SUMMARY

Work operations involving high air temperatures, radiant heat sources, high humidity, direct physical contact with hot objects, or strenuous physical activities have a high potential for inducing heat stress in employees engaged in such operations. These activities are often conducted in the following locations: the steam tunnels; boiler rooms; pipe chases; some mechanical rooms; outdoor construction activities particularly on roofs; and outdoor construction activities that require the use of protective clothing, landscaping or ground maintenance activities.

Although no one questions that there is a relationship between heat stress and occupational accidents, it is difficult to predict who will be affected and when. Two people can work at the same job, under the same conditions, and while one will be affected by the heat, the other will not. Age, weight, degree of physical fitness, degree of acclimatization, metabolism, use of alcohol or drugs, and a variety of medical conditions all affect a person's sensitivity to heat. Even the type of clothing worn must be considered. In addition, the measurement of a hot environment involves more than just measuring the ambient air temperature – radiant heat, air movement, and relative humidity are all factors that must be determined.

The risk of heat-induced illnesses and injuries may be increased and productivity reduced in situations when the total heat load exceeds the capacities of the body to maintain normal body functions. The purpose of this Guideline is to assist departments in eliminating or reducing those risk factors.

REFERENCE REGULATIONS:

The General Duty Clause (State of Michigan Act 154 of 1974, MIOSHA Act, Section 408.1011)

Heat Stress Threshold Limit Value (American Conference of Governmental Industrial Hygienists Threshold Limit Values for Chemical and Physical Agents)

Occupational Safety & Health Administration Technical Manual, Section II, Chapter 4, Heat Stress

DEFINITIONS:

Heat Stress – any set of environmental and workload conditions which places excessive demands on the normal regulations of body temperature. When heat stress causes an imbalance between body heat gain and body heat loss, this can result in heat strain.

Heat Strain – a physiological reaction to environmental heat stress. Depending on individual tolerance and specific environmental conditions, heat strain can manifest itself in a variety of heat disorders, including heat cramps, heat exhaustion, heat syncope, heat stroke, and rashes. Appendix A of this Guideline provides more detailed information on heat disorders.

RESPONSIBILITY:

Deans, Directors and Department Heads

Designate and empower individuals who will be responsible for implementation of this program.

Ensure an environment where principal investigators/supervisors and other personnel are encouraged to follow this Guideline.

Supervisors

Implement all procedures in accordance with this Guideline.

Follow Work Connections procedures for any accident or injury, scheduling workers into the medical surveillance program or if there is an accident or injury.

Contact the EHS Manager to request technical assistance when necessary. Maintain records of heat stress training.

Employees

Comply with this Guideline and any further safety recommendations made by their supervisors or EHS Manager.

Conduct assigned tasks in a safe manner, wear all assigned personal protective equipment, and only use equipment for which they have been formally trained.

Report any job related injuries or illnesses, questions on health and safety, or any unsafe or unhealthy working conditions to their supervisors.

Public Safety & Environmental Health

Conduct on-site heat stress evaluations to identify work environments where precautions are needed using the OSHA Technical Manual as a guideline. (See Appendix A for excerpts) when requested by a supervisor. Provide technical assistance to departments in implementing the appropriate controls for their situation.

Provide training on heat stress to workers and their supervisors upon request.

Serve as a University liaison for local, county, and state agencies regarding safety issues and inspections.

Schedule and maintain records of all medical surveillance services.

Review and revise the heat Stress Program as needed.

PROCEDURES:

1. *Determining when a Heat Stress program should be implemented.*
The incidence of heat stress is the result of a variety of factors. Factors to be evaluated when considering the need for a Heat Stress Program include the following:

a. Ambient temperature
b. Relative humidity
c. Work location and air movement for cooling
d. Type of work required – the metabolic heat generated during heavy, moderate or light work
e. Required work clothing and safety equipment – impermeable work clothing increases the potential for heat stress
f. Employees symptoms and/or complaints
g. Employee conditioning and/or acclimatization

2. *Heat Stress Control Measures*

Implement the appropriate control measures for the specific work condition, from among the following possible control methods:

a. Engineering Controls

Ventilation, air cooling, fans, shielding, and insulation are the five major types of engineering controls used to reduce heat stress in hot work environments. Heat reduction can also be achieved by using power assists and tools that reduce the physical demands placed on a worker. However, for this approach to be successful, the metabolic effort required for the worker to use or operate these devices must be less than the effort required without them.

