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John C. Stennis Space Center
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John C. Stennis Space Center

HEAT STRESS PROGRAM

Approved by

original signed by — *8/1/2023*

Michael A. Pannell, PhD, CIH — Date

Occupational Health Officer

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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.
Revision C	07/01/16	M. Pannell 688-2555	Administrative changes throughout document. Updated references and acronyms. Updated responsibilities; provided additional means to evaluate worker heat stress; updated FOSC to Stennis Operating Contractor; and added Table 5-1, Heat Index Values, Flags, Health Effects, and Protective Measures.

Status/Change/ Revision	Change Date	Originator/ Phone	Description
Revision D	12/1/18	M. Pannell 8-2555	Replace Heat Stress Competent Person with Heat Stress Monitor. Clarify training requirements. Clarify responsibilities.
Revision E	12/1/22	M. Pannell 8-2555	5-Year Review. Update references and links.
Revision F	8/1/23	M. Pannell	Correct errors in Heat Index Table 5-1
Revision F-1	8/1/23	M. Pannell	Corrected expiration date to reflect 5 year review.

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1.0 PURPOSE

This Stennis Common Work Instruction (SCWI) establishes procedures and responsibilities for the effective prevention and control of heat-related injury at John C. Stennis Space Center (SSC). Specifically, this SCWI will provide guidance to: 1) anticipate and identify weather conditions requiring heat stress control measures; 2) incorporate heat stress control measures into work practices; 3) identify physiological monitoring to evaluate the effectiveness of implemented control measures; and, 4) evaluate and modify heat stress control measures.
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 SCWI applies to all National Aeronautics and Space Administration (NASA) SSC civil servant employees, all SSC and resident contractors, and all outside contractors conducting NASA-related work 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), 2022.
b. International Organization for Standardization (ISO) 12894:2004, *Ergonomics of the Thermal Environment – Medical Supervision of Individuals Exposed to Extreme Hot or Cold Environments*
c. *NOAA National Weather Service Heat Index*, http://www.nws.noaa.gov/om/heat/index.shtml, 2009
d. Occupational Safety and Health Administration (OSHA) DTSEM FS-3743 08/2014, *Protecting Workers from the Effects of Heat,* 2014
e. "Heat Stress: Improving Safety in the Arabian Gulf Oil and Gas Industry." Oliver F. McDonald, Nigel J. Shanks, and Laurent Fragu, *Professional Safety*, August 2008

4.0 ROLES AND RESPONSIBILITIES

4.1 NASA Center Operations Directorate

a. The NASA SSC Center Operations Directorate shall have overall responsibility for this SCWI.
b. The Center Operations Directorate shall maintain an alert system notifying employees of heat stress conditions as defined by the National Oceanic and Atmospheric Administration (*NOAA) National Weather Service Heat Index*.

4.1.1 Stennis Operating Contractor (SOC) Certified Industrial Hygienist (CIH)

The SOC CIH shall:

a. Act as the NASA Heat Stress Program Manager.
b. Manage the SSC Heat Stress Program.
c. Provide monitoring support for measuring the Wet Bulb Globe Temperature (WBGT) for tasks posing a potential heat stress risk, or designate Industrial Hygiene staff to perform monitoring support.
d. As necessary, designate other SOC Industrial Hygienist(s) (IHs) to act as the Heat Stress Monitor (HSM).
e. Develop and conduct heat stress training appropriate to the task performed. Employees will receive general awareness training, while HSMs receive more detailed training to include heat stress control measures and signs and symptoms of heat stress.
f. Perform physiological monitoring, as described in section 5.6, to determine the effectiveness of implemented control measures.
g. When physiological monitoring indicates that implemented control measures are ineffective, implement the ACGIH Work-Rest Cycle as described in Table 5-3.
h. Perform assessments to determine whether employees are exposed above the Action Limit or the Heat Stress Threshold Limit Value® (TLV®).
i. Evaluate and train prospective HSMs nominated by managers, supervisors, or team leads as described in section 4.7 of this SCWI.

