) or below if they are suffering from diseases or taking medication which interferes with normal body temperature regulation or reduces tolerance to work in cold environments. Workers who are routinely exposed to temperatures below -24°C (-11.2°F) with wind speeds less than five miles per hour, or air temperatures below -17.5°C (0°F) with wind speeds above five miles per hour, should be medically certified as a suitable for such exposures.

Trauma sustained in freezing or subzero conditions requires special attention because an injured worker is predisposed to cold injury. Special provisions should be made to prevent hypothermia and freezing of damaged tissues in addition to providing for first aid treatment.

HEAT STRESS AND HEAT STRAIN

Assessment of both heat stress and heat strain can be used for evaluating the risk to worker safety and health. A decision-making process such as that shown in Figure 1 is required. The guidance provided in figure 1 and in the associated documentation of the TLV® represents conditions under which it is believed that nearly all adequately hydrated, un-medicated, healthy workers may be repeatedly exposed without adverse health effects. The guidance is not a fine line between safe and dangerous levels. Professional judgment and a program of heat stress management are required to ensure adequate protection for each situation.

TABLE 1. Additions to Measured WBGT Values (°C)
For Some Clothing Ensembles

Clothing Type	WBGT Addition*
Summer work uniform	0
Cloth (woven material) overalls	+3.5
Double-cloth overalls	+5

*These values must not be used for encapsulating suits or garments that are impermeable or highly resistant to water vapor or air movement through fabrics.

Heat Stress is the net heat load to which a worker may be exposed from the combined contributions of metabolic cost of work, environmental factors (i.e., air temperature, humidity, air movement, and radiant heat exchange) and clothing requirements. A mild or moderate heat stress may cause discomfort and may adversely affect performance and safety, but it is not harmful to health. As the heat stress approaches human tolerance limits, the risk of heat-related disorders increases.

Heat strain is the overall physiological response resulting from heat stress. The physiological adjustments are dedicated to dissipating excess heat from the body. Acclimatization is a gradual physiological adaptation that improves an individual's ability to tolerate heat stress.

The decision process should be started if there are reports of discomfort due to heat stress or when professional judgment indicates it.

Section 1: Clothing. Ideally, free movement of cool, dry air over the skin's surface maximizes heat removal by both evaporation and convection. Evaporation of sweat from the skin is usually the predominant heat removal mechanism. Water-vapor-impermeable, air-impermeable, and thermally insulating clothing, severely restrict heat removal. With heat removal hampered by clothing, metabolic heat may produce life-threatening heat strain even when ambient conditions are considered cool.

Figure 1 requires a decision about clothing and how it might affect heat loss. The WBGT-based heat exposure assessment was developed for a traditional work uniform of a long-sleeved shirt and pants. If the required clothing is adequately described by one of the ensembles in Table 1, then the YES branch can be taken.

If workers are required to wear clothing not represented by an ensemble in Table 1, then the NO branch should be taken. This decision is especially applicable for clothing ensembles that are 1) barriers to water vapor or air movement, 2) encapsulating suits, or 3) multiple layers. For these kinds of ensembles, Table 2 is not a useful screening method to determine a threshold for heat stress management actions and some risk must be assumed. Physiological and behavioral monitoring described in Section 4 and Table 4 should be followed to assess the exposure, unless a detailed analysis method appropriate to the clothing requirements is available.

Section 2: Screening Threshold Based on Wet Bulb, Globe Temperature (WBGT). The WBGT offers a useful, first-order index of the environmental contribution to heat stress. It is influenced by air temperature, radiant heat, and humidity. As an approximation, it does not fully account for all the interactions between a person and the environment and cannot account for special conditions such as heating form a radiofrequency/microwave source.

WBGT values are calculated using one of the following equations:

- With direct exposure to sunlight:

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

- Without direct exposure to the sun:

  $WBGT_{in} = 0.7_{nwb} + 0.3T_{g}$

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)

Because WBGT is only an index of the environment, the screening criteria are adjusted for the contributions of work demands and clothing as well as state of acclimatization. Table 2 provides WBGT criteria suitable for screening purposes. For clothing adjustment factors are added to the environmental WBGT.

