4.13 HEAT INJURY PREVENTION
National Park Service Heat Injury Prevention Policy

Heat-induced occupational illness, injury and reduced productivity occur in situations in which the total heat load (environmental plus metabolic) exceeds the body's capacity to maintain normal body functions without excessive strain. The reduction of adverse health effects shall be accomplished by: the proper application of engineering and work practice controls, worker training and acclimatization, measurements and assessment of heat stress, medical supervision, and proper use of heat-protective clothing and equipment.

Parks shall establish a system to assess heat stress, alert employees of increased risk of heat strain and implement control measures adequate to prevent heat-strain injuries. A tiered system that begins with a broad heat-stress-screening index and becomes progressively more detailed as needed to address task specific risks will be most efficient.

Definitions

1. *Heat Stress* is the net heat load to which a worker may be exposed from the combined contributions of metabolic heat generated during work, environmental factors (air temperature, humidity, air movement and radiant heat) and clothing requirements.

2. *Heat Strain* is the overall physiological response resulting from heat stress.

Scope: This program applies to all employees and volunteers who may be exposed to excessive heat strain.

References

1. Heat Stress and Heat Strain in: 2002. ACGIH. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH.

2. Occupational Exposure to Hot Environments, Revised Criteria Document, 1986, NIOSH.

Program Elements

1. *Establish a Heat Stress Alert System.* Parks shall establish an alert system to identify and alert employees to environmental conditions that pose increased potential for heat stress.

2. *Conduct Heat Stress Screening.* Evaluate work-site and task-specific heat stress. Use the Wet Bulb Globe Temperature (WBGT) Index and Heat Stress Exposure Screening Criteria when the Heat Stress Alert system (Program element 1, above) has identified conditions of increased potential for heat stress.

3. *Conduct Personal Medical (Physiological) Surveillance.* Institute medical physiological surveillance for all workers required to operate under conditions that exceed Heat Stress Exposure Screening Criteria (Program element 2, above).

4. *Implement General Heat Stress Controls.* General heat stress controls shall be implemented when a heat stress alert has been issued and whenever elevated heat stress conditions exist or are anticipated.

5. *Implement Task-Specific Heat Stress Controls.*Task-specific controls consisting of engineering controls, administrative controls and use of personal protective clothing and equipment shall be implemented when Heat Stress Screening Criteria (Program Element 2) are exceeded or when work must be conducted in clothing that restricts vapor and heat loss.

6. *Train Employees.* Train supervisors and other employees in the causes and recognition of illness, personal care procedures to minimize risk, proper care and use of heat-protective clothing and equipment, and the effects of non-occupational factors on tolerance to occupational heat stress.

Heat Injury Prevention Program
Implementation Action Items

Step 1 ❑ Establish a "Heat Stress Alert System" using the NOAA Heat Index (HI) (Apparent Temperature). Appendix A explains the use of the HI system. Assign individual(s) responsible for determining heat stress index. When the index is 105ºF or greater, alert employees, initiate work-site and task-specific environmental (WBGT) and metabolic heat screening (step 2), and implement control measures (step 3).

Step 2 ❑ Conduct heat stress screening. Evaluate work-site and task-specific heat stress by determining the WBGT Index. Characterize worker activity to determine metabolic heat stress; then compare with the Heat Stress Screening Criteria to determine risk. Determination of the WBGT Index and use of the screening criteria are described in Appendix B.

Step 3 ❑ Conduct personal medical (physiological) surveillance. Medical surveillance must be conducted for all workers required to work under conditions that exceed the Heat Stress Exposure Screening Criteria (WBGT). Physiological parameters are monitored to determine whether heat strain experienced by the employee is excessive. Medical surveillance is discussed in Appendix C.

Step 4 ❑ Implement General Heat Stress Controls. General controls must be implemented when heat stress is elevated and the risk of excessive heat strain exists. Elevated heat stress conditions occur when the HI is 105ºF or greater and when the WBGT Heat Stress Screening Criteria are exceeded, but may also exist for certain individuals and circumstances. General controls are described in Appendix D.