4.2 Stennis Operating Contractor (SOC)

The SOC shall:

a. Develop, implement, and maintain the SSC Heat Stress Program, conforming to the procedural requirements in Section 5.0 of this SCWI for SOC and NASA civil servant personnel.
b. Respond to heat stress alerts by implementing the Heat Stress Program for employees exposed above the Heat Stress TLV®.

4.3 Contractors and Construction Contractors

Contractors and construction contractors shall:

a. Follow the requirements of this SCWI or develop, implement, and maintain a Heat Stress Program for their employees, conforming to this SCWI.
b. Contractors and construction contractors shall appoint a project specific HSM for each project and contract where heat stress is identified as a potential hazard. The credentials of each contractor-appointed HSM shall be verified by the SOC IH.
c. Respond to heat stress alerts by implementing the Heat Stress Program for employees exposed above the Heat Stress TLV®.
d. Ensure employees are acclimated to the temperatures and associated heat stressors expected on the job site.

4.4 Heat Stress Monitor (HSM)

Each HSM shall:

a. Manage the day-to-day operation and implementation of a Heat Stress Program for the Center, conforming to the requirements of Section 5.0 of this SCWI.
b. Utilize historical weather patterns and the Heat Stress Index as the primary sources of determining control measures.
c. Monitor the Heat Index Alert System. Current SSC weather conditions and heat index can be viewed via the following address: https://ssccommunity.ssc.nasa.gov/..
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 stress.
e. Provide heat stress training that includes identifying the signs and symptoms of heat stress and physiological monitoring as identified in section 5.6 of this SCWI.

4.5 Facility Engineers and Design Engineers

Facility and design engineers shall implement heat control processes and cooling principles by including air conditioning and ventilation in the design and modifications of facilities, where practical, whenever projected heat index values exceed 90° F.

4.6 Managers, Supervisors, and Team Leads

Managers, Supervisors, and Team Leads shall:

a. Nominate to the SOC CIH prospective HSM(s) to ensure sufficient availability for each work task. Each HSM nominee shall be evaluated and trained by the SOC CIH. For non-NASA and non-SOC contractors, tenants, and residents, the HSM credentials shall be evaluated by the SOC CIH.
b. Notify their respective HSM of employees who work in potential high heat stress areas.
c. Notify their HSM of any changes in operations requiring heat stress determinations or evaluations.
d. Ensure consideration is given to heat exposure reduction in the design, development, and implementation of new processes or changes to existing processes.

4.7 Individual Employees

Individual employees shall:

a. Attend New Employee Safety and Health Orientation (NESHO) Heat Stress Awareness training provided by the SOC Training Group.
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 HSM of areas or operations with high heat stress potential or tasks that may have changed to increase the potential heat stress hazard.

5.0 PROCEDURES

5.1 Heat Index

The heat index is a single value that takes both temperature and humidity into account. When planning outdoor projects or tasks, contractors shall assess the potential for elevated heat index values and take appropriate measures to provide adequate protections against heat stress.

Contractors shall monitor the SSC Heat Stress Alert System at https://ssccommunity.ssc.nasa.gov/. Table 5-1 shows the heat index values, the flag indicators used on the SSC Heat Stress Alert System, the general signs of exposure, and protective measures. General heat stress controls are listed in section 5.5 of this SCWI.

Tasks that pose a potential Heat Stress risk shall be evaluated for potential heat stress hazards. The evaluation will consist primarily of historic weather patterns and the Heat Stress Index. The evaluation will include an assessment of the contribution of employee metabolic rate and adjustment for the type of clothing (see Table 5-2) worn during the task. The assessment will result in the determination and selection of heat stress control measures.

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. HSMs may be contacted for additional expertise.