Where feasible, eliminate steam leaks and shut down hot machinery and equipment.

b. Administrative Controls

The worker should be allowed to take frequent rest breaks in a cooler environment. The higher the heat stress conditions, the longer the rest period should be. The supervisor and worker(s) should agree on a reasonable work schedule that minimizes the duration of heat exposure to the extent possible. Rotation of workers may be one feasible alternative.

c. Protective Clothing

If working outside, wear loose fitting, light colored, porous clothing which allows free air circulation over the body. Wear a well ventilated broad brimmed hat. If working inside, wear as little clothing as necessary.

d. Work Practices

Cool water (50-60 degrees F) or any cool liquid (except alcoholic beverages) should be made available to workers to encourage them to drink small amounts frequently, e.g., one cup every 20 minutes. An amply supply of liquids should be placed close to the work area. Although some commercial replacement drinks contain salt, this is not necessary for acclimatized individuals because most people add enough salt to their diets.

In some situations, a buddy system (no less than two employees) may be appropriate so the employees can observe each other for early signs of heat strain. Establish a means of communication so that employees can call for assistance or medical emergency when necessary. The EHS Manager can assist supervisors in determining when a buddy system and communications would be appropriate.

e. Training

Heat stress training is the key to good work practices for both employees and supervisory personnel. All employees need to understand the reasons for using appropriate work practices to prevent heat stress and ensure a successful program.

3. *Medical Surveillance*

Employees identified by the EHS Manager evaluation as working in hot work environments will be provided with a medical evaluation. The Medical Surveillance Program is administered by Public Safety & Environmental Health: for more information, contact the EHS Manager at 3-4914.

RELATED DOCUMENT: "Heat Stress: Its Effects, Measurements & Control", Chapter 21, Patty's Industrial Hygiene and Toxicology, Vol. I, Part A, 4th Edition

TECHNICAL SUPPORT: Supervisors may refer to Appendix A or contact the EHS Manager for technical assistance in evaluating potential heat stress environments and implementing appropriate control measures.

ATTACHMENTS: Appendix A – Excerpts from Section II, Chapter 4 – "Heat Stress" OSHA Technical Manual

APPENDIX A

EXCERPTS FROM OSHA TECHNICAL MANUAL, SECTION II
CHAPTER 4 – HEAT STRESS

INTRODUCTION

Operations involving high air temperatures, radiant heat sources, high humidity, direct physical contact with hot objects, or strenuous physical activities have a high potential for inducing heat stress in employees engaged in such operations. Such places include: iron and steel foundries, nonferrous foundries, brick-firing and ceramic plants, glass products facilities, rubber products factories, electrical utilities (particularly boiler rooms), bakeries, confectioneries, commercial kitchens, laundries, food canneries, chemical plants, mining sites, smelters, and steam tunnels.

Out door operations conducted in hot weather, such as construction, refining, asbestos removal, and hazardous waste site activities, especially those that require workers to wear semi-permeable or impermeable protective clothing, are also likely to cause heat stress among exposed workers.

Casual Factors

Age, weight, degree of physical fitness, degree of acclimatization, metabolism, use of alcohol or drugs, and a variety of medical conditions such as hypertension all affect a person's sensitivity to heat. However, even the type of clothing worn must be considered. Prior heat injury predisposes an individual to additional injury.

It is difficult to predict just who will be affected and when, because individual susceptibility varies. In addition, environmental factors include more than the ambient air temperature. Radiant heat, air movement, conduction, and relative humidity all affect an individual's response to heat.

DEFINITION

The American Conference of Governmental Industrial Hygienists (1992) states that workers should not be permitted to work when their deep body temperature exceeds 38 degrees C (100.4 degrees F).

