BNL ALARA Center Database

PREVENTION OF HEAT STRESS DURING RADIOLOGICAL WORK

This instruction provides guidance on actions that can be taken to reduce the possibility of encountering heat stress related injuries during radiological work.

Heat stress is caused by hot environments and the physical demands of work. It is further complicated by protective clothing requirements commonly used to perform radiological work. The resulting physiological strain is reflected in increased sweating, heart rate and body temperature. Uncontrolled exposures to heat stress can lead to decreased performance and increased risk of accidents and heat disorders.

The five most common heat-related disorders are described as follows:

TITLE	CAUSE	TREATMENT
Heat Rash	Caused by obstruction of the sweat glands brought on by chronically wet skin. Symptoms are itchy skin with small red spots and an unusual sensitivity to radiant heat.	To treat, allow intermittent relief from the hot environment. Heat rash can be prevented by keeping the skin clean, and periodically allowing the skin to dry.
Heat Cramps	Caused by profuse sweating and hard work which results in an excessive loss of salts. This results in painful muscle cramps in legs, arms or abdomen. The cramps may occur during or after exertion.	Massage cramping muscles to obtain relief and give water orally. Prevent heat cramps by adding extra salt* to food.
Heat Syncope (sin-ka-pee)	Occurs when a worker maintains one work posture (e.g., standing or squatting) for too long a time. This allows blood to pool in the legs, away from the head. Standing or sitting up quickly will cause a dizzy feeling("grey out")or a brief fainting spell ("black out"), of less than 30 seconds.	Treat Heat Syncope by allowing the worker to rest laying down. Administer water or other suitable fluids orally. To prevent or reduce heat syncope, instruct workers to flex their leg muscles several times before moving from a stationary position, and to stand or sit up slowly.

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Heat Exhaustion	Often precipitated by heavy sweating, which causes dehydration. If a person is already dehydrated due to an illness (vomiting or diarrhea), the onset of heat exhaustion will be hastened. The symptoms are a general feeling of fatigue or weakness, uncoordinated actions, headache, thirst, and weak pulse.	The treatment is to simply rest in a cool environment. Prevent heat Exhaustion by drinking water or other suitable fluids frequently, and by adding salt* to food.
Heat Stroke	This is a life-threatening condition. It may be brought on by a pre-existing illness (e.g., fever or flu), an abnormal intolerance to heat stress, excessive exposure to heat stress, or by drug or alcohol abuse. A person in heat stress will have difficulty recognizing surroundings or people and may exhibit irrational or unexpected behavior. The skin will be dry and convulsions/unconsciousness for periods greater than 30 seconds may also occur.	Treat heat stroke by immediately and aggressively lowering the person's body temperature. This can be accomplished by wetting the skin and clothing and increasing the air flow by using fans, ventilation trunks, or hand fans. Ice packs may also be used if available. Transport the person immediately to an emergency medical facility. Prevent heat stroke by training personnel to recognize the symptoms of heat related disorders in themselves and in others, and by allowing the workers to participate in the determination of heat stress exposures. Workers who maintain a healthy life-style will be less likely to have heat stroke.

*** NOTE:** Lightly salting food at mealtimes is encouraged both a treatment for and prevention of some heat disorders. Those individuals on salt restricted diets should consult their personal physicians regarding the advisability to heat stress and the supplementing of salt intake. Salt tablets, however, should never be used. In addition to causing stomach irritation, salt tablets retard the absorption of water into the body where it is needed to support adequate blood flow and sweating.

In order to accomplish radiological work in hot environments, it is necessary to manage the work, recognizing the potential for heat stress and take measures to prevent it. Effective management requires that an evaluation be performed to assess the potential for heat stress situations and then use

control measures to mitigate the stress. Most facilities have an Industrial Safety/Industrial Hygiene person that can help with this evaluation. Contact the IS/IH technician **prior to the start of the job** to review the work package, environmental heat sources, work demands, and clothing requirements. This review may include a job walkdown and participation in mockup training.

Environmental sources of heat stress include convection, which is reflected in air temperature and air movement; radiant heat, which depends on the temperatures of surrounding walls, equipment and other surfaces; and air humidity, which affects the body's ability to cool by sweat evaporation.

Work demands are divided into three categories. Light work includes instrument repair, supervision, valve lineups, etc. Moderate work is typical of most maintenance tasks and heavy work requires a great deal of physical effort (e.g., continuous shoveling, mopping, installing shielding).

