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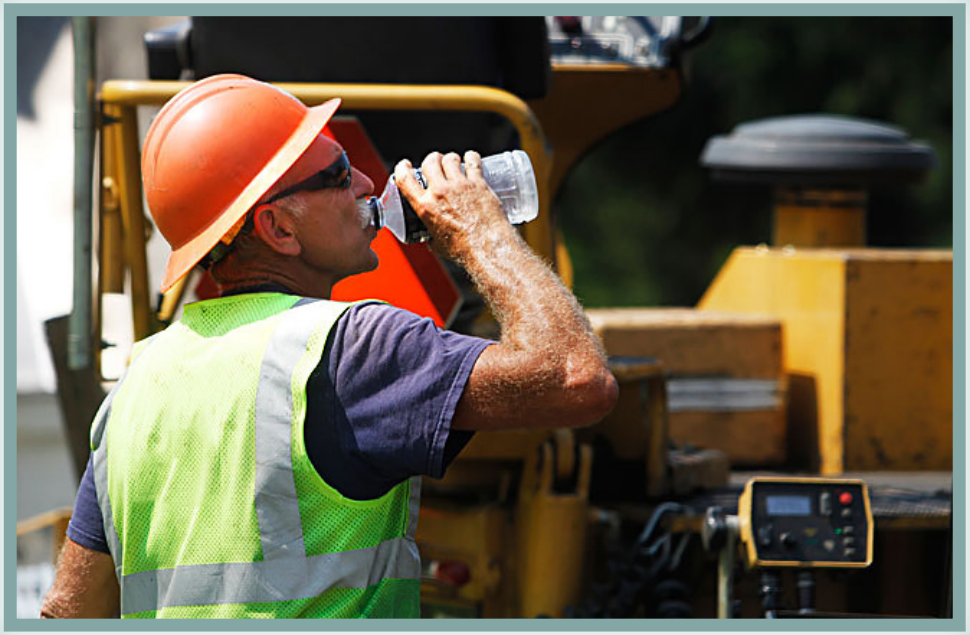

A Hot Topic: Preventing and Recognizing Heat-Related Illnesses

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During warmer weather months, it's imperative to consider the risks associated with working in hot environments, their effects on Department of Energy (DOE) employees and contractors, and how those risks can be mitigated. Heat-related illnesses generally occur when high ambient temperatures, either indoor or outdoor, overcome the body's natural ability to dissipate heat, resulting in heat illnesses.

These heat-related illnesses include heat stroke and heat exhaustion, with the possibility of heat syncope (i.e., fainting) or collapse, as well as heat rashes and heat cramps. The symptoms of each of these illnesses, and the first aid measures that should be taken if a worker shows signs of a heat-related illness, are provided in Table 1-1.

If left untreated, heat illnesses can lead to serious complications, and in the case of heat stroke, even death. According to the Centers for Disease Control, between 1999 and 2010, a total of 7,415 deaths in the U.S. occurred as a result of exposure to extreme heat—an average of 618 deaths per year. The National Institute for Occupational Safety and Health (NIOSH) advises that workers suffering from heat-related illness are also more prone to make mistakes and suffer other injuries. For those who do survive a serious heat-related illness, there may be long-term or permanent effects.

DOE reports document various incidents of heat-related illnesses experienced by workers throughout the Complex. From January 1, 2012, through March 1, 2016, three reports were filed in the Occurrence Reporting and Processing System (ORPS) related to heat illness. During the same time period, there were 19 incidents filed in the Computerized Accident and Reporting System (CAIRS) under "Heat Stroke/Other High Temp Effect," including the following.