Heat is a measure of energy in terms of quantity.

A calorie is the amount of heat required to raise 1 gram of water 1 degrees C (based on a standard temperature of 16.5 to 17.5 degrees C).

Conduction is the transfer of heat between materials that contact each other. Heat passes from the warmer material to the cooler material. For example, a worker's skin can transfer heat to a contacting surface if that surface is cooler, and vice versa.

Convection is the transfer of heat in a moving fluid. Air flowing past the body can cool the body if the air temperature is cool. On the other hand, air that exceeds 35 degrees C (95 degrees F) can increase the heat load on the body.

Evaporative cooling takes place when sweat evaporates from the skin. High humidity reduces the rate of evaporation and thus reduces the effectiveness of the body's primary cooling mechanism.

Radiation is the transfer of heat energy through space. A worker whose body temperature is greater than the temperature of the surrounding surfaces radiates heat to these surfaces. Hot surfaces and infrared light sources radiate heat that can increase the body's heat load.

Globe temperature is the temperature inside a blackened, hollow, thin copper globe.

Metabolic heat is a by-product of the body's activity.

Natural wet bulb (NWB) temperature is measured by exposing a wet sensor, such as a wet cotton wick fitted over the bulb of a thermometer, to the effects of evaporation and convection. The term natural refers to the movement of air around the sensor.

Dry bulb (DB) temperature is measured by a thermal sensor, such as an ordinary mercury-in-glass thermometer, that is shielded from direct radiant energy sources.

HEAT DISORDERS AND HEALTH EFFECTS

Heat Stroke

Heat stroke occurs when the body's system of temperature regulation fails and body temperature rises to critical levels. This condition is caused by a combination of highly variable factors, and its occurrence is difficult to predict.
Heat stroke is a medical emergency. The primary signs and symptoms of heat stroke are confusion; irrational behavior; loss of consciousness; convulsions; a lack of sweating (usually); hot, dry skin; and an abnormally high body temperature, e.g., a recta temperature of 41 degrees C (105.8 degrees F). If body temperature is too high, it causes death. The elevated metabolic temperatures caused by a combination of work load and environmental heat load, both of which contribute to heat stroke, are also highly variable and difficult to predict.

If a worker shows signs of possible heat stroke, professional medical treatment should be obtained immediately. The worker should be placed in a shady area and the outer clothing should be removed. The worker's skin should be wetted and air movement around the worker should be increased to improve evaporative cooling until professional methods of cooling are initiated and the seriousness of the condition can be assessed. Fluids should be replaced as soon as possible. The medical outcome of an episode of heat stroke depends on the victim's physical fitness and the timing and effectiveness of first aid treatment.

Regardless of the worker's protests, no employee suspected of being ill from heat stroke should be sent home or left unattended unless a physician has specifically approved such an order.

Heat Exhaustion

The signs and symptoms of heat exhaustion are headache, nausea, vertigo, weakness, thirst, and giddiness. Fortunately, this condition response readily to prompt treatment

Heat exhaustion should not be dismissed lightly, however, for several reasons. One is that the fainting associated with heat exhaustion can be dangerous because the victim may be operating machinery or controlling an operation that should not be left unattended; moreover, the victim may be injured when he or she faints. Also, the signs and symptoms seen in heat exhaustion are similar to those of heat stroke, a medical emergency.

Workers suffering from heat exhaustion should be removed from the hot environment and given fluid replacement. They should also be encouraged to get adequate rest.

Heat Cramps

Heat cramps are usually caused by performing hard physical labor in a hot environment. These cramps have been attributed to an electrolyte imbalance caused by sweating. It is important to understand that cramps can be caused by both too much and too little salt.

Cramps appear to be caused by the lack of water replenishment. Because sweat is a hypotonic solution (=/-0.3% NaCl), excess salt can build up in the body if the water lost through sweating is not replaced. Thirst cannot be relied on as a guide to the need for water; instead, water must be taken ever 15 to 20 minutes in hot environments.

