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John C. Stennis Space Center
Heat Stress Program

Approved by

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Date

Document History Log

Status/Change/ Revision	Change Date	Originator/ Phone	Description
Basic	07/23/09	M. Jones, 8-1187	Initial Release
Revision A	03/26/10	M. Rewis, 8-2663	Changed section 1.0 to exclude disclaimer. 4.3, redundant reference to Heat Stress Program Manager deleted. 5.3, Medical Determination, to suggest that medical evaluations should be conducted (vice 'will') in concert with the appropriate heat stress cases.
Revision B	04/01/13	R. Gargiulo 688-3842 K. Wright 688-3263 A. Rice 688-2972	Added requirement for fresh water at construction sites and cleaning/sanitizing water coolers. Added Acronym List. Revised NIHM Responsibility. Added address for SSC weather conditions. Added acronym for TWA. Moved procedures to page 7, gave the requirements for training.

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Tables

1.0 PURPOSE

This Work Instruction establishes procedures and responsibilities for the effective prevention and control of heat-related injury at John C. Stennis Space Center (SSC).

Injury due to hot environments is a serious threat to people exposed to high heat and humidity levels. Environmental factors associated with heat stress include ambient air temperature, radiant heat, air movement, conduction, and relative humidity.

It is SSC policy to conduct operations in a manner to prevent heat-related injury associated with working in hot environments through the implementation of this Heat Stress Program.

2.0 APPLICABILITY

This Work Instruction applies to all NASA SSC civil servant employees, all SSC contractors, and all outside contractors working at SSC.

3.0 REFERENCES

All references are assumed to be the latest version unless otherwise indicated.

a. Heat Stress & Heat Strain, Threshold Limit Values for Chemical Substances and Physical Agents, American Conference of Governmental Industrial Hygienists (ACGIH), 2007.

b. International Organization for Standardization (ISO) 12894:2001, *Ergonomics of the Thermal Environment – Medical Supervision of Individuals Exposed to Extreme Hot or Cold Environments.*

c. *NOAA's National Weather Service Heat Index.* http://www.nws.noaa.gov/om/heat/index.shtml, 2009.

d. Occupational Safety and Health Administration (OSHA) Fact Sheet 95-16, *Protecting Workers in Hot Environments,* 1995.

e. "Heat Stress: Improving Safety in the Arabian Gulf Oil & Gas Industry." Oliver F. McDonald, Nigel J. Shanks, and Laurent Fragu, *Professional Safety*, August 2008.

4.0 ROLES AND RESPONSIBILITIES

4.1. NASA SSC Safety and Mission Assurance Directorate

The NASA SSC Safety and Mission Assurance Directorate shall have overall responsibility for this Instruction.

4.2. NASA Industrial Hygiene Manager

The NASA Industrial Hygiene Manager (NIHM) shall provide technical support to the NASA Safety and Mission Assurance Directorate.

4.3. Center Operations Directorate

The Center Operations Directorate shall maintain an alert system notifying employees of heat stress conditions as defined by National Oceanic and Atmospheric Administration 's (*NOAA)'s National Weather Service Heat Index.*

4.4. Facility Operating Services Contractor

The Facility Operating Services Contract (FOSC) shall:

a. Designate a Heat Stress Program Manager to oversee the implementation of this Program.

b. Provide support to the Environmental Management Lead by developing, implementing, and maintaining the SSC Heat Stress Program conforming to the procedural requirements in Section 5.0 of this instruction for FOSC and NASA civil servant personnel.

c. Respond to heat stress alerts by implementing the Heat Stress Program for employees exposed above the Heat Stress Threshold Limit Value (TLV©).

4.5. Contractors and Construction Contractors

NASA contractors and construction contractors shall:

a. Follow the requirements of this instruction or develop, implement, and maintain a Heat Stress Program for their employees conforming to this instruction.

b. Respond to heat stress alerts by implementing the Heat Stress Program for employees exposed above the Heat Stress TLV.

4.6. Heat Stress Program Manager

Each Heat Stress Program Manager shall:

a. Manage the day-to-day operation and implementation of a Heat Stress Program, conforming to the requirements of Section 5.0 of this instruction.

b. Provide monitoring support for measuring the Wet Bulb Globe Temperature (WBGT) for tasks posing a potential heat stress risk. Current Stennis Space Center weather conditions can be viewed via the following address: http://sscintranet.ssc.nasa.gov/.

c. Perform assessments to determine whether employees are exposed above the Action Limit or the TLV.

d. Advise employees and their supervisors of the results of the assessment and the need to implement general and job-specific controls to limit heat strain.

e. Provide heat stress training that conforms to Section 9 of this Instruction.

4.7. Facility Engineers and Design Engineers

Facility and design engineers shall implement cooling principles by including air conditioning and ventilation in the design and modifications of facilities, where practical.