Step 5 ❑ Implement Task-Specific Controls. When screening criteria are exceeded and general controls are not sufficient to prevent excessive heat strain, engineering and administrative controls must be developed and implemented. The use of personal protective clothing and equipment must also be implemented.

Step 6 ❑ Train employees. Train supervisors and other employees in the causes and recognition of illness, personal care procedures to minimize risk, proper care and use of heat-protective clothing and equipment, and the effects of non-occupational factors on tolerance to occupational heat stress. Refer to Appendix E for a summary of important training points that should be included — heat-related illness, recognition, predisposing factors, physiological nature of the illness, first aid and prevention.

Technical Appendices

Appendix A: Heat Stress Alert Systems

Appendix B: Heat Stress Screening Criteria

Appendix C: Medical Surveillance

Appendix D: Controlling Heat Strain

Appendix E: Signs and Symptoms of Heat Strain and First Aid Procedures

Appendix A: Heat Stress Alert System — Heat Index (Apparent Temperature)

Parks shall establish a Heat Stress Alert System to easily identify and anticipate environmental conditions that may result in an increased heat stress potential. The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) Heat Index Program provides a convenient mechanism for initial screening of heat stress potential for a general locale.

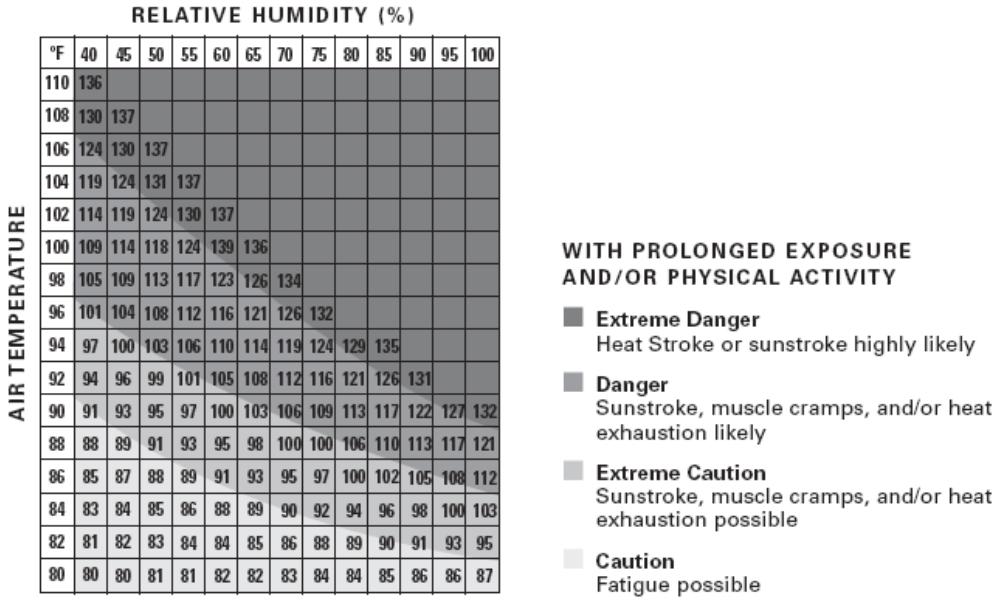
The NWS system utilizes an index called the "Apparent Temperature Index" or "Heat Index." The index provides a measure of environmental heat on an area basis. It is calculated from the air temperature and the relative humidity.

The NWS will issue advisories or warnings via special weather statements, releases to the media and NOAA's Weather radio programming when the Heat Index (HI) is expected to have a significant impact on public safety. A common guideline for the issuance of excessive heat alerts is when the maximum daytime HI is expected to equal or exceed 105°F and the nighttime minimum HI is expected to equal or exceed 80°F for two or more consecutive days.