Under extreme conditions, such as working for 6 to 8 hours in heavy protective gear, a loss of sodium may occur. Recent studies have shown that drinking commercially available carbohydrate-electrolyte replacement liquids is effective in minimizing physiological disturbances during recovery.

Heat Collapse ("Fainting")

In heat collapse, the brain does not receive enough oxygen because of blood pools in the extremities. As a result, the exposed individual may lose consciousness.

This reaction is similar to that of heat exhaustion and does not affect the body's heat balance. However, the onset of heat collapse is rapid and unpredictable. To prevent heat collapse, the worker should gradually become acclimatized to the hot environment.

Heat Rashes

Heat rashes are the most common problem in hot work environments.

Prickly heat is manifested as red papules and usually appear in areas where the clothing is restrictive. As sweating increases, these papules give rise to a prickling sensation. Prickly heat occurs in skin that is persistently wetted by unevaporated sweat, and heat rash papules may become infected if they are not treated.

In most cases, heat rashes will disappear when the affected individual returns to a cool environment.

Heat Fatigue

A factor that predisposes to heat fatigue is lace of acclimatization. The use of a program of acclimatization and training for work in hot environments is advisable.

The signs and symptoms of heat fatigue include impaired performance of skilled sensorimotor, mental or vigilance jobs. There is no treatment for heat fatigue except to remove the heat stress before a more serious heat-related condition develops.

CONTROL

Ventilation, air cooling, fans, shielding, and insulation are the five major types of engineering controls used to reduce heat stress in hot work environments.

Heat reduction can also be achieved by using power assists and tools that reduce the physical demands placed on a worker. However, for this approach to be successful, the metabolic effort required for the worker to use or operate these devices must be less than the effort required without them. Another method is to reduce the effort necessary to operate power assists.

The worker should be allowed to take frequent rest breaks in a cooler environment.

Acclimatization

The human body can adapt to heat exposure to some extent. This physiological adaptation is called acclimatization. After a period of acclimatization, the same activity will produce fewer cardiovascular demands. The worker will sweat more efficiently (causing better evaporative cooling), and thus will more easily be able to maintain normal body temperatures.

A properly designed and applied acclimatization program decreases the risk of heat-related illnesses. Such a program basically involves exposing employees to work in a hot environment for progressively longer periods. NIOSH (1986) says that, for workers who have had previous experience in jobs where heat levels are high enough to produce heat stress, the regimen should be 50% exposure on day 1, 60%on day 2, 80%on day 3, and 100% on day 4. For new workers who will be similarly exposed, the regimen should be 20% on day 1, with a 20% increase in exposure each additional day.

Fluid Replacement

Cool (50-60 degrees F) water or any cool liquid (except alcoholic beverages) should be made available to workers to encourage them to drink small amounts frequently, e.g., one cup every 20 minutes. Ample supplies of liquids should be placed close to the work area. Although some commercial replacement drinks contain salt, this is not necessary for acclimatized individuals because most people add enough salt to their summer diets.

Engineering Controls

General ventilation is used to dilute hot air with cooler air (generally cooler air that is brought in from the outside). This technique clearly works better in cooler climates than in hot ones.

A permanently installed ventilation system usually handles large areas or entire buildings. Portable or local exhaust systems may be more effective or practical in smaller areas.

Air treatment/air cooling differs from ventilation because it reduces the temperature of the air by removing heat (and sometimes humidity) from the air.

Air conditioning is a method of air cooling, but it is expensive to install and operate.

An alternative to air conditioning is the use of chillers to circulate cool water through heat exchangers over which air from the ventilation system is then passed; chillers are more efficient in cooler climates or in dry climates where evaporative cooling can be used.

Local air cooling can be effective in reducing air temperature in specific areas. Two methods have been used successfully in industrial settings. One type, cool rooms, can be used to enclose a specific workplace or to offer a recovery area near hot jobs. The second type is a portable blower with built-in-air chiller. The main advantage of a blower, aside from portability, is minimal set-up time.