4.8. Directors, Managers, Supervisors and Team Leads

Directors, Managers, Supervisors, and Team Leads shall:

a. Notify their respective Heat Stress Program Manager of employees who work in potential high heat stress areas.

b. Notify their Heat Stress Program Manager of any changes in operations requiring Heat Stress determinations or evaluations.

c. Ensure employees who work in potential high heat stress areas receive information and training on Heat Stress Prevention.

d. Attend Heat Stress Prevention training.

e. Ensure consideration is given to heat exposure reduction in the design, development, and implementation of new processes or changes to existing processes.

4.9. Individual Employees

Individual employees shall:

a. Attend annual training if exposed at or above the Action Limit, along with their supervisors.

b. Utilize control procedures described in Section 5.0 to reduce heat stress and to prevent heat-related injuries.

c. Notify supervisors and/or their Heat Stress Program Managers of areas or operations with high heat stress potential.

d. Perform individual physiological heat strain monitoring as specified by their organization's Heat Injury Prevention Program.

5.0 PROCEDURES

5.1. Screening Threshold Assessment

A Screening Threshold Assessment will be conducted for employees performing tasks that pose a potential heat stress risk. The screening threshold will be based on the WBGT, which is recognized as a useful first order index of the environmental contribution to heat stress. The assessment will include an evaluation of the contribution of employee metabolic rate and adjustment for the type of clothing (see Table 5-1) worn during the task. The assessment will result in the determination and selection of an Action Limit and TLV from Table 5-2.

5.2. Detailed Analysis

If the screening threshold indicates workers may be exposed above the TLV, a detailed analysis should be performed to verify the exposure exceeds the TLV. The detailed analysis may consist of calculating a Time-Weighted Average (TWA) of the effective WBGT and metabolic rate, or other recognized method.

5.3. Medical Determination

Employees working in environments where they are exposed at or above the Heat Stress and Heat Strain TLV should receive a medical screening assessment conforming to the guidance in ISO 12894:2004, *Ergonomics of the Thermal Environment – Medical Supervision of Individuals Exposed to Extreme Hot or Cold Environments*, Annex F.

5.4. General Controls

The following are general controls for employees exposed above the Action Limit:

a. Provide verbal and written instructions, annual training, and other information on heat stress and strain.

b. Encourage drinking small volumes (approximately one (1) cup) of cool, palatable water, or a fluid replacement drink about every twenty (20) minutes.

   1) Fresh drinking water (plumbed, bottled or water coolers) shall be provided daily at construction sites. If coolers are used, they shall be changed daily, taped/sealed and dated.
   2) Water coolers shall be cleaned/sanitized as needed but no less than once per month per the following guidance: Wash, wipe and/or rinse the cooler with a detergent and water (wipe/wash away visible algae/grime/dirt). Sanitize the water cooler with a chlorine to water mixture of 1:250 (1 tablespoon per gallon of water). Sanitize all surfaces in contact with the drinking water. Let it stand for two (2) minutes and then

empty the cooler through the spigot to sanitize it. The cooler can be air dried or rinsed with potable water.

c. Permit self-limitation of exposures and encourage coworker observation to detect signs and symptoms of heat strain in others.

d. 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.

e. Encourage healthy lifestyles, ideal body weight, and electrolyte balance.

f. Adjust expectations of and encourage consumption of salty foods by those returning to work after absence from heat exposure situations where they may lose acclimatization.

g. Monitor heat stress conditions and reports of heat-related disorders.

5.5. Physiological Heat Strain Monitoring

If exposures exceed the TLV, physiological monitoring will be performed to demonstrate adequate protection is provided. One (1) or more of the measures stated below will be used as a measure of excessive heat strain. An individual's exposure to heat stress should be discontinued when any of the following occur:

a. Sustained (several minutes) heart rate is in excess of 180 Beats Per Minute (BPM) minus the individual's age in years for individuals with assessed normal cardiac performance.

b. Body core temperature is greater than 38.5 °C (101.3 °F) for acclimatized personnel with medical clearance or is greater than 38 °C (100.4 °F) in unacclimatized workers.

c. Recovery heart rate at one minute after a peak work effort is greater than 120 BPM.

d. Symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness.

e. Profuse sweating is sustained over hours.

f. Weight loss over a shift is greater than 1.5% of body weight.

g. 24-hour urinary sodium excretion is less than 50 mmoles.

5.6. Job-Specific Controls

If physiological heat stress monitoring indicates excessive heat strain is occurring, job-specific controls shall be implemented. Job-specific controls may include:

a. Scheduling of outdoor work during the cooler morning or evening hours.

b. Engineering controls that reduce the metabolic rate, provide general air movement, provide air-conditioned air, reduce process heat and water vapor release, provide shade, and shield radiant heat sources.

c. Administrative controls that set acceptable exposure times, allow sufficient recovery, and limit physiological strain.

d. Personnel controls requiring Personal Protective Equipment (PPE), such as evaporative cooling vests, phase-change material cooling vests, or circulating water vests.

