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**Subcommittee on Workforce Protections**
**Committee on Education and Labor**
**US House of Representatives**
***From the Fields to the Factories: Preventing Workplace Injury and Death from Excessive Heat***
**July 11, 2019**

Chairwoman Adams, Ranking Member Byrne, and distinguished members of the Subcommittee. My name is Thomas Bernard and I am a professor in the college of public health at the University of South Florida. My Ph.D. in occupational health is from the University of Pittsburgh. Thank you for the opportunity to talk about heat stress in the workplace and to support an OSHA standard.

Over 40 years, I have had the opportunity to help develop heat stress management programs over a wide range of industries. Good heat stress management programs can be adopted to meet the needs and resources of individual employers.

**Heat Stress Is Serious**

First of all, heat stress is an underappreciated workplace hazard. We all have worked or played in hot environments, and may even have felt some of the symptoms of heat exhaustion. This common experience leads us to under-appreciate the real risks.

Overexposures to heat stress occur when the heat generated by the body cannot be dissipated to the ambient environment. This leads to heat accumulating in the body and rising body temperature. Heat exhaustion happens when the heart is not able to circulate enough blood to the skin to cool the body by sweat evaporation, and that failure leads to difficulty performing the work. There are times that the heat builds up rapidly enough that the body temperate exceeds 104°F. This is heat stroke. The brain ceases to function well, and the heating of tissue and the breakdown of protein cause liver and kidney damage. The longer the body stays above 104°F and the greater the elevation above 104°F, the more likely a heat stroke will become fatal. Even if a heat stroke is not fatal, it can cause permanent damage to the brain, kidneys and liver.

Heat stress exposures can be fatal when the workplace is not prepared to deal with it. One fatal heat stroke with which I am familiar was a young man, a high school football player, who died on his first day working for a landscaping company in New Hampshire. Another was a roofer in Louisiana who threw down his tools and drove off the job site to die in his car down the road. Yet another was a postal worker who was trying to do the best he could but who was not prepared to deal with heat stress due to a long absence.

Heat exhaustion sometimes leads to hospital admissions [1,2] with costs to employers and employees. Most discussions of heat stress effects center on heat-related disorders. Increasing levels of heat stress are also associated with increased frequency of accidents [3,4] and lost productivity [5]. Few people seem to appreciate the fact that heat stress is associated with accidents. There is clear evidence that heat stress is associated with acute injuries [3,4], and then by extrapolation to accidents that might involve equipment loss. Because heat stress places a physiological demand on the body, there is less capacity for work and thus it reduces productivity [5]. Accidents and lost productivity have underappreciated costs to employers and employees.

**Epidemiology Related to Heat Stress**

To help establish the relationship between an exposure and a health outcome, we rely on epidemiological studies. For heat stress, there is sufficient evidence to make a strong case.

In the United States between 1992 and 2006 (15 years), the rate of heat-related fatalities among all occupational groups was 0.02/100,000 FTE. The rate during the same period for crop workers was 0.39/100,000 FTE, 18 times more. That is, those who work outside are at 18 times greater risk than those who may not work in a hot environment at all.

Compared to an overall heat-related claim rate of 1.7/100,000 FTE, there were higher incident rates among outdoor workers in Washington State for roofing construction 59.0/100,000 FTE, and highway, bridge and street construction 44.8/100,000 FTE [6], which are 35 and 26 times more likely respectively. There is no reason to suspect that Washington State is unique. That is, the incidence increases with increasing heat stress.

More direct evidence for the role of the ambient environment is seen in the following studies. The ambient conditions are expressed in terms of wet bulb globe temperature (WBGT) which includes the effects of humidity. The probability of a heat stress case among gulf clean-up workers increased steadily above comfortable (not warm or hot) conditions [4]. The association between ambient heat stress conditions and heat stress cases was also reported during football practices by comparing exposures below 73°F-WBGT (comfortable conditions) to those above [7]. Among jogging military recruits, there a 4-fold increase in the odds ratio at 90°F-WBGT (hot conditions) vs. 73°F-WBGT [8]. Looking at occupational heat exposures in outdoor environments, Spector et al. found that 75% of cases were above 82°F-WBGT [9] (warm conditions).