Convection

Another way to reduce heat stress is to increase the air flow or convection using fans, etc. in the work area (as long as the air temperature is less than the worker's skin temperatures).

Changes in air speed can help workers stay cooler by increasing both the convective heat exchange (the exchange between the skin surface and the surrounding air) and the rate of evaporation. Because this method does not actually cool the air, any increases in air speed must impact the worker directly to be effective.

If the dry bulb temperature is higher than 35 degrees C (95 degrees F), the hot air passing over the skin can actually make the worker hotter. When the temperature is more than 35 degrees C and the air is dry, evaporative cooling may be improved by air movement, although this improvement will be offset by the convective heat. When the temperature exceeds 35 degrees C and the relative humidity is 100%, air movement will make the worker hotter.

Increases in air speed have no effect on the body temperature of workers wearing vapor-barrier clothing.

Heat conduction methods include insulating the hot surface that generates the heat and changing the surface itself.

Radiant Heat

Simple engineering controls, such as shields, can be used to reduce radiant heat, i.e., heat coming from hot surfaces within the worker's line of sight.

Surfaces that exceed 35 degrees C (95 degrees F) are sources of infrared radiation that can add to the worker's heat load. Flat black surfaces absorb heat more than smooth, polished ones. Having cooler surfaces surrounding the worker assists in cooling because the worker's body radiates heat toward them.

With some sources of radiation, such as heating pipes, it is possible to use both insulation and surface modifications to achieve a substantial reduction in radiant heat.

Instead of reducing radiation from the source, shielding can be used to interrupt the path between the source and the worker. Polished surfaces make the best barriers, although special glass or metal mesh surfaces can be used if visibility is a problem.

Shields should be located so that they do not interfere with air flow, unless they are also being used to reduce convective heating. The reflective surface of the shield should be kept clean to maintain its effectiveness.

Administrative Control And Work Practices

Training is the key to good work practices. Unless all employees understand the reasons for using new, or changing old, work practices, the chances of such a program succeeding are greatly reduced.

NIOSH (1986) states that a good heat stress training program should include at least the following components:

- Knowledge of the hazards of heat stress,
- Recognition of predisposing factors, danger signs, and symptoms,
- Awareness of first-aid procedures for, and the potential health effects of, heat stroke,
- Employee responsibilities in avoiding heat stress,
- Dangers of using drugs, including therapeutic ones, and alcohol in hot work environments,
- Use of protective clothing and equipment, and
- Purpose and coverage of environmental and medical surveillance programs and the advantages of worker participation in such programs.

Hot jobs should be scheduled for the cooler part of the day, and routine maintenance and repair work in hot areas should be scheduled for the cooler seasons of the year.

Worker Monitoring Programs

Every worker who works in extraordinary conditions that increase the risk of heat stress should be personally monitored. These conditions include wearing semipermeable or impermeable clothing when the temperature exceeds 21 degrees C (69.8 degrees F), working at extreme metabolic loads (greater than 500 kcal/hour), etc.

Personal monitoring can be done by checking the heart rate, recovery heart rate, oral temperature, or extent of body water loss.

To check the heart rate, count the radial pulse for 30 seconds at the beginning of the rest period. If the heart rate exceeds 110 beats per minute, shorten the next work period by one third and maintain the same rest period.

The recovery heart rate can be checked by comparing the pulse rate taken at 30 seconds (P(I)) with the pulse rate taken at 2.5 minutes (P(3)) after the rest break starts. The two pulse rates can be interpreted using Table II:4-4.

Oral temperature can be checked with a clinical thermometer after work but before the employee drinks water. If the oral temperature taken under the tongue exceeds 37.6 degrees C, shorten the next work cycle by one third.

Body water loss can be measured by weighing the worker on a scale at the beginning and end of each work day. The worker's weight loss should not exceed 1.5% of total body weight in a work day. If a weight loss exceeding this amount is observed, fluid intake should increase.