Clothing requirements mostly effect the body's ability to cool by sweat evaporation. Multiple layers of clothing, especially impermeable plastic clothing, significantly reduce the body's ability to evaporate sweat, and therefore cause greater physiological strain.

Planning personnel and the Person-in-Charge (PIC) should review local Safety Standards and Guides when preparing for work that has a high potential for heat stress:

There are two common elements in managing any potential heat stress: training of the individual and the commitment each individual makes to following good health practices.

Training provides individuals with the knowledge required to deal rationally with heat stress. This training is usually repeated periodically and covers subjects such as the sources of heat stress, physiological responses, heat stress hygiene practices, acclimation, recognition, prevention and first aid for heat disorders.

The prejob briefing conducted just before the work starts should include these same key points and a reminder to personnel that if they feel they have the symptoms of heat stress to notify personnel and exit the work area.

The primary method of preventing heat stress is to <u>follow good health practices.</u> This is solely in the hands of exposed workers. Site management has a responsibility to minimize the barriers so that good heat stress practices can be followed, but it is ultimately an **individual responsibility**. Good health practices for workers who will be exposed to a heat stress environment are:

<u>Fluid Intake</u> is needed to replace water lost by sweating. Ideally, water is replaced on a frequent schedule (e.g., 3-4 times per hour). On some radiological jobs, there may be restrictions on drinking to avoid ingestion of radioactive or chemical contaminants. Workers should be encouraged to prehydrate (drink more than usual before the heat exposure), and then to drink additional water afterwards. An ample supply of cold water, fruit juice,

Gaterade, etc should be available for the workers. The use of caffeinated beverages such as coffee, tea, and colas, should be discouraged since these products are natural diuretics that cause increased urine output.

Balanced Diet: Workers should be encouraged to eat a "light" meal before entry to control nauseous feelings. In addition, eating a "light" meal will reduce the amount of blood required for digestion and allow more blood to flow to the surface of the skin for cooling.

Self Determination is both a health practice and an administrative control. The individual worker must understand there are differences among workers for heat tolerance and each individual should stop work and exit the work area at the first symptoms of fatigue, nausea, or other signs of heat disorders.

Life Style relates to the worker's personal activities off-the-job, such as alcohol and drug abuse, and heat exposures outside of the work environment. These activities can greatly effect each worker's ability to perform work in a heat stress environment.

Health Status is the recognition that chronic or acute illness can increase the risk of a heat disorder. Personnel who are sick should not work in a heat stress environment.

Acclimation is frequently considered an administrative control. It recognizes that performance under heat stress conditions improves with successive exposures, and that expectations should be adjusted accordingly. For example: ten successive days of heat exposures lasting at least two hours are required to obtain the most benefits of acclimation. As a rule of thumb, one day of acclimation is lost for every two days that a person is not exposed to heat stress. (The ratio is one-to-one if the absence is due to illness.)

After the job is evaluated by planning personnel and the Industrial Safety/Hygienist, specific actions can be identified that will reduce the probability that heat stress will occur. Priorities should be given to controlling the greatest contributors to heat stress. There are three categories of specific actions: use of engineering controls, administrative controls and personal protection.

Engineering Controls. Permanent and temporary engineering controls are the first consideration. Any mechanical assistance that can reduce work demands will cause a significant reduction in the level of heat stress. For instance, the use of pneumatic powered tooling to remove/replace fasteners reduces the physical work of the user. In terms of effectiveness, engineering controls to reduce metabolism are followed by reductions in air temperature and humidity.

Dilution ventilation and air conditioning can cool the work environment inside a facility or a containment. Ventilation systems can be used to remove smoke and heat from the work area or confined spaces. Air conditioning containment tents is possible but requires a large A/C unit to make up for losses through the non-insulated fabric or metal walls. Normally, the air discharged from the HEPA ventilation blower is cooled by the air conditioner and then a large

portion of the discharged air is returned to the containment as "make-up air".

Where radiant heat is a factor, shielding, insulation and decreasing surface radiated heat are possible solutions. The more reflective a surface is (shinier), the lower is its ability to radiate heat to a person. Sometimes work area temperatures can be reduced by covering the work area with white or reflective materials so that it is shaded and sunlight is reflected. If the work is inside a tank or building, a garden hose/sprinkler can be placed on top of the area to cool down the structure and reduce the radiated heat. Water should not be allowed to drain into the work area. Closed circuit TV cameras can be mounted so that personnel outside the work area can observe the workers and look for signs of heat stress. Inexpensive communication systems are available that can be worn under protective clothing and not interfere with the wearing of a respirator. If used, the workers and personnel at the work are boundary could communicate with each other frequently to detect early signs of heat stress.