5.7. Emergency Response

If an employee appears to be disoriented or confused, suffers inexplicable irritability, malaise, or chills, the worker shall be removed for rest in a cool location with rapidly circulating air and kept under observation. This occurrence should be considered a medical emergency and shall be reported by calling 911 from a land line phone or 228-688-3636 from a cellular phone.

5.8. Acclimatization

Acclimatization is a gradual adaptation to working in hot environments to improve the body's ability to tolerate heat stress. This adaptation requires physical activity under heat stress conditions. Working in heat stress conditions for two (2) hours a day for five (5) to ten (10) days over one (1) to two (2) weeks is adequate to acclimate an individual. Because of the gradual nature of acclimatization, a person cannot rapidly acclimate to a sudden higher level of heat stress, such as in a heat wave.

Acclimatization is lost when activity under heat stress conditions stops. A noticeable loss of acclimatization occurs after four (4) days away from the heat stress conditions and may be completely lost in three (3) to four (4) weeks.

5.9. Employee Training

All supervisors of employees who work in elevated heat areas should ensure heat stress training is available. Types of training include, but are not limited to, a formal presentation by the Heat Stress Program Manager; "Toolbox talks" led by the supervisor, or computer based training. Training should incorporate identifying heat related conditions, measures to overcome elevated heat conditions, and a description of the site-wide heat stress alert system.

Table 5-1 – Clothing Adjustment Factors

From *ACGIH Heat Stress & Strain*, 2007

Clothing Type	Addition to (WBGT) (ºC)
Work clothes (long–sleeved shirt and pants)	0
Double-layer woven clothing	3
SMS polypropylene coveralls	0.5
Polyolefin coveralls	1
Limited-use vapor-barrier coveralls	11

Note:

These values must not be used for completely encapsulating suits, often called Level A. Clothing Adjustment Factors cannot be added for multiple layers. The coverall factors assume that only modesty clothing is worn underneath, not a second layer of clothing.

Table 5-2 – Screening Criteria for TLV and Action Limit for Heat Stress Exposure

From *ACGIH Heat Stress & Strain*, 2007

Allocation of Work in a Cycle of Work and Recovery	TLV (WBGT)				Action Limit (WBGT)			
	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
75% to 100%	31.0 °C 87.8 °F	28.0 °C 82.4 °F	-	-	28.0 °C 82.4 °F	25.0 °C 77.0 °F	-	-
50% to 75%	31.0 °C 87.8 °F	29.0 °C 84.2 °F	27.5 °C 81.5 °F	-	28.5 °C 83.3 °F	26.0 °C 78.8 °F	24.0 °C 75.2 °F	-
25% to 50%	32.0 °C 89.6 °F	30.0 °C 86.0 °F	29.0 °C 84.2 °F	28.0 °C 82.4 °F	29.5 °C 85.1 °F	27.0°C 80.6 °F	25.5 °C 77.9 °F	24.5 °C 76.1 °F
0% - 25%	32.5 °C 90.5 °F	31.5 °C 88.7 °F	30.5 °C 86.9 °F	30.0 °C 86.0 °F	30.0 °C 86.0 °F	29.0 °C 84.2 °F	28.0 °C 82.4 °F	27.0 °C 80.6 °F

Notes:

- See Table 5-3 and the TLV Documentation for work demand categories.
- WBGT values are expressed to the nearest 0.5 °C.
- Thresholds are computed as a Time-Weighted Average (TWA) Metabolic Rate where the metabolic rate for rest is taken as 115 W and work is the representative (mid-range) value of Table 5-3. The time base is taken as the proportion of work at the upper limit of the percent work range (e.g., 50% for the range of 25% to 50%).
- If work and rest environments are different, hourly TWA WBGT should be calculated and used. TWAs for work rates should also be used when the work demands vary within the hour, but note that the metabolic rate for rest is already factored into the screening limit.
- Values in the table are applied by reference to the "Work-Rest Regimen" section of the TLV Documentation and assume 8-hour workdays in a 5-day workweek with conventional breaks as discussed in the TLV Documentation. When workdays are extended, consult the "Application of the TLV" section of the Documentation.
- Because of the physiological strain associated with Heavy and 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 for Very Heavy work. The screening criteria are not recommended, and a detailed analysis and/or physiological monitoring should be used.