Other Administrative Controls

The following administrative controls can be used to reduce heat stress:

- Reduce the physical demands of work, e.g., excessive lifting or digging with heavy objects.
- Provide recovery areas, e.g., air-conditioned enclosures and rooms.
- Use shifts, e.g., early morning, cool part of the day, or night work.
- Use intermittent rest periods with water breaks.
- Use relief workers.
- Use worker pacing.
- Assign extra workers and limit worker occupancy, or the number of workers present, especially in confined or enclosed spaces.

TABLE II: 4-4. HEART RATE RECOVERY CRITERIA

Heart rate recovery pattern	P(3)	Differences between P(1) and P(3)
Satisfactory Recovery	<90	- - -
High Recovery (Conditions require further study)	90	10
No Recovery (May indicate too much stress)	90	< 10

PERSONAL PROTECTIVE EQUIPMENT

Reflective Clothing

Reflective clothing, which can vary from aprons and jackets to suits that completely enclose the worker from neck to feet, can stop the skin from absorbing radiant heat. However, since most reflective clothing does not allow air exchange through the garment, the reduction of radiant heat must more than offset the corresponding loss in evaporative cooling. For this reason, reflective clothing should be worn as loosely as possible.

In situations where radiant heat is high, auxiliary cooling systems can be used under the reflective clothing.

Auxiliary Body Cooling

Commercially available ice vests, though heavy, may accommodate as many as 72 ice packets, which are usually filled with water. Carbon dioxide (dry ice) can also be used as a coolant.

The cooling offered by ice packets lasts only 2 to 4 hours at moderate to heavy heat loads, and frequent replacement is necessary. However, ice vests do not encumber the worker and thus permit maximum mobility. Cooling with ice is also relatively inexpensive.

Wetted clothing is another simple and inexpensive personal cooling technique. It is effective when reflective or other impermeable protective clothing is worn. The clothing may be wetted terry cloth coveralls or wetted two-piece, whole-body cotton suits.

This approach to auxiliary cooling can be quite effective under conditions of high temperature and low humidity, where evaporation from the wetted garment is not restricted.

Water-cooled garments range from a hood, which cools only the head, to vests and "long-johns," which offer partial or complete body cooling. Use of this equipment requires a battery-driven circulating pump, liquid-ice coolant, and a container.

Although this system has the advantage of allowing wearer mobility, the weight of the components limits the amount of ice that can be carried and thus reduces the effective use of time. The heat transfer rate in liquid cooling systems may limit their use to low-activity jobs; even in such jobs, their service time is only about 20 minutes per pound of cooling ice.

To keep outside heat from melting the ice, an outer insulating jacket should be an integral part of these systems.

Circulating air is the most highly effective, as well as the most complicated, personal cooling system. By directing compressed air around the body from a supplied air system, both vaporative and convective cooling are improved. The greatest advantage occurs when circulating air is used with impermeable garments or double cotton overalls.

One type, used when respiratory protection is also necessary, forces exhaust air from a supplied-air hood ("bubble hood") around the neck and down inside an impermeable suit. The air then escapes through openings in the suit.

Air can also be supplied directly to the suit without using a hood. This can be done in three ways:

- by a single inlet,
- by a distribution tree, or
- by a perforated vest.

In addition, a vortex tube can be used to reduce the temperature of circulating air. The cooled air from this tube can be introduced either under the clothing or into a bubble hood. The use of a vortex tube separates the air stream into a hot and cold stream; these tubes also can be used to supply heat in cold climates.

Circulating air, however, is noisy and requires a constant source of compressed air supplied through an attached air hose. One problem with this system is the limited mobility of workers whose suits are attached to an air hose. Another is that of getting air to the work area itself. These systems should therefore be used in work areas where workers are not required to move around much or to climb.

Another concern with these systems is that they can lead to dehydration. The cool, dry air feels comfortable and the worker may not realize that it is important to drink liquids frequently.

Respirator Usage

The weight of a self-contained breathing apparatus (SCBA) increases stress on a worker, and this stress contributes to overall heat stress.

Chemical protective clothing such as totally encapsulating chemical protection suits will also add to the heat stress problem.

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