Administrative Controls. If engineering controls provide only a lessening of the heat stress (not an elimination) or if they are not practical, then administrative controls can be used to reduce the risk of an overexposure to heat stress. Some of these controls are:

Self determination is an acknowledgement that workers may and must terminate a heat stress exposure at the onset of symptoms of a heat related disorder. This is one of the most important factors in managing heat stress.

An environmental "stay time" and/or work/rest regimen can be established for various work steps by reviewing applicable Safety Standards and consulting with the facility Industrial Safety/Hygienist. Table 1 provides a guide for determining the work/rest regimen. The stay time is the maximum time a person may be in the heat stress situation. Personnel should be ordered out of the work area in advance so they can be out of their protective clothing when the stay time expires. They should then be required to rest in a cool location for a minimum time determined by review of Table 1. In addition, at periodic intervals, the PIC and/or other personnel running the job should question each person in the work area to determine (1) if they are experiencing any symptoms of heat disorders, and (2) if they can continue to work. Each person should be asked the questions and a decision made on whether to continue based on the response of each individual.

Recovery allowance and work/rest cycles are designed to allow sufficient recovery from previous heat stress exposures before a subsequent exposure is undertaken. The work/rest regimen observed should be established by the facility Industrial Safety/Hygiene per instructions of the American Conference of Governmental Industrial Hygienists and modified to reflect worker acclimatization, work type and clothing type for "physically fit" workers. See Table 1. The "rest" area selected should be shaded, cooled and preferably indoors. If temperatures are high, a Wet Bulb Globe Thermometer (WBGT) can be installed in the work area by Industrial Hygiene.

Scheduling hot work to a time of lower heat stress is a commonly recognized control method. Working hot jobs on back shifts when air temperatures are

cooler, or scheduling the work to be accomplished in late fall through early spring are examples of this strategy.

Clothing requirements can be reviewed and possibly reduced to lower the potential for heat stress by Radiological Control. This may require areas be decontaminated or covered in order to reduce the possibility of skin/clothing contamination in order to justify the reduction of PPE. The modesty clothing worn under the protective clothing could be specified to be shorts/tee shirt instead of the standard coveralls worn at many facilities. With the concurrence of the Radiological Control Manager, and at worker option, the tee shirt and/or inner hood could be wetted before dressing in protective clothing.

During work, personnel in the work area should use the "buddy" system to observe each other for signs of heat stress. The Person-in-Charge should control the work rate by allowing the workers to set their own pace.

With the assistance of the Industrial Hygienist, commercial equipment is available to monitor body temperature and heart rate. Trained personnel must be on hand to evaluate the readings and determine required actions.

Personal protection in the form of personal cooling and reflective clothing is recommended when the environmental stay time is very short. Personal cooling can consist of circulating air systems or ice garments. One type of circulating air system consists of a compressor capable of supplying large amounts of air at the proper purity for breathing, with or without a vortex cooling device supplied to personnel wearing an air fed hood. The inner bib of the hood is tucked inside the protective coveralls so that air flow is into the hood, over the person's face, down through the coveralls and out through the protective clothing. If used, the vortex cooler can cool the air by up to 50 degrees fahrenheit for up to four personnel. Other companies sell small vortex cooling devices that are attached to the person's belt. If wearing impermeable plastic clothing, the air exhausts around the ankles or through special vents installed in the leg/arm of the plastic clothing. Information on vortex breathing air coolers and special cooling vests that contain pockets for "blue ice strips" are included in attached references. The ice vest weighs about 12 pounds and allows a great deal of worker mobility with typical service times of 1-2 hours. Ice vests do not work well for longer jobs unless the blue ice strips can be changed out after they thaw.

If there is a high potential for heat stress on a particular job and personnel can be continuously observed, consideration should be given to establishing a "Hero" watch at the work area entrance. The Hero watch would be dressed in protective clothing and have the proper dosimetry so he/she could enter the work area at any moment if anyone showed signs of heat stress.