Acclimatization is a set of physiological adaptations, the development and loss of which are described in the Documentation. Full-heat acclimatization requires up to 3 weeks of continued physical activity under heat-stress conditions similar to those anticipated for the work. Its loss begins when the activity under those heat-stress conditions is discontinued, and a noticeable loss occurs after 4 days. With a recent history of heat-stress exposures (e.g. 5 of the last 7 days), a worker can be considered acclimatized for the purpose of using Table 2.

To determine the degree of heat-stress exposure, the work pattern and demands must be considered. If the work (and rest) is distributed over more than one location, then a time-weighted WBGT should be used for comparison to Table 2 limits.

As metabolic rate increases (i.e. work demand increase), the criteria values in Table 2 decrease to ensure that most workers will not experience a core body temperature above 38°C. Correct assessment of work rate is of equal importance to environmental assessment in evaluating heat stress. Table 3 provides broad guidance for selecting the work rate category to be used in Table 2. Often there are natural or prescribed rest breaks within an hour of work, and Table 2 provides the screening criteria for three allocations of work and rest.

Based on acclimatization state, metabolic rate category for the work, and the approximate proportion of work within an hour, a WBGT criterion can be found in Table 2. If the measured time-weighted WBGT adjusted for clothing is less than the table value, the NO branch in Figure 1 is taken, and there is little risk of excessive exposures to heat stress. Nevertheless, if there are reports of the symptoms of heat-related disorders such as fatigue, nausea, dizziness, and lightheadedness, then the analysis should be reconsidered.

If the work conditions are above the criteria in Table 2, then a further analysis is required following the YES branch.

Section 3: Detailed Analysis. Table 2 is intended to be used as a screening step. It is possible that a condition may be above the criteria provided in Table 2 and still not represent an unacceptable exposure. To make this determination, a detailed analysis is required. Methods are fully described in the Documentation, in industrial hygiene and safety books, and in other sources.

TABLE 2. Screening Criteria for Heat Stress Exposure (WBGT values in °C (°F)

	Acclimatized				**Unacclimatized**			
Work Demands	**Light**	**Moderate**	**Heavy**	**Very Heavy**	**Light**	**Moderate**	**Heavy**	**Very Heavy**
100 % Work	29 (84.2)	27 (80.6)	26 (78.8)		27 (80.6)	25 (77)	22 (71.6)	
75% Work; 25% Rest	30 (86)	28 (82.4)	27 (80.6)		29 (84.2)	26 (78.8)	24 (75.2)	
50% Work; 50% Rest	31 (87.8)	29 (84.2)	28 (82.4)	27 (80.6)	30 (86)	28 (82.4)	26 (78.8)	25 (77)
25% Work; 75% Rest	32 (89.6)	31 (87.8)	30 (86)	29 (84.2)	31 (87.8)	29 (84.2)	28 (82.4)	26 (78.8)

Notes:

- See Table 3 and the Documentation for work demand categories.
- WBGT values are expressed in ˚C, and represent thresholds near the upper limit of the metabolic rate category.
- If work and rest environments are different, hourly time-weighted averages (TWA) should be calculated and used. TWAs for work rates should also be used when the work demands vary within the hour.
- Values in this table are applied by reference to the "Work-Rest Regimen" section of the Documentation and assume 8-hour workdays in a 5-day workweek with conventional breaks, as discussed in the Documentation. When workdays are extended, consult the "Application of the TVL®" section of the Documentation.
- Because of the physiological strain associated with Very Heavy work among less fit workers regardless of WBGT, criteria values are not provided for continuous work and for up to 25% rest in an hour. The screening criteria are not recommended, and a detailed analysis and/or physiological monitoring should be used.

Table 3. Examples of Activities within Metabolic Rate Categories

Categories	Example Activities
Resting	Sitting quietly Sitting with moderate arm movements
Light	Sitting with moderate arm and leg movements Standing with light work at machine or bench while using mostly arms Using table saw Standing with light or moderate work at machine or bench and some walking about
Moderate	Scrubbing in a standing position Walking about with moderate lifting or pushing Walking on level at 6 Km/hr while carrying 3 Kg weight load
Heavy	Carpenter sawing by hand Shoveling dry sand Heavy assembly work on a noncontinuous basis Intermittent heavy lifting with pushing or pulling (e.g., pick –and-shovel work)
Very Heavy	Shoveling wet sand