Table 1-1. Heat-Related Ilnesses, Symptoms, and First Aid[1]

Illness	Symptoms	First Aid Measures
Heat Stroke	• Confusion • Fainting • Seizures • Excessive sweating or red, hot, dry skin (with no sweating) • Very high body temperature	• **Call 911.** While waiting for help, do the following. – Place worker in shady, cool area – Loosen clothing, remove outer clothing – Fan air on worker and place cold packs in armpits – Wet worker with cool water, apply ice packs, cool compresses, or ice, if available – Provide fluids, preferably water, as soon as possible – Stay with worker until help arrives
Heat Exhaustion (possibly with Heat Syncope)	• Cool, moist skin • Heavy sweating • Headache • Nausea or vomiting • Dizziness • Light headedness • Weakness • Thirst • Irritability or giddiness • Fast heart beat	• Have worker sit or lie down in a cool, shady area • Give worker plenty of water or other cool beverages to drink • Cool worker with cold compresses/ice packs • If signs or symptoms worsen or do not improve within 60 minutes, take the worker to a clinic or emergency room for medical evaluation or treatment
Heat Cramps	• Muscle spasms • Pain, usually in abdomen, arms, or legs	• Have worker rest in shady, cool area • Worker should drink water or other cool beverages • Wait a few hours before allowing worker to return to strenuous work • If cramps don't go away, have worker seek medical attention
Heat Rash	• Clusters of red bumps on skin • Often appears on neck, upper chest, folds of skin	• Try to work in a cooler, less humid environment, when possible • Keep the affected area dry

- On July 28, 2015, a worker who was wearing impermeable coveralls, gloves, and a helmet-type powered air purifying respirator (PAPR) was noticed to have "a dazed look" and was sweating profusely. Upon questioning, he "appeared disoriented" and slurred his speech. It was noted that his heart rate monitor was under his coveralls, where it could not be seen by him or his coworker. (CAIRS Report ID 134023)
- On May 8, 2014, a worker at Bettis Atomic Power Lab experienced a heat-related illness and had to be treated at the hospital with IV infusion after working "seven hours straight with no breaks" on a "hot humid day." (CAIRS Report ID 132350)
- On June 13, 2013, a security canine was discovered in the cab of a security vehicle that was parked at Big Hill Strategic Petroleum Reserve, exhibiting signs of heat exhaustion. Attempts to revive the canine were unsuccessful and it died. (ORPS Report FE--SPRO-SPR-BH-2013-0001)
- On June 11, 2013, a worker at Sandia National Laboratory experienced heat exhaustion, which may have been influenced by a pre-existing medical condition of low blood pressure. The worker fainted and leaned against a drainage pipe, causing an abrasion to her arm. (CAIRS Report ID 131275)
- On August 15, 2012, three incidents of skin contamination were identified to have been caused by excessive perspiration of the affected individuals at Portsmouth/Paducah Project Office (PPPO). The "wicking" of perspiration caused contamination to migrate through the permeable layer of Personal Protective Equipment (PPE) (Quantum Wear breathable coveralls) that was selected to complete the work task, based on consideration of the heat stress concerns. Contamination levels in each event were below reporting criteria thresholds, and in all instances workers were successfully decontaminated. (ORPS Report EM--PPPO-LKY-PGDPENVRES-2012-0005)
- On March 9, 2011, a PPPO employee experienced dizziness and a loss of consciousness after performing trough maintenance on a polychlorinated biphenyl (PCB) oil collection unit. The worker was wearing impermeable barrier coveralls (Saranex), neoprene gloves, and a face shield. (ORPS Report EM--PPPO-LKY-PGDPENVRES-2011-0003)

Title 10, Code of Federal Regulations, Part 851 and DOE Order (O) 440.1B, *Worker Protection Program for DOE (Including NNSA) Federal Employees*, outline DOE Contractors' and DOE Offices' requirements to comply with the more stringent of Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PEL) or the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV). For heat stress, the requirement is to comply with ACGIH. The ACGIH TLVs for permissible heat exposure for various workloads (light, moderate, or heavy) and work/rest regimes are outlined in Table 1-2 below.