Some regions and municipalities are more sensitive to excessive heat than others. Cities pose special hazards because stagnant atmospheric conditions may trap pollutants in urban areas and add the stresses of severe pollution to the already dangerous stresses of hot weather.

Calculating the Heat Index.

Parks may determine the heat index value for their locale by referring to the Heat Index chart below and using the forecast or measured temperature and relative humidity values. Or the heat index may be calculated online at *http://www.crh.noaa.gov/lsx/calc.htm*.



To find the Heat Index, look at the Heat Index Chart. For example, if the air temperature is 95°F (found on the left side of the table) and the relative humidity is 55% (found at the top of the table), the HI — or how hot it really feels — is 110°F. This is at the intersection of the 95° row and the 55% column.

An HI of 105ºF or greater corresponds with environmental conditions that may cause increasingly severe heat disorders with continued exposure and/or physical activity. At this level, general heat stress controls must be implemented.

Remember that this is a coarse index of environmental heat stress and does not factor site-specific environmental conditions, metabolic heat stress, general health of workers or other predisposing factors. Heat Index values were devised for shady, light wind conditions. Exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous. Therefore, if continued exposure and physical activity are required, a work-site and task-specific screening evaluation using the Heat Stress Screening Criteria and the WBGT Index must be conducted (see Appendix B).

Appendix B. Heat Stress Screening Criteria Using the WBGT Index

Once an elevated heat stress potential has been determined by use of the HI, general controls must be implemented (see Appendix D) and further evaluation must be conducted to determine the environmental and metabolic heat load of the employee specific to the work site and the task. This is done using the Heat Stress Screening Criteria and the Wet Bulb Globe Temperature (WBGT) Index[1].

WBGT is an index of environmental heat load, which considers the combined contribution of ambient temperature, wind, relative humidity and solar energy gains. To obtain an estimate of worker heat stress, the WBGT must be adjusted to account for the contributions of physical work activity (metabolic heat), clothing and employee acclimatization.

Here is how Heat Stress Screening Criteria are used with the WBGT Index:

Step 1

Measure Environmental Heat. Use a WBGT meter to assess environmental heat and determine the WBGT Index. The WBGT meter will provide three temperature measurements. The natural wet bulb temperature provides an indication of the effects of relative humidity, wind speed and evaporative cooling on the body. The globe temperature provides an indication of solar heat gains, while the dry bulb temperature factors the impact of the heat in ambient air. Additions are made to the WBGT value for some clothing ensembles (see Table B1).

Table B1. Additions to WBGT Values for Some Clothing Ensembles

CLOTHING TYPE	WBGT ADDITION
Summer work uniform*	0
Cloth (woven material) overalls	Add 6ºF
Double-cloth overalls	Add 9ºF

*Traditional work uniform consisting of a long-sleeved shirt and pants.

The WBGT Index is calculated as follows:

WBGT Index = 0.7 Tnwb + 0.2 Tg + 0.1 Tdb + Clo

Where Tnwb = natural wet bulb temperature
Tg = globe temperature
Tdb = dry bulb (air) temperature
Clo = clothing value

1 Heat Stress and Heat Strain in: 2002. ACGIH. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH.

Sensors should always be located so that the readings obtained will be truly representative of the environmental conditions to which the worker is exposed. In locating the meter, consider worker height, radiation sources and direction of air movement. Allow sufficient time for thermometer equilibration before taking readings.

One-hour time-weighted averages may be used when work and rest environments are different. For example, [(WBGT at work site x 45 minutes) + (WBGT in air conditioned building during rest x 15)]/60 = TWA.

Step 2

Determine Metabolic Heat. Characterize the worker's physical activity (metabolic heat) using Table B2.