Provided that there is adequate information on the heat stress effects of the required clothing, the first level of detailed analysis is a task analysis that includes a time-weighted average of the WBGT and the metabolic rate. Some clothing adjustment factors have been suggested in Table 1. Factors for other clothing ensembles appearing in the literature can be used in similar fashion following good professional judgment. The TLVs® for acclimatized and unacclimatized workers are provided in the Documentation, which, respectively, are the same as Recommended Exposure Limit (REL) and the Recommended Action Limit (RAL) recommended by NIOSH in 1989. [(1)] The second level of detailed analysis would follow a rational model of heat stress, such as the International Standards Organization (ISO) required sweat rate.[(2)] While a rational method (versus the empirically derived WBGT thresholds) is computationally more difficult, it permits a better understanding of the sources of the heat stress and is a means to appreciate the benefits of proposed modifications in the exposure. Guidance to the ISO method is provided in the Documentation and elsewhere, and other rational methods are described in the literature.

The screening criteria require the minimal set of data to make a determination. Detailed analyses require more data about the exposures. Following Figure 1, the next question asks about the availability of data for a detailed analysis. If these data are not available, the NO branch takes the evaluation to physiological monitoring to assess the degree of heat strain.

TABLE 4. Guidelines for Limiting Heat Strain

Monitoring signs and symptoms of heat-stressed workers is sound industrial hygiene practice, especially when clothing may significantly reduce heat loss. For surveillance purposes, a pattern of workers exceeding the limits is indicative of a need to control the exposures. On an individual basis, the limits represent a time to cease an exposure until recovery is complete.

Excessive heat strain may be marked by one or more of the following measures, and an individual's exposure to heat stress should be discontinued when any of the following occur:

- Sustained (several minutes) heart rate is in excess of 180 bpm (beats per minute) minus the individual's age in years (180-age), for individuals with assessed normal cardiac performance; or
- Body core temperature is greater than 38.5°C (101.3°F) for medically selected and acclimatized personnel; or greater than 38°C (100.4°F) in unselected, Unacclimatized workers; or
- Recovery heart rate at one minute after a peak work effort is greater than 110 bpm; or
- There are symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness.

An individual may be at greater risk if:

- Profuse sweating is sustained over hours; or
- Weight loss over a shift is greater than 1.5% of body weight; or
- 24-hour urinary sodium excretion is less than 50 moles

If a worker appears to be disoriented or confused, or suffers inexplicable irritability, malaise, or flu-like symptoms, the worker should be removed for rest in a cool location with rapidly circulating air and kept under skilled observation. Immediate emergency care may be necessary. If sweating stops and the skin becomes hot and dry immediate emergency care with hospitalization is essential.

If the data are available, the next step in Figure 1 is the detailed analysis. If the exposure does not exceed the criteria for the appropriate detailed analysis (e.g., WBGT analysis, another empirical method, or a rational method), then the NO branch can be taken. Because the criteria in Table 2 have been exceeded, general heat stress controls are appropriate. General controls include training for workers and supervisors, heat stress hygiene practices, and medical surveillance. If the exposure exceeds the limits in the detailed analysis, the YES branch leads to physiological monitoring as the only alternative to demonstrate that adequate protection is provided.

Section 4: Heat Strain. The risk and severity of excessive heat strain will vary widely among people, even under identical heat stress conditions. The normal physiological responses to heat stress provide an opportunity to monitor heat strain among workers and to use this information to assess the level of heat strain present in the workforce, to control exposures, and to assess the effectiveness of implemented controls. Table 4 provides guidance for acceptable limits of heat strain.

Following good industrial hygiene sampling practice, which considers likely extremes and the less tolerant workers, the absence of any of these limiting observations indicates acceptable management of the heat stress exposures. With acceptable levels of heat strain, the NO branch in Figure 1 is taken. Nevertheless, if the heat strain among is considered acceptable at the time, the general controls are necessary. In addition, periodic physiological monitoring should be continued to ensure acceptable levels of heat strain.

If limiting heat strain is found during the physiological assessments, then the YES branch is taken. This means that suitable job-specific controls must be considered and implemented to a sufficient extent to control heat strain. The job-specific controls include engineering controls, administrative controls, and personal protection. After implementation of the job-specific control, it is necessary to assess their effectiveness, and to adjust them as needed. The decision tree in Figure 1 returns to the detailed analysis step, and in the absence of detailed information, then the only method to ensure protection is to return to physiological monitoring.