**There Are Practical Interventions**

By asking simple questions about the environment like the temperature and humidity; about the intensity of work; and about the work clothing, interventions can be selected to reduce the risks of heat illness. For instance, the military, which has a physically fit population with strict routines for eating and sleeping, limits what work can be done and for how long at different levels of heat stress. Other key elements of the military procedures are clear assignments of responsibility from the base commander down to the line enlisted personnel, training in heat stress and clear communications about the heat stress level.

Occupational health and safety professionals have learned lessons from the military. For instance, OSHA and NIOSH prepared similar guidelines for the Deepwater Horizon clean-up operations. Working along the Gulf coast in the summer means high temperatures and humidity. BP was very attuned to the risks of heat stress and provided training and specified work and rest cycles based on the ambient conditions. For instance, BP restricted work to 20 minutes followed by 40 minutes of rest in a shaded area when the temperature was between 92 and 98°F. Considering BP employed 50,000 often unfit workers on long shifts and having long commutes, it was amazing that there were few serious heat exhaustions and no heat strokes.

With the additional concerns for outdoor workers without considering climate change, thinking about interventions have evolved over the last 20 years. The 2016 *NIOSH Criteria Document on Occupational Exposure to Heat and Hot Environments* has captured most of the lessons.

Based on the NIOSH criteria document and my experience, the essential components of a heat illness prevention program that is organized and run by the employer are training to understand the effects and prevention strategies for heat stress, heat stress hygiene are practices that an individual can do to protect themselves like drinking small amounts often enough to make it a habit, surveillance, and an emergency plan. While the individual practices heat stress hygiene, the employer must facilitate them in order to make the prevention effective. For instance, providing cool water or other drink that is conveniently available.

In addition, specific interventions that are dictated by the circumstances of the work include the usual hierarchy of controls: engineering controls, administrative controls and personal protection. Not all interventions are appropriate to all workplaces. While the standard can lay out a menu of specific interventions, the employer is in the best position to know which interventions are will best protect workers in their workplace.

Engineering controls change the exposure conditions. Examples include reducing the work demands through mechanization, reducing air temperature and humidity, and shielding high radiant heat sources.

Administrative controls change the way work is done to reduce the risk. For instance, acclimatization is the natural response of the body to heat stress exposures that allows workers to better tolerate the heat. For instance, the work demands can be progressively increased over a few days to allow for acclimatization. Another administrative control is to allocate work and rest periods as done in the military, used during the Deepwater Horizon clean-up, and recommended by NIOSH.

Personal protection is useful when the heat stress is high and specially trained personnel are critical to the task. Specifically, ice vests, air or water cooling systems under the clothing, or forearm immersion in cold water during recovery provide greater cooling than sweat evaporation. Personal cooling is most likely to be used in manufacturing or plant maintenance operations.

Finally, the training of employees and supervisors in the recognition of and first aid for heat-related disorders is essential. With early identification and first aid and an emergency response plan, heat stroke can be reversed.

More information on interventions is provided in the appendix.

**Conclusion**

It is my opinion based on my experience and practice that an enforceable standard can bring visibility and clarity to the structure and function of an effective heat stress management program. The 2016 *NIOSH Criteria Document on Occupational Exposure to Heat and Hot Environments* is an excellent starting point.

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**Appendix on Heat Stress Interventions**
The following is a generic framework for a heat stress management. The elements are divided into General Controls and Job Specific Controls.

General Controls are those actions that should be taken once heat stress is identified as a workplace hazard.