Table B2. Metabolic Heat

CATEGORIES	EXAMPLE ACTIVITIES	METABOLIC RATE KCAL/HR
Resting	Sitting quietly	100
Light	Sitting with moderate arm movements Sitting with moderate arm and leg movements Standing with light work at machine or bench while using mostly arms Using a table saw Standing with light or moderate work at machine or bench and some walking about	113-140 140-160 140-160
Moderate	Scrubbing in a standing position Walking about with moderate lifting or pushing Walking on level at 3.5 mph while carrying 3 kg weight load	165-190 250-350
Heavy	Carpenter sawing by hand Shoveling dry sand Heavy assembly work on a noncontiguous basis Intermittent heavy lifting with pushing or pulling (e.g., pick-and-shovel work)	380-500
Very Heavy	Shoveling wet sand	500-600

Step 3

Determine Worker Acclimatization. Acclimatization refers to the physiological adjustment to heat stress conditions. Full heat acclimatization requires up to three weeks of continued physical activity under heat-stress conditions similar to those anticipated for the work to be conducted. Loss of acclimatization may begin within four days after discontinuing work. A worker may be considered acclimatized when there has been a recent history of heat-stress exposure, such as five of the last seven days.

Step 4

Determine Whether Screening Criteria Have Been Exceeded. Use Table B3, WBGT Index Screening Criteria and the information gathered in Steps 1-3 to determine if screening criteria have been exceeded. If work conditions exceed the criteria shown in Table B3, medical surveillance will be initiated.

Table B3. WBGT Index (ºF) Screening Criteria for Heat Stress Exposure

	ACCLIMATIZED				UNACCLIMATIZED			
WORK DEMANDS	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	85.1	81.5	78.8	Conduct physiological monitoring	81.5	77	72.5	Conduct physiological monitoring
75% Work 25% Rest	86.9	83.3	81.5	Conduct physiological monitoring	84.2	79.9	76.1	Conduct physiological monitoring
50% Work 50% Rest	88.7	85.1	83.3	81.5	86	82.4	79.9	77
25% Work 75% Rest	90.5	87.8	86	85.1	87.8	84.2	82.4	79.5

Regardless of whether the screening criteria have been exceeded, symptoms of heat strain (heat related illness), such as fatigue, nausea, dizziness and lightheadedness, must not be ignored. The presence of these symptoms indicates the need for medical evaluation as well as the need to re-evaluate heat stress.

These screening criteria must not be used when workers are wearing clothing that is highly restrictive or impermeable to heat or vapor (i.e., multiple-layered clothing or encapsulating suits).

Appendix C. Medical (Physiological) Surveillance

Workers required to work in hot environments that exceed the WBGT Screening Criteria[2] must be medically evaluated to determine whether they can do so without excessive heat strain. The Park shall institute a medical surveillance program for all workers who exceed the heat stress screening criteria in Table B3. Medical examination and procedures will be performed by or under the direction of a licensed physician or health care provider.

By monitoring one or more physiological parameters, we can determine excessive heat strain. Excessive heat strain is indicated when any of the following occur:

- Sustained heart rate is in excess of 180 beats per minute less the worker's age in years for individuals with assessed normal cardiac performance.
- Core body temperature is greater than 101.3ºF in healthy, unmedicated and acclimatized workers.
- Core body temperature is greater than 100.4ºF for unselected, unacclimatized workers.
- Recovery heart rate at one minute after a peak work effort is greater than 110 beats per minute.
- There are symptoms of sudden and severe fatigue, nausea, dizziness or light-headedness.

Worker exposure must be discontinued when any of these conditions occur.

An individual may be at greater risk if there has been sustained profuse sweating over a period of hours, when weight loss over the work shift is greater than 1.5% of body weight, and when 24-hour urinary sodium excretion is less than 50 mmoles.

Consideration must always be given to variable tolerance of workers to heat stress. 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.

