Using the Heat Index: A Guide for Employers

Monitoring Workers at Risk of Heat-related Illness

NIOSH/OSHA/USCG/EPA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, Chapter 8 (1985) offers guidance for performing physiological monitoring of workers at hot worksites. It describes the following options for worker monitoring to help manage the risk of heat-related illness:

- Heart rate. Count the radial pulse during a 30-second period as early as possible in the rest period.
    - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.
    - If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.

- Oral temperature. Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
    - If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.
    - If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third.
    - Do not permit a worker to wear a semi-permeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C).

- Body water loss, if possible. Measure the worker's weight on a scale (ideally accurate to ±0.25 lb) at the beginning and end of each work day to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee wears similar clothing (changes of clothing or damp clothing can cause an inaccurate reading). The body water loss should not exceed 1.5 percent total body weight loss in a work day.

Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar load and the level of physical work (see table below). The length of the work cycle will be governed by the frequency of the required physiological monitoring.

Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers[a]		
Adjusted Temperature (see notes below)	**For workers with normal work clothes, conduct monitoring…**	**For workers wearing impermeable protective clothing conduct monitoring…**
90°F or above	After each 45 minutes of work	After each 15 minutes of work
87.5°-90°F	After each 60 minutes of work	After each 30 minutes of work
82.5°-87.5°F	After each 90 minutes of work	After each 60 minutes of work
77.5°-82.5°F	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F	After each 150 minutes of work	After each 120 minutes of work

Notes:
[a] Assumes work levels of 250 kilocalories/hour (e.g., a moderate work level). Consider increasing the frequency for heavy work rates.

[b] Adjusted Air Temperature: Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 x % sunshine).

Measure the air temperature (ta) with a standard thermometer, with the bulb shielded from radiant heat.

Estimate the percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow.

100 percent sunshine = no cloud cover and a sharp, distinct shadow;

0 percent sunshine = no shadows

[c]For the purpose of this chart, a normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

Adapted from: NIOSH/OSHA/USCG/EPA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, Chapter 8 (1985).

More Advanced Methods for Monitoring Workers

Employers can choose to evaluate a range of physiological responses to heat. The example above briefly mentions heart rate (pulse), oral temperature, and body water loss, but other options are also available. New types of tools (e.g., specialized sensors and personal monitors) are becoming widely available to help employers monitor workers, but effective monitoring can still be performed using simple equipment (e.g., a wrist watch). This section provides examples of the range of options available for monitoring workers.

Examples of Monitoring Options

Physiological monitoring for workers at risk of heat illness usually focuses on vital signs, individually or in any combination:

- Heat exposure history
- Pulse rate
- Temperature (oral, tympanic [ear], or core]
- Body weight
- Blood pressure
- Respiratory rate
- Alertness

The following table lists when and how each of these monitoring methods is performed.

Examples of Physiological Monitoring Used by Some Employers to Prevent Heat Illness			
Monitoring Method	**When Assessed**	**How Assessed**	**More Information**
Heat Exposure History	Before work begins, physiological monitoring may start with a brief history review	Interview or questionnaire	Recent heat illness increases the risk of a repeat occurrence, so the worker should be monitored more closely. Some workers might choose to alert their employers of medical conditions, such as kidney failure, which increase the risk of heat illness.
Pulse Rate (heart rate)	Before work begins to determine the initial baseline level and then again after heat exposure (for example in the first minute and the third minute after the work period ceases)	Count the number of beats per minute (using a wristwatch), or monitor electronically using a heart rate sensor.	The pulse rate should fall rapidly and soon approach the baseline level. The pulse will remain elevated in a worker experiencing a heat illness.
Temperature			Increased temperature indicates that the body is not cooling itself as rapidly as necessary to keep temperature from rising.
	Initial baseline and again	*Oral temperature* –	Inaccurate if the worker