Section 5: Heat Stress Management and Controls. The requirement to initiate a heat stress management program is marked by 1) heat stress levels that exceed the criteria in Table 2 or 2) work in clothing ensembles that limit heat loss. In either case, workers should be covered by a general controls (see Table 5).

Heat stress hygiene practices are particularly important because they reduce the risk that an individual may suffer a heat-related disorder. The key elements are fluid replacement, self-determination of exposures, health status monitoring, maintenance of a healthy life-style, and adjustment of expectations based on acclimatization state. The hygiene practices require the full cooperation of supervision and workers.

In addition to general controls, appropriate job-specific controls are often required to provide adequate protection. During the consideration of job-specific controls, Table 2, along with Tables 1 and 3, provide a framework to appreciate the interactions among acclimatization state, metabolic rate, work/rest cycles, and clothing. Among administrative control, Table 4 provides acceptable physiological and behavioral limits. The mix of job-specific controls can only be selected and implemented after a review of the demands and constraints of any particular situation. Once implemented, their effectiveness must be confirmed and the controls maintained.

TABLE 5. Guidelines for Heat Stress Management

- Monitor heat stress (e.g., WBGT Screening Criteria in Table 2) and heat strain (Table 4) to confirm adequate control.

General Controls

- Provide accurate verbal and written instructions, frequent training programs, and other information about heat stress and strain.
- Encourage drinking small volumes (approximately 1 cup) of cool, palatable water about every 20 minutes (refer to Documentation for choice of the contents provided in drinks for fluid replacement).
- Permit self-limitation of exposures and encourage co-worker observation to detect signs and symptoms to heat strain in others.
- Counsel and monitor those who take medications that may compromise normal cardiovascular, blood pressure, body temperature regulation, renal, or sweat gland functions; and those who abuse or are recovering from the abuse of alcohol or other intoxicants.
- Encourage healthy life-styles, ideal body weight and electrolyte balance.
- Adjust expectations of those returning to work after absence from hot exposure situations and encourage consumption of salty foods (with approval of physician if on a salt-restricted diet).
- Consider pre-placement medical screening to identify those susceptible to systemic heat injury.

Job-Specific Controls

- Consider engineering controls that reduce the metabolic rate, provide general air movement, reduce process heat and water-vapor release, and shield radiant heat sources, among others.
- Consider administrative controls that set acceptable exposure times, allow sufficient recovery, and limit physiological strain.
- Consider personal protection that is demonstrated effective for the specific work practices and conditions at the location.

--NEVER ignore anyone's signs or symptoms of heat-related disorders—

In all cases, the prime objective of heat stress management is the prevention of heat stroke, which is life-threatening and the most serious of the heat-related disorders. Heat stroke develops when thermoregulation has been overwhelmed, and the body has lost its major defenses to combat hyperthermia. The heat stroke victim is often manic, disoriented, confused, delirious, or unconscious. The victim's skin may be hot or dry, sweating has ceased, and the body core temperature is greater than 40°C (104°F). Immediate, appropriate, emergency care and hospitalization are essential if signs of heat stroke develop. The prompt treatment of other heat-related disorders generally results in full recovery, but medical advice should be sought for treatment and return-to-work protocols. It is worth noting that the possibility of accidents and injury increases with the level of heat stress. Prolonged increases in deep body temperatures and chronic exposures to high levels of heat stress are associated with other disorders such as temporary infertility (male and female), elevated heart rate, sleep disturbance, fatigue and irritability. During the first trimester of pregnancy, a sustained core temperature greater than 39°C (102.2°F) may endanger the fetus.

References:

1. U.S. National Institute for Occupational Safety and Health: Criteria for a Recommended Standard – Occupational Exposure to Hot Environments (Revised); 1986. In: NIOSH Criteria Documents Plus CD-ROM, Disk 2. DHHS (NIOSH) Pub. No. 97-106; NTIS Pub. No. PB-502082. National Technical Information Service, Springfield, VA (1997).

International Organization for Standardization (ISO): Hot Environments – Analytical Determination and Interpretation of Thermal Stress Using Calculation of Required Sweat Rate. ISO 7933: (1989). ISO Geneva (