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, written instructions, training, and other information on heat stress.
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. Wherever practical, fresh drinking water shall be cool, either by refrigeration or added ice.
    2. Water coolers shall be cleaned/sanitized as needed, but no less than once per week 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 exposure and encourage co-worker observation to detect signs and symptoms of heat stress 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 Stress Monitoring

If exposures exceed the TLV® Action Limit as shown in Table 5-3, *Screening Criteria for TLV® and Action Limit for Heat Stress Exposure*, physiological monitoring will be performed to demonstrate adequate protection(s) has been implemented. One (1) or more of the measures listed below will be used as a measure of excessive heat stress. An individual's exposure to heat stress should be discontinued when any of the following occur:

a. 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 non-acclimated workers. This may be measured via tympanic membrane (eardrum).

b. 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.
c. Recovery heart rate at one (1) 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 for more than an hour.
f. Weight loss over a shift is greater than 1.5% of body weight.
g. 24-hour urinary sodium excretion is less than 50 millimoles (mmoles).

If the physiological monitoring indicates employees are not adequately protected from the effects of elevated heat stress, in addition to removing effected individuals from the exposure, the HSM shall implement additional control measures. Individuals removed from heat stress exposure shall be closely monitored using tympanic (eardrum temperature) and/or heart rate criteria listed above.

5.6 Job-Specific Controls

If physiological heat stress monitoring indicates excessive heat stress is occurring, additional 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 or increase 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 stress.
d. Personnel controls requiring Personal Protective Equipment (PPE), such as evaporative cooling vests, phase-change material cooling vests, or circulating water vests.
e. Evaluation of clothing adjustment factors and wearing clothes with lower WBGT adjustment factors.

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 landline phone or 228-688-3636 from a cellular phone.

5.8 Acclimatization

Acclimatization is the 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 most individuals. 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 and "Toolbox Talks" led by the supervisor, the HSM, or computer-based training. Training should incorporate identifying heat-related conditions, measures to overcome elevated heat conditions, and the signs and symptoms of heat stress.

Table 5-1: Heat Index Values, Flags, Health Effects, and Protective Measures

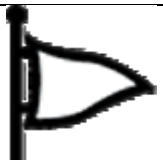
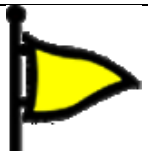
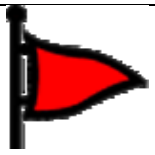
Category	Flag	Heat Index	Health Effects	Recommended Protective Measures
Okay		Less than 80°F (<27°C)		
Caution		80 to 90 °F (27 to 32°C)	Fatigue possible with prolonged exposure and/or physical activity.	Basic heat safety and planning.
Extreme Caution		91 to 103°F (32 to 39°C)	Sunstroke, muscle cramps, and/or exhaustion possible with prolonged exposure and/or physical activity.	Implement precautions and heighten awareness.
Danger		104 to 127°F (39 to 54°C)	Sunstroke, muscle cramps, and/or heat exhaustion likely. Heat stroke possible with prolonged exposure and/or physical activity.	Additional precautions to protect workers.
Extreme Danger		>128°F (>54°C)	Heat stroke or sunstroke likely.	Triggers even more aggressive protective measures.

Table 5-2: 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 5-3: 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 5-4 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 115W and work is the representative (mid-range) value of Table 5-4. 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 environment 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 stress 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 5-4: Metabolic Rate Categories and 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
CIH	Certified Industrial Hygienist
°	Degrees
F	Fahrenheit
HSM	Heat Stress Monitor
IH	Industrial Hygienist
ISO	International Organization for Standardization
mmoles	millimoles
NASA	National Aeronautics and Space Administration
NESHO	New Employee Safety and Health Orientation
NOAA	National Oceanic and Atmospheric Administration
OHO	Occupational Health Officer
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
SCWI	Stennis Common Work Instruction
SOC	Stennis Operating Contractor
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 insert:
https://www.osha.gov/sites/default/files/publications/heat_stress.pdf

Appendix B: Dehydration Guide

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