The TLVs are based on the assumption that nearly all acclimatized, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C

Table 1-2. Permissible Heat Exposure Threshold Limit Value[2]

	Work Load*		
Work / Rest Regimen	**Light**	**Moderate**	**Heavy**
Continuous Work	30.0°C (86°F)	26.7°C (80°F)	25.0°C (77°F)
75% Work / 25% Rest each hour	30.6°C (87°F)	28.0°C (82°F)	25.9°C (78°F)
50% Work / 50% Rest each hour	31.4°C (89°F)	29.4°C (85°F)	27.9°C (82°F)
25% Work / 75% Rest each hour	32.2°C (90°F)	31.1°C (88°F)	30.0°C (86°F)

*Values are in °C and °F, Wet-Bulb Globe Temperature (WBGT)

(100.4°F). Accurate application of the TLV is dependent on the user's understanding of the ACGIH's considerations when developing the standard, which can be found in ACGIH's "Heat Stress and Strain: TLV® Physical Agents 7th Edition Documentation." Additionally, OSHA's Technical Manual contains information for evaluating heat stress, including guidance on how to apply the TLV.[3]

The steps to be followed by employers to address risk from an elevated heat index[4] are the same as those used to address other hazards. They include the following.

- Develop an illness prevention plan for work.
- Train your workers how to recognize and prevent heat-related illness.
- Track worksite conditions that affect heat stress; communicate that information and the required precautions to workers.
- Perform heat-strain (physiological) monitoring when excessive heat stress is expected.
- Implement your plan; review and revise it throughout the summer.

Work Planning

DOE and Contractor sites must address heat-related illnesses in their written worker safety and health program consistent with 10 CFR 851 and DOE O 440.1B and, therefore, with the ACGIH Heat Stress and Heat Strain TLV. Job planning must take into account the hazards of heat stress, including the anticipated ambient temperature, work load, permeability and weight of the PPE, and the acclimatization of workers. Controls to prevent heat strain and monitor heat stress when workers are under excessive heat stress conditions should be anticipated at the early stages of job planning so as to be available in advance of the work start date.

Acclimatization

Over time, the human body can adapt to heat exposure through a process called acclimatization. During the first few work days in a hot environment or after returning from an extended absence, a worker's sweat-salt conservation may not be fully developed. After a period of 5 to 10 days, the same level of physical exertion will result in fewer cardiovascular demands on the body. One investigation by California's Division of Occupational Safety and Health (Cal/OSHA) found that 80 percent of heat illness incidents occurred in the first 4 days on the job, with 46 percent of incidents occurring on the first day of the job.[5] This study highlights the importance of implementing an acclimatization schedule of work/rest, such as the one shown in Table 1-3, recommended by NIOSH.

The benefits of acclimatization are reduced if the body's natural cooling by perspiration is impeded by impermeable clothing. Rest should be in a cool, shady, or air-conditioned location and occur at regular intervals throughout the day.

Hydration

Cool water (50–60°F) or sports drinks should be available to all workers, and workers should be encouraged to drink one cup every 15 to 20 minutes during work to avoid dehydration.

**Table 1-3.
NIOSH Recommended Heat Exposure During Acclimatization[6]**

Day Number	Experienced Heat Worker	New Worker
1	50%	20%
2	60%	40%
3	80%	60%
4	100%	80%
5	100%	100%

Acclimatization, while essential, does not reduce water requirements. Some studies have shown that workers offered flavored drinks, including carbohydrate/electrolyte beverages, were more likely to stay hydrated. Warmer water and poor-tasting water seems to have the opposite effect and may actually discourage fluid replacement.

Even when potable water is available, however, workers may not voluntarily drink enough water to maintain proper hydration—a phenomenon known as "involuntary dehydration." Thirst is not stimulated until the body reaches a level that is 1 to 2 percent dehydrated. This involuntary effect, coupled with the sometimes conscious desire to avoid fluid-intake issues such as the need for elimination, may cause workers to drink less water than is necessary to maintain full hydration. The Cal/OSHA study found that 78 percent of its cases showed evidence of dehydration. Managers, in addition to ensuring the availability of cool water or sports drinks, should educate workers on the importance of maintaining hydration and encourage workers to hydrate before and throughout the workday.

Clothing Selection

Clothing selection is an important part of work planning, as illustrated by the March 9, 2011, and August 15, 2012, incidents at PPPO. The March 9, 2011, incident listed the following lesson learned: "Levels of personal protection equipment must be taken into consideration when determining hazard controls for an activity that may be impacted by temperature extremes." The August 15, 2012, event highlighted the need to determine an adequate compromise when selecting barriers like Personal Protective Equipment (PPE) for both the contamination hazard and the personnel heat exposure hazard. PPE is an important part of work planning since normal work clothes that are waterlogged with perspiration become impermeable and no longer allow effective evaporation from the skin. A variety of specialty clothing exists, from air and water-cooled garments to ice vests and personal cooling systems (Figure 1-1).