General Controls include

- ***Heat Stress Training.*** Pre-placement and periodic training with re-enforcement.
    - *Causes of heat stress*
    - *Heat-related disorders* including causes, recognition and first aid
    - *Heat stress hygiene practices*
    - *Local risk mitigation strategies including a heat-related disorder response plan*
- ***Heat Stress Hygiene Practices.*** Heat-stress hygiene practices are the actions taken by an individual to reduce the risks of a heat disorder. The individual is responsible for practicing good heat stress hygiene. Site management informs the workers of good practices and helps the workers practice them.
    - *Self-determination*. The individual should seek relief from a heat stress exposure once extreme discomfort or the initial symptoms of a heat-related disorder are sensed. Often an employee can have significant physiological strain before they report that they are very uncomfortable or have the symptoms of heat exhaustion or stroke. Thus, the early recognition is important.
    - *Fluid replacement*. Because thermal regulation depends on sweating and the necessary loss of water, the water must be replaced at frequent intervals to maintain acceptable hydration.
    - *Lifestyle and diet*. Practicing a generally accepted healthy lifestyle (getting adequate sleep, limiting non-work exposures to heat stress, exercising, not abusing alcohol or drugs, and eating a well-balanced diet) greatly reduces the risk of heat-related disorders.
    - *Health status*. Those with any chronic disease should inform their physician of occupational exposures to heat stress and follow the recommendations. Those with an acute illness should report the condition to a supervisor, and the heat stress exposures should be restricted or reduced.
    - *Acclimatization*. Because acclimatization requires about 5 days, allowances must be made for those workers who are not acclimatized to the heat, and performance expectations should therefore be reduced. Note: Some professionals and literature would include acclimatization under administrative controls rather than a hygiene practice.
- ***Surveillance***
    - Environmental. Following a heat stress assessment that made the determination that heat stress is a potential hazard, environmental monitoring with appropriate triggers should be implemented so that workers and supervisors are aware of the risk at a given time.
        - While a WBGT or other detailed analysis of the work situation is ideal, there are other acceptable approaches that are a hybrid of a screening analysis and a detailed analysis.
    - Medical. Following NIOSH recommendations, medical surveillance encompasses physicals and monitoring of sentinel health events. Both pre-placement and periodic physicals appropriate to evaluation of an individual's capacity to deal with heat stress are recommended. The physical should include comprehensive medical and work histories, comprehensive physical examination and tests, and

assessment of prescription drug use. Good practice dictates that there be a written opinion as to the suitability of exposing the individual to heat stress. Monitoring of sentinel health events includes monitoring individuals as well as the population. Relevant events are heat-related disorders, patterns of accidents, absenteeism, and chronic fatigue.

    - An alternative to the physical exams, the employer may wish to employees with chronic diseases to consult with their personal physician and to clearly convey to the physician that heat stress is part of their jobs.
    - The employer should track sentinel events, which should include reports of heat exhaustion as first aid events and recordables
    - If the employer finds that an employee has lower heat tolerance than others based on sentinel events or advice of personal physician, then interventions can be designed for them (e.g., adjust work requirements during high levels of heat stress or personal monitoring).

- ***First aid and emergency response plan.*** The plan should include the ability to recognize early symptoms of heat-related disorders by first line supervisors and workers. In the event of a suspected heat stroke, a method for immediate emergency cooling of the person (ice water immersion or other aggressive method) and arrangements for transport to the hospital are necessary. It is crucial to start cooling immediately and not to wait for an emergency service to arrive.
    - While the prevalence of heat stroke is very low, it is life threatening. The buddy system is important for the recognition of heat stroke, especially because the person may not have the cognitive function to understand the risk and to take any protective steps. In addition to recognizing the signs and symptoms of heat stroke, the observing employee needs to take aggressive action to cool the person experiencing symptoms and execute the emergency response plan including calling 911. These steps also require training.

Job Specific Controls are those that apply to specific situations. While not all job specific controls apply to the postal service, they are provided here as an opportunity to think about possibilities. The job specific controls follow the traditional hierarchy of engineering controls followed by administrative controls, and then personal protection, usually in the form of personal cooling.

Specific Controls follow.