	after the work period	measure with an oral thermometer (available from drug stores)	drinks cool beverages frequently (as is recommended).
	Initial baseline and again after the work period	*Tympanic temperature* – measure with an infrared thermometer (available from drug stores)	A more reliable indicator of core temperature than oral readings (Beaird, Bauman, and Leeper, 1996).
	Continuous sensing devices measure temperature during both work and rest periods	*Core temperature* – measure with electronic or color-changing sensing devices (e.g., sensors that are ingestible, in-ear, or part of skin patches)	Core temperature is the most reliable measure of body temperature. Although not widely used in the workplace, modern advances in sensing technology are making core temperature measurements increasingly practical (HQI, 2007; NASA Spinoff, 2006; Mini Mitter, no date; IonX, no date; Quest, no date).
Bodyweight	Measured as baseline and again immediately after heat exposure	Step on a bathroom scale that has good precision (consistent readings). Must wear same clothes for measurements before and after work period. Account for moisture (sweat) in the clothes	Daily bodyweight loss can indicate that the worker is not drinking a sufficient amount of water. At worksites, the need to account for moisture held in clothes damp with sweat greatly complicates this otherwise simple measure.
Blood pressure	Initial baseline and again after the work period	Blood pressure cuff	Blood pressure does not recover as quickly when a worker is suffering heat illness. Posture can also affect blood pressure in workers with heat-related illness and is the basis for some physiological monitoring

			methods.
Respiratory (breathing) rate	Initial baseline and again after the work period	Count breathes per minute using a stop watch	Breathing rate does not return to baseline as quickly when a worker is suffering heat-related illness.
Alertness	During and after the work period	Converse with the worker	Assess whether the worker shows signs of confusion, a symptom of heat-related illness.
Other monitoring methods			
Perceived skin wetness zones	After the work period	Self-evaluation by the worker	An experimental method, which showed some promise for workers wearing normal clothing doing light work, but was less effective for workers wearing impermeable protective clothing doing strenuous work (Lee, Nakao, and Tochihara, 2011).
Personal Monitors	During and after the work period	The most common include skin temperature sensors and heart rate monitors	Electronic personal monitors worn by workers can measure one or more physiological parameters and help workers judge their own condition (Buller et al, 2008; Metrosonics, no date; IonX, no date).
Sources: *NFPA, 2002. NFPA 471: Recommended Practice for Responding to Hazardous Materials Incidents, 2002 edition.* *NFPA, 2008. NFPA 473: Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents, 2008 edition.* *Also sources listed in "Notes Column".*			

Checklist for Worker Monitoring

OSHA provided two examples of vital signs monitoring checklists in Best Practices for Hospital-Based First Receivers of Victims from Mass Casualty Incidents (OSHA Document 3249), Appendix I – Vital Signs and PPE Checklists. These checklists were developed by employers to record monitoring results for workers who wear heavy protective equipment during chemical emergencies involving the Release of Hazardous Substances. The checklists have space for monitoring results before and after work periods. A comparison of the two measurements confirms that an individual worker's physiological state returns to baseline (pre-work) conditions before the worker begins the next work/rest cycle.

Monitoring Criteria

The criteria to which monitoring results are compared can vary depending on the workplace circumstances and some professional judgment is required. The individual performing the monitoring should be knowledgeable of the monitoring methods and which criteria to use in determine whether a worker is suffering from a heat-related illness or is ready to return to work under hot conditions.

The National Fire Protection Association published an extensive procedure and list of physiological monitoring criteria for evaluating workers at high risk of heat-related illness, particularly those wearing heavy protective clothing, in *Recommended Practice for Responding to Hazardous Materials Incidents (NFPA 471, 2002), Section 10*. Although still available for inspection online, this detailed information was withdrawn as an NFPA standard and in its place NFPA incorporated an less detailed monitoring procedure (without criteria) into the more recent *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents (NFP 473, 2008), section 5.4.5*. Rather than providing specific criteria for each measurement, this 2008 edition of NFPA 473 relies on the professional judgment of the emergency medical personnel in assessing worker response to stressors encountered during hazardous materials response (primarily heat illness if the protective gear adequately protects the worker from chemical hazards). However, NFPA 471 remains an interesting reference for studying the monitoring methods that were historically considered important for evaluating workers wearing heavy protective clothing (i.e., at high risk of heat illness) and assessing their ability to continue work under those conditions.

Monitoring Workers - References cited in the table

Beaird, Bauman, and Leeper, 1996. Oral and tympanic temperatures as heat strain indicators for workers wearing chemical protective clothing. Am Ind Hyg Assoc J. 57(4):344-7 (April).

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