2 In the absence of detailed heat stress evaluations conducted by an industrial hygienist.

Appendix D: Controlling Heat Strain

General Heat Stress Controls

General controls must be implemented when heat stress is elevated and the risk of excessive heat strain exists. Elevated heat stress conditions occur when the HI is 105ºF or greater and when the WBGT Heat Stress Screening Criteria are exceeded. Also note that elevated heat stress conditions may also exist for certain individuals and circumstances.

- 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.
- Permit self-limitation of exposures and encourage co-worker observation to detect signs and symptoms of heat strain in others.
- Counsel and monitor those who take medication 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 lifestyles, 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 the approval of a physician if on a salt-restricted diet).
- Consider pre-placement medical screening to identify those susceptible to systematic heat injury.
- Task-specific controls must be implemented for workers at high risk of increased heat stress due to their work environment or required protective equipment. Examples are firefighters and emergency responders to hazardous materials incidents.
- 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.

Task-Specific Controls

- 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.

Table D1. Checklist for Controlling Heat Stress

❿	Control metabolic heat (reduce body heat production)	• Reduce physical demands of the work. • Provide powered assistance for heavy tasks.
❿	Reduce radiant heat load	• Interpose a line-of-sight barrier. • Furnace wall insulation, metallic reflecting screen, heat reflective clothing. • Cover exposed part of the body.
❿	Reduce convective heat load	• If air temperature is above 95ºF, reduce air temperature, reduce air speed across skin, and wear clothing. • If air temperature is less than 95ºF, increase air speed across skin and reduce clothing.
❿	Maximize evaporative cooling by sweating	• Decrease humidity, increase air speed, and decrease clothing.
❿	Modify work practices	• Shorten duration of each exposure. More frequent short exposures are better than fewer long exposures. • Schedule very hot jobs in cooler part of the day when possible.
❿	Exposure limit	• Allow self-limiting of exposure based on formal indoctrination of workers and supervisors on signs and symptoms of excessive strain.
❿	Recovery	• Provide air-conditioned space nearby.
❿	Personal protection	• Provide cooled air, cooled fluid or ice-cooled conditioned clothing. • Provide reflective clothing or aprons.
❿	Other	• Determine by medical evaluation, primarily of cardiovascular status. • Careful break-in of unacclimatized workers. • Water intake at frequent intervals to prevent hypohydration. • Fatigue or mild illness such as low-grade infection, diarrhea, sleepless night or alcohol ingestion not related to the job may temporarily contraindicate exposure.
❿	Heat wave	• Introduce a heat alert program.

Never Ignore Anyone's Signs or Symptoms of Heat-Related Disorders

Appendix E: Signs and Symptoms of Heat Strain and First Aid Procedures

Prevention of serious heat-induced illness depends on the early recognition of signs and symptoms and prompt implementation of control measures. Therefore, employees must receive training in the following topics:

- Recognition of the signs and symptoms of heat strain (see Table E1).
- Personal care procedures that employees should use to reduce the risk of illness.
- The influence of non-occupational factors such as alcohol use, medication, obesity and other health factors on employees' tolerance to occupational heat stress.
- Workers who use heat-protective clothing and equipment must be instructed in their proper care and use.