If air supplied respirators are worn, the hose length should be minimized and the hose should not be laid against hot surfaces. Consider insulating the hose with foam pipe insulation and wrapping the outside with white or reflective material. If portable air bottles are used for the breathing air, the bottles could be wrapped in white or reflective material, placed in the shade and sprayed with water.

With the permission of Radiological Control, personnel who are monitored on a bio-assay program and not wearing respirators may be able to drink liquids while in the radiological work area. Follow the instructions of the Radiological Control Technician (RCT). As a minimum these instructions should include: (1) step to a location at the work area boundary designated by the RCT, (2) stop all other airborne contamination producing work, (3) survey the worker's hands and face, changing gloves as necessary, (4) use a closed container approved by the RCT to dispense fluids, and (5) survey any equipment passing over the work area boundary at the completion of drinking. Dispose of drinking cups/utensils after each use. Refilling is normally allowed, but the cup/utensils cannot be left unattended and reused.

Definitions of Terms used in Table 1:

ACGIH: American Conference of Governmental Industrial Hygienists - An organization of professionals in governmental agencies or educational institutions engaged in occupational safety and health programs. ACGIH develops and publishes recommended occupational exposure limits for chemical substances and physical agents.

WBGT: Wet Bulb Globe Temperature - usually determined by Industrial Hygienists using an instrument that compares dry bulb, wet bulb and globe temperature

TLV: Threshold Limit Value - Term used to describe exposure levels that all workers can be exposed day-after-day without adverse effects.

REST: Is a total cessation of work in a shaded environment to allow for cool-down between work periods. Personal protective equipment (PPE) should be removed as required during rest periods.

References:

1. Bernard,T, "Features of Heat Stress Control", 1989; Radiation Protection Management, Vol 6, No 4

2. Carls, D, "Heat Stress Control", Waste Tank Safety Support, Westinghouse-Hanford Company

Products:

1. Automatic Vortex Breathing Air Cooler, Innovative Systems, Bremerton, Wa; 206/698-9416

2. Personal Vortex Cooling Device and Air-Fed Hoods, Lano's Industries, Kirkland, Wa; 206/823-6634

3. Air-Fed Hoods, Nuclear Power Outfitters, Crystal Lake, IL; 815/455-3777

TABLE 1. Modified ACGIH Guidelines for Heat Stress Protection (for acclimatized workers)[a]

WORK TYPE	CLOTHING TYPE	Percent Ratio of work/rest for each hour based on TLVs in Table			
		100	75/25	50/50[b]	25/75[b]
		TEMPERATURE IN DEGREES FAHRENHEIT			
Light	Street and Summer clothing	86	87	89	90
	Anti-c with modesty clothing[c]	86	87	89	90
	Double anti-c with modesty clothing[c]	83	84	86	87
	Anti-c w/modesty clothing in containment[c]*	77	78	80	81
Moderate	Street and Summer clothing	80	82	85	88
	Anti-c with modesty clothing[c]	80	82	85	88
	Double anti-c with modesty clothing[c]	77	79	82	85
	Anti-c w/modesty clothing in containment[c]*	71	73	76	79
Heavy	Street and Summer clothing	77	78	82	86
	Anti-c with modesty clothing[c]	77	78	82	86
	Double anti-c with modesty clothing[c]	74	75	79	83
	Anti-c w/modesty clothing in containment[c]*	68	69	73	77

a For unacclimated workers performing moderate level of work, reduce the permissible heat exposure TLV by 4.5 degrees fahrenheit, i.e., subtract 4.5 from the WBGT in the Table.

b For conditions in these columns (50/50 and 25/75), contact the facility Safety Support IH group for increased monitoring. Less stressful conditions (100 and 75/25 percent columns) are usually monitored at less frequent intervals by Safety personnel and the PIC.

c Reduce the permissible heat exposure TLV by 1 degree F for summer clothing under anti-c's. Reduce the permissible heat exposure TLV by 2 degrees F for street clothing under anti-c's. Subtract 1 degree F for use of a respirator (i.e., subtract 1 or 2 degrees from the WGBT in the Table.

* TLV's are estimated for containment work. Use actual WBGT values and clothing types when available.

NOTE: Contact Safety Support personnel for advise when impermeable clothing will be used.

To use this Table, obtain the "Work Area Temperature" and locate the work/rest ratio appropriate for the current WBGT, work load, and clothing taking in to account the notes at the bottom of the Table.