Training

Figure 1-1. Personal Cooling Vest[7]

DOE regulations and Orders require DOE and Contractors to include heat in the hazard identification and control components of their training for workers and supervisors. OSHA offers free cards in English and in Spanish on the subject of heat stress that can be downloaded and printed as flyers and posters. (See Figure 1-2 on the following page.)

DOE and Contractor sites should have an Emergency Response Plan (ERP) that includes procedures for contacting emergency medical services and, if necessary, for transporting employees to a point where they can be reached by an emergency medical service provider. Procedures should be in place for ensuring that clear and precise directions to the work site can and will be provided as needed to emergency responders.

Monitoring the Worksite

Management has a responsibility to monitor the worksite in order to anticipate and recognize when environmental conditions warrant implementation of the heat stress control program. A heat stress condition may exist when any of the following conditions are met.

- Ambient temperatures exceed 85°F (dry-bulb temperature, which is the air temperature measured by a thermometer that is exposed to the air but shielded from radiation and moisture);
- Wet-Bulb Globe Temperature (WBGT) readings exceed 75°F (see the next paragraph for a description of WBGT);

OSHA QUICK CARD™

Protect Yourself
Heat Stress

When the body is unable to cool itself by sweating, several heat-induced illnesses such as heat stress or heat exhaustion and the more severe heat stroke can occur, and can result in death.

Factors Leading to Heat Stress
High temperature and humidity; direct sun or heat; limited air movement; physical exertion; poor physical condition; some medicines; and inadequate tolerance for hot workplaces.

Symptoms of Heat Exhaustion
- Headaches, dizziness, lightheadedness or fainting.
- Weakness and moist skin.
- Mood changes such as irritability or confusion.
- Upset stomach or vomiting.

Symptoms of Heat Stroke
- Dry, hot skin with no sweating.
- Mental confusion or losing consciousness.
- Seizures or convulsions.

Preventing Heat Stress
- Know signs/symptoms of heat-related illnesses; monitor yourself and coworkers.
- Block out direct sun or other heat sources.
- Use cooling fans/air-conditioning; rest regularly.
- Drink lots of water; about 1 cup every 15 minutes.
- Wear lightweight, light colored, loose-fitting clothes.
- Avoid alcohol, caffeinated drinks, or heavy meals.

What to Do for Heat-Related Illness
- Call 911 (or local emergency number) at once.

While waiting for help to arrive:
- Move the worker to a cool, shaded area.
- Loosen or remove heavy clothing.
- Provide cool drinking water.
- Fan and mist the person with water.

For more complete information:
OSHA Occupational Safety and Health Administration
U.S. Department of Labor
www.osha.gov (800) 321-OSHA

OSHA 3154-07R-06

OSHA DATOS RÁPIDOS

Protéjase del
Estrés por calor

Cuando el cuerpo no puede bajar su temperatura mediante el sudor, pueden ocurrir varias enfermedades debido al calor, tales como estrés o agotamiento por calor e insolación o golpe de calor, las cuales pueden resultar en la muerte.

Factores que llevan al estrés por calor
Alta temperatura y humedad, calor o sol directo, movimiento limitado de aire, esfuerzo físico, pobre condición física, algunas medicinas y tolerancia inadecuada para lugares de trabajo calurosos.

Síntomas de agotamiento por calor
- Dolores de cabeza, mareos, vértigo o desmayo.
- Debilidad y piel húmeda.
- Cambios de humor como irritabilidad o confusión.
- Nauseas o vómitos.

Síntomas de insolación
- Piel seca y caliente sin sudor.
- Confusión mental o pérdida de conocimiento.
- Convulsiones o ataques.