Table 5-3 – Metabolic Rate Categories and the Representative Metabolic Rate with Example Activities

Category	Metabolic Rate (W)*	Examples
Rest	115	Sitting
Light	180	Sitting with light manual work with hands or with hands and arms, and driving. Standing with some light arm work and occasional walking.
Moderate	300	Sustained moderate hand and arm work, moderate arm and leg work, moderate arm and trunk work, or light pushing and pulling. Normal walking.
Heavy	415	Intense arm and trunk work, carrying, shoveling, manual sawing; pushing and pulling heavy loads; and walking at a fast pace.
Very Heavy	520	Very intense activity at fast to maximum pace.

* The effect of body weight on the estimated metabolic rate can be accounted for by multiplying the estimated rate by the ratio of actual body weight divided by 70 kg (154 lb).

6.0 ACRONYMS

ACGIH	American Conference of Industrial Hygienists
BPM	Beats Per Minute
FOSC	Facility Operating Services Contract
ISO	International Organization for Standardization
OSHA	Occupational Safety and Health Administration
NIHM	NASA Industrial Hygiene Manager
NOAA	National Oceanic and Atmospheric Administration
PPE	Personal Protective Equipment
SSC	Stennis Space Center
TLV	Threshold Limit Value
TWA	Time-Weighted Average
WBGT	Wet Bulb Globe Temperature

Appendix A – Heat Disorders

From OSHA Fact Sheet No. 95-16, *Protecting Workers in Hot Environments*.

Four (4) environmental factors affect the amount of stress a worker faces in a hot work area: temperature, humidity, radiant heat (such as from the sun or a furnace), and air velocity. Perhaps most important to the level of stress an individual faces are personal characteristics such as age, weight, fitness, medical condition, and acclimatization to the heat.

The body reacts to high external temperature by circulating blood to the skin, which increases skin temperature and allows the body to give off its excess heat through the skin. However, if the muscles are being used for physical labor, less blood is available to flow to the skin and release the heat.

Sweating is another means the body uses to maintain a stable internal body temperature in the face of heat. However, sweating is effective only if the humidity level is low enough to permit evaporation; and if the fluids and salts lost are adequately replaced.

Of course, there are many steps a person might choose to take to reduce the risk of heat stress, such as moving to a cooler place, reducing the work pace or load, or removing or loosening some clothing.

But if the body cannot dispose of excess heat, it will store it. When this occurs the body's core temperature rises and the heart rate increases. As the body continues to store heat, the individual begins to lose concentration and has difficulty focusing on a task, may become irritable or sick, and often loses the desire to drink. The next stage is most often fainting, and death is possible if the person is not removed from the heat stress.

Heat stroke, the most serious health problem for workers in hot environments, is caused by the failure of the body's internal mechanism to regulate its core temperature. Sweating stops and the body can no longer rid itself of excess heat. Signs include (1) mental confusion, delirium, loss of consciousness, convulsions, or coma; (2) a body temperature of 106 °F or higher; and (3) hot, dry skin which may be red, mottled, or bluish. Victims of heat stroke will die unless treated promptly. While awaiting medical help, the victim must be removed to a cool area and his or her clothing soaked with cool water. He or she should be fanned vigorously to increase cooling. Prompt first aid can prevent permanent injury to the brain and other vital organs.

Heat exhaustion results from loss of fluid through sweating when a worker has failed to drink enough fluids or take in enough salt or both. The worker with heat exhaustion still sweats but experiences extreme weakness or fatigue, giddiness, nausea, or headache. The skin is clammy and moist, the complexion pale or flushed, and the body temperature normal or slightly higher. Treatment is usually simple: the victim should rest in a cool place and drink an electrolyte solution (a beverage used by athletes to quickly restore potassium, calcium, and magnesium salts). Severe cases involving victims who vomit or lose consciousness may require longer treatment under medical supervision.

Heat cramps, painful spasms of the muscles, are caused when workers drink large quantities of water but fail to replace their bodies' salt loss. Tired muscles (those used for performing the work) are usually the ones most susceptible to cramps. Cramps may occur during or after working hours and may be relieved by taking liquids by mouth or saline solutions intravenously for quicker relief, if medically determined to be required.

Fainting (heat syncope) may be a problem for the worker unacclimatized to a hot environment who simply stands still in the heat. Victims usually recover quickly after a brief period of lying down. Moving around, rather than standing still, will usually reduce the possibility of fainting.

Heat rash, also known as prickly heat, may occur in hot and humid environments where sweat is not easily removed from the surface of the skin by evaporation. When extensive or complicated by infection, heat rash can be so uncomfortable that it inhibits sleep and impedes a worker's performance or even results in temporary total disability. It can be prevented by resting in a cool place and allowing the skin to dry.

Appendix B – Dehydration Guide

From "Heat Stress: Improving Safety in the Arabian Gulf Oil & Gas Industry." Oliver F. McDonald, Nigel J. Shanks, and Laurent Fragu, *Professional Safety*, August 2008, page 37.