Table E1.1. Recognition, Medical Aspects and Prevention of Heat Illness

ILLNESS	RECOGNITION, CLINICAL FEATURES	PREDISPOSING FACTORS	PHYSIOLOGICAL BASIS	FIRST AID AND TREATMENT	PREVENTION
Heat stroke	Hot dry skin usually red, mottled or cyanotic; rectal temperature 104ºF or greater; confusion, loss of consciousness, convulsions, rectal temp. continues to rise, fatal if treatment delayed	Sustained exertion in heat by un acclimatized workers Lack of physical fitness and obesity Recent alcohol intake; dehydration; individual susceptibility; chronic cardiovascular disease	Partial or complete failure of sweat mechanism leading to loss of evaporative cooling and uncontrolled rise in body temperature	Immediate and rapid cooling by immersion in chilled water with massage or by wrapping in wet sheet with vigorous fanning with cool dry air, avoid over-cooling, treat shock if present	Medical screening of workers, selection of workers for tasks based on health and physical fitness, acclimatization, monitoring of workers during sustained work in severe heat
Heat syncope	Fainting while standing erect and immobile in heat	Lack of acclimatization	Pooling of blood in dilated vessels of skin and lower parts of body	Remove to cooler area, rest in recumbent position, recovery prompt and complete	Acclimatization, intermittent activity to assist venous return to heart
Heat exhaustion	Fatigue, nausea, headachy, giddiness; skin clammy and moist, complexion pale, muddy, or hectic flush; may faint on standing with rapid thready pulse and low blood pressure; Oral temperature normal or low but rectal temperature, usually elevated; water restriction types: urine volume small, highly concentrated; salt restriction type: urine less-concentrated	Sustained exertion in heat; lack of acclimatization; and failure to replace water lost in sweat	Dehydration form deficiency of water; depletion of circulating blood volume; circulatory strain from competing demands for blood flow to skin and to active muscles	Remove to cooler environment, rest in recumbent position, administer fluids by mouth, keep at rest until urine volume indicates that water balances have been restored	Acclimatize worker using a break-in schedule for 5-7days, supplement dietary salt only during acclimatization, ample drinking water to be available at all times and to be taken frequently during workday

Table E1.2. Recognition, Medical Aspects and Prevention of Heat Illness

ILLNESS	RECOGNITION,CLINICAL FEATURES	PREDISPOSINGFACTORS	PHYSIOLOGICALBASIS	FIRST AID ANDTREATMENT	PREVENTION
Heat cramps	Painful spasms ofmuscles used during work (arms,legs, or abdominal);onset during orafter work hours	Heavy sweatingduring hot work;drinking largevolumes of waterwithout replacingsalt loss	Loss of body salt insweat, water intakedilutes electrolytes,water enters muscles, causing spasm	Salted liquids bymouth or moreprompt relief by IVinfusions	Adequate saltintake with meals;in unacclimatizedworker supplementsalt intake at meals
Heat rash	Profuse tiny raisedred vesicles (blister-like) on affectedareas, pricking sensations duringheat exposure	Unrelieved exposure to humid heatwith skin continuously wet withunevaporatedsweat	Plugging of sweatgland ducts withretention of sweatand inflammatoryreaction	Mild drying lotions,skin cleanliness toprevent infection	Cool sleeping quarters to allow skin todry between heatexposures
Anhidrotic heatexhaustion	Extensive areas of skin which do not sweat on heatexposure, butpresent goosefleshappearance, whichsubsides with coolenvironments;associated withincapacitationin heat	Weeks or months ofconstant exposureto climatic heatwith previous history of extensive heatrash and sunburn	Skin trauma (heatrash; sunburn)causes sweat retention deep in skin,reduced evaporative cooling causesheat intolerance	No effective treatment available foranhidrotic areas ofskin, recovery ofsweating occursgradually on returnto cooler climate	Treat heat rash andavoid further skintrauma by sunburn,periodic relief fromsustained heat
Heat fatigue—transient	Impaired performance of skilledsensorimotor, mental, or vigilancetasks, in heat	Performance decrement greater inunacclimatized andunskilled workers	Discomfort andphysiologic strain	Not indicatedunless accompanied by other heatillness	Acclimatization andtraining for work inthe heat
Heat fatigue—chronic	Reduced performance capacity, lowering of self-imposed standardsof social behavior(e.g., alcoholic over-indulgence). Inabilityto concentrate	Workers at riskcome from temperate climates, forlong residence intropical latitudes	Psychosocial stresses probablyas important asheat stress, mayinvolve hormonalimbalance but notpositive evidence	Medical treatmentfor serious cases,speedy relief ofsymptoms onreturning home	Orientation to lifein hot regions (customs, climate, living conditions, etc.)