Evita el estrés por calor
- Conozca las señales y los síntomas de las enfermedades relacionadas al calor; obsérvese a si mismo y a sus colegas.
- Bloquee el sol directo u otras fuentes de calor.
- Utilice ventiladores (abanicos) o aire acondicionado; descanse con regularidad.
- Beba mucha agua, como 1 taza cada 15 minutos.
- Vístase con ropa ligera, de colores claros y no ajustada.
- Evite el alcohol, bebidas con cafeína o comidas pesadas.

Qué hacer en caso de enfermedades relacionadas al calor
- Llame al 911 (u otro número local para emergencias) inmediatamente.

Mientras espera por ayuda:
- Mueva a la persona a un lugar fresco y sombreado.
- Suéltele o quitele la ropa pesada.
- Ofrézcale agua fresca para beber.
- Abanique y rocíe con agua a la persona.

Para información más completa:
OSHA Administración de Seguridad y Salud Ocupacional
Departamento del Trabajo de EE.UU.
www.osha.gov (800) 321-OSHA

Figure 1-2. OSHA Heat Stress Cards

- Work is performed in containment areas with minimal air movement that could result in heat buildup;
- Work loads or PPE requirements may result in high metabolic demands;
- Impermeable clothing prevents evaporative cooling of workers' skin;
- Sources of radiant heat are present; or
- Where direct contact with hot objects is a part of the work scope.

The WBGT method is deemed most useful for calculating heat stress potential because it considers the dry-bulb temperature, humidity, and the effects of solar radiation. Three temperatures are used to calculate the WBGT. The first, measured by a "black globe thermometer" integrates the effects of solar radiation and wind.

The second, or "natural wet-bulb thermometer," incorporates the effects of humidity, wind, and radiation. The third is a weather-shielded thermometer that produces the absolute (dry-bulb) air temperature normally quoted in weather observations. (See Figure 1-3 for examples of WBGT site-monitoring instruments.) These three elements are combined into a weighted average to produce the WBGT, which is the measurement referenced in the ACGIH TLVs. ACGIH TLVs also include guidance for adjusting the WBGT values to account for the type of clothing worn, whether the worker is acclimatized, the

Figure 1-3. Examples of WBGT Site-monitoring Instruments[8,9]

physical demands of the work, and similar issues. A variety of stationary, portable, and hand-held WBGT site-monitoring instruments are commercially available.

When possible, consider rescheduling work to cooler times of the day or season. Alternatively, plan to implement engineering controls such as cooling stations, air conditioners, swamp coolers, and overhead shade tents at the worksite.

Monitoring the Worker

Physiological monitoring shuld be performed as necessary, when determined by a site industrial hygienist. Table 1-4 lists OSHA guidelines for frequency of physiological monitoring of fit and acclimatized workers performing at a moderate work level, wearing semi-permeable and impermeable encapsulating clothing.

Table 1-4. Suggested Frequency of Physiological Monitoring (work time)[10]

Adjusted Temperature	Normal Work Clothing	Impermeable Clothing
90°F or above	Every 45 minutes	Every 15 minutes
87.5° – 90°F	Every 60 minutes	Every 30 minutes
82.5° – 87.5°F	Every 90 minutes	Every 60 minutes
77.5° – 82.5°F	Every 120 minutes	Every 90 minutes
72.5° – 77.5°F	Every 150 minutes	Every 120 minutes

A pulse oximeter, which is applied on the worker's finger during rest periods, or a continuous heart rate monitor, which is worn throughout the work activity, can be used to measure heart rate for an estimate of heat strain that worker is experiencing. According to the ACGIH, excessive heat strain is indicated when one or more of the following occur: (1) Sustained (several minutes) heart rate is in excess of 180 beats per minute (bpm) minus the individual's age in years, for individuals with normal cardiac performance; (2) Recovery heart rate at 1 minute after a peak work effort is greater than 120 bpm; (3) Body core temperature is greater than 38.5°C (101.3°F) for medically selected and acclimatized personnel, or greater than 38°C (101.4°F) in unselected, unacclimatized workers; or (4) There are symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness. It is very difficult to estimate a person's core body temperature based on peripheral measurements.