- ***Engineering Controls.*** Engineering controls change the conditions so that the level of heat stress is reduced, ideally below the exposure thresholds.
    - *Reduce the metabolic rate.* A very effective means to reduce heat stress is to reduce the amount of internal heat generation.
    - *Change clothing requirements.* This generally applies to protective clothing.
    - *Reduce temperature and humidity.* Reductions of air temperature and humidity are frequently achieved through spot or dilution ventilation. This is another method to significantly reduce the level of heat stress in the workplace. The ventilation systems can be temporary or permanent and may include mechanical cooling.
    - *Increase air motion.* Increasing air speed via fans is a time-honored method to enhance evaporative cooling, but it is of limited value once air speed exceeds 2 m/s. When air temperature is greater than 40 °C (104 °F), increasing air motion may actually increase heat stress.

    - *Control radiant heat.* When radiant heat is high, the effects can be reduced through combinations of insulating exterior surfaces and reducing surface emissivity. In addition, shields can be very effective.
- ***Administrative Controls.*** Administrative controls manage the risk through work practices. They are relatively easy to implement, although they may not be the most cost-effective.
    - *Acclimatization.* Providing a schedule of work that introduces an unacclimatized person to progressively higher levels of heat stress over a week.
    - *Planned work time.* Limiting the heat stress exposure to a time period that would ensure that most workers are not overexposed is one way to limit the risk. The work time limit can be based on the WBGT or ISO methods of estimating safe exposure times.
    - *Self-determination.* Giving employees the opportunity to subjectively control the pace of work and the work time is frequently used as a means of controlling heat stress exposures. Self-pacing is a valuable means of reducing the physiological strain and improving efficiency. Subjective self-limitation, however, may not be reliable. Physiological monitoring to provide objective information on heart rate and body temperature will improve the reliability. The advantage of personal monitoring is that it allows the more heat-tolerant workers more exposure time. In this way, personal monitoring can improve productivity while controlling the risk of heat-related disorders.
    - *Recovery allowances.* It is important to provide adequate recovery from heat stress exposures. Including recovery times and locations in the analysis of overall evaluation of heat stress exposure provides insight as to whether or not the recovery allowance is adequate.
    - *Scheduling work.* To the extent possible, scheduling work to times when the heat stress levels may be lower (e.g., night) is a useful way to control exposures.
- ***Personal Protection.*** Personal protection for heat stress exposures means providing a microenvironment around the worker that allows a greater loss of heat.
    - *Circulating air systems.* Venting air from supplied-air hoods or supplying breathing grade air directly under clothing enhances evaporative and convective cooling. Many times, the cooling is sufficient to virtually eliminate heat strain. The major disadvantage is that worker mobility is restricted with the airline.
    - *Liquid cooling systems.* This type of personal cooling is based on circulating cooling liquid (e.g., water) around some portion of the body within enclosed tubes or channels. The rate of cooling depends on the surface area of the body covered. The heat is taken up by a heat sink that is usually composed of ice but could theoretically be another material. The service time depends on the size of the heat sink or the ability to replenish the heat sink. The major disadvantage to these systems is the cost.
    - *Ice cooling (phase change) garments.* Ice cooling and phase change garments cool the body by direct transfer of heat from the body to the heat sink by conduction. These are sometimes referred to as passive systems because there is no mechanical movement of air or liquid.
    - *Forearm immersion in cold water*. By placing the forearms in a cold/ice water bath, the recovery from a heat stress exposure can be accelerated.

Good safety and health program management practices include periodic review and continuous improvement.

### *Physiological Monitoring*

The ACGIH® TLV® for Heat Stress and Strain points out that work often occurs at levels above the TLV. Under these circumstances, adequate management of heat stress can be demonstrated though physiological (heat strain) monitoring. For instance, the assessment and logging of oral temperature might be a step in this direction. To be complete the log should be recorded in an accessible database and be periodically reviewed by health and safety personnel. There should be an oversampling of hot days and random sampling by trained personnel would provide a necessary quality control check.