It is important to note that individuals vary in their susceptibility to heat-related illnesses, which is one reason why preventing heat-stress-related illnesses is so challenging. A few examples of individual factors that influence a worker's capability of performing work where there is a risk for heat related illnesses include their level of physical fitness, age, weight, alcohol and drug use, infection, and chronic disease.

The "buddy system" should be encouraged between workers as well. Educating workers to recognize the signs and symptoms of heat illnesses in themselves and in their co-workers can save lives. Upon recognition of heat illness symptoms, workers should inform management and exit the work area. Symptoms of a heat illness should never be ignored. The administration of prompt first aid can reverse most detrimental effects to a worker's body.

Conclusion

Preventive measures should be considered during the work planning process, and implemented as deemed necessary during the work. Managers should monitor the worksite to anticipate and recognize when to implement a heat stress control program. When possible, work should be rescheduled to cooler times of the day or cooler seasons. The work plan should have a system with metrics (e.g., heat index, WBGT) to identify the risk level and appropriately inform workers. Utilization of physiological monitoring, a buddy system, and self-awareness to monitor workers' heat strain while working will further reduce the likelihood of a worker developing a heat illness and allow for a prompt response if and when a worker begins showing signs of heat strain. Managers and workers should recognize that some PPE can magnify heat stress, and that overheated individuals can reduce the effectiveness of PPE.

It is important that workers be educated on the risks of heat exposure, preventive measures to mitigate the risk, and signs, symptoms, and treatment for heat illnesses. Looking out for one another during work performance and monitoring ourselves and co-workers, as well as service animals, for signs of heat illness, can save lives.

KEYWORDS

Heat, Heat Stress, Heat Illness, Hydration, Dehydration, Acclimatization, Temperature, Hot Weather, Environment, PPE, Work Clothing, Wet-Bulb Globe Temperature, WBGT

Endnotes

[1] United States Dept. of Labor. Occupational Safety and Health Administration (OSHA). Heat Related Illnesses and First Aid. https://www.osha.gov/SLTC/heatstress/heat_illnesses.html

[2] U.S. Dept of Labor. Occupational Safety and Health Administration (OSHA). OSHA Technical Manual: Section III: Chapter 4. Heat Stress. https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html

[3] Ibid

[4] The heat index may be determined from tables or on line calculator and is normally given as a function of dry-bulb temperature and relative humidity: http://www.srh.noaa.gov/epz/?n=wxcalc The relative humidity (as well as dew point) can be determined from the wet-bulb and dry-bulb temperatures: http://www.wrh.noaa.gov/sto/rhtbl.php

[5] State of California. Memorandum to Len Walsh, Acting Chief. "Cal/OSHA Investigations of Heat-Related Illnesses." February 17, 2006. https://www.dir.ca.gov/dosh/heatillnessinvestigations-2005.pdf

[6] Centers for Disease Control and Prevention (CDC). National Institute for Occupational Safety and Health (NIOSH). Workplace Safety and Health Topics. Heat Stress: Acclimatization. http://www.cdc.gov/niosh/topics/heatstress/acclima.html

[7] http://www.veskimo.com/

[8] http://www.skcinc.com/catalog/index.php?cPath=500000000_503000000_503000050

[9] http://www.scientificgear.com/Thermal/WBGT

[10] U.S. Dept. of Labor. Occupational Safety and Health Administration (OSHA). Monitoring Workers at Risk of Heat-related Illness. https://www.osha.gov/SLTC/heatillness/heat_index/monitoring_workers.html

The Office of Environment, Health, Safety and Security (AU), Office of Analysis publishes the *Operating Experience Summary* to promote safety throughout the Department of Energy (DOE) Complex by encouraging the exchange of lessons-learned information among DOE facilities.

To issue the Summary in a timely manner, AU relies on preliminary information such as daily operations reports, notification reports, and conversations with cognizant facility or DOE field office staff. If you have additional pertinent information or identify inaccurate statements in the Summary, please bring this to the attention of Ms. Ashley Ruocco, (301) 903-7010, or e-mail address ashley.ruocco@hq.doe.gov, so we may issue a correction. We would like to hear from you regarding how we can make our products better and more useful. Please forward any comments to Ms. Ruocco at the e-mail address above.