Designation: E3279 – 21

Standard Guide for Managing Heat Stress and Heat Strain in Foundries[1]

This standard is issued under the fixed designation E3279; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is intended to establish best practices for recognizing and managing occupational heat stress and heat strain in foundry environments.

1.2 Objectives of the foundry heat stress and heat strain management guide are as follows:

1.2.1 Provide an objective framework for recognizing heat stress and heat strain, and

1.2.2 Facilitate use of best practices to manage heat exposures to minimize heat strain and prevent heat-related illness.

1.3 In this guide, procedures necessary to manage heat stress and heat strain in foundries are described.

1.4 Key elements of this guide include definitions of heat stress and heat strain, plus techniques for recognizing, communicating, managing, and controlling heat stress and heat strain to prevent heat-related illnesses.

1.5 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1542 Terminology Relating to Occupational Health and Safety

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this standard, refer to Terminology E1542.

3.1.2 *acclimatization, n*—the beneficial physiological adaptations that occur during repeated exposure to a hot environment.

3.1.3 *dew point, n*—the temperature to which air is cooled (at a specific humidity) where the air can hold no more moisture.

3.1.3.1 *Discussion*—When air in contact with the skin reaches the dew point, evaporation of sweat ceases.

3.1.4 *heat cramps, n*—a heat-related illness characterized by spastic contractions of the voluntary muscles (mainly arms, hands, legs, and feet), usually associated with restricted salt intake and profuse sweating without significant body dehydration.

3.1.5 *heat exhaustion, n*—a heat-related illness characterized by elevation of core body temperature above 38 °C (100.4 °F) and abnormal performance of one or more organ systems, without injury to the central nervous system.

3.1.5.1 *Discussion*—Heat exhaustion may signal impending heat stroke.

3.1.6 *heat rash, n*—also known as prickly heat and miliaria, develops when blocked pores (sweat ducts) trap perspiration under your skin. Symptoms range from superficial blisters to deep, red lumps.

3.1.7 *heat strain, n*—the body's physiological response to heat stress (for example, sweating).

[1] This guide is under the jurisdiction of ASTM Committee E34 on Occupational Health and Safety and is the direct responsibility of Subcommittee E34.80 on Industrial Heath.

Current edition approved May 15, 2021. Published May 2021. DOI: 10.1520/E3279-21.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.7.1 *Discussion*—The body's natural way to keep the core body temperature from rising to unhealthy levels is through an increase in heart rate and sweating. This physiological response to the heat load (internal and external) is how the body attempts to increase heat loss to the environment in order to maintain a stable body temperature.

3.1.8 *heat stress, n*—the net heat load to which a worker is exposed.

3.1.8.1 *Discussion*—The net heat load to which a worker is exposed is from the combined contributions of metabolic heat (workload), environmental factors, and clothing worn which results in an increase in heat storage in the body. Environmental factors include radiant heat, air temperature, relative humidity, and air velocity.

3.1.9 *heat stroke, n*—an acute medical emergency caused by exposure to heat from an excessive rise in body temperature (above 41.1 °C (106 °F)) and failure of the temperature-regulating mechanism.

3.1.9.1 *Discussion*—Injury occurs to the central nervous system characterized by a sudden and sustained loss of consciousness preceded by vertigo, nausea, headache, cerebral dysfunction, bizarre behavior, and excessive body temperature.

4. Significance and Use

4.1 This guide is intended to describe heat management program elements that foundries use to prevent or manage heat strain and heat-related illness. Specifically, the guide:

4.1.1 Provides an objective framework for recognizing heat stress and heat strain, and

4.1.2 Facilitates use of best practices to manage heat exposures to minimize heat strain and prevent heat-related illness.

5. Heat Exposure Control Program Responsibilities

5.1 Foundry management shall be responsible for the following:

5.1.1 With supervisors, evaluate indoor and outdoor temperatures.

5.1.2 Issue heat alerts that initiate actions.

5.1.3 Ensure heat exposure provisions and controls are in place and functional and that prescribed PPE is employed.

5.1.4 Review heat exposure incident reports and approve corrective actions recommended as a follow-up to reports of excessive heat strain.

5.2 Human Resources, a program manager, or safety staff (or combinations thereof) shall be responsible for the following:

5.2.1 Establish procedures and conduct training for employees working under heat conditions and for people associated with the program, such as supervisors and first responders.

5.2.2 Work with engineering to employ measures to reduce heat exposure.

5.2.3 Evaluate areas with significant heat sources as part of job safety assessments.

5.2.4 Oversee the actions taken in the program in response to a report of excessive heat strain by a worker or their supervisor to the point of clearance to return to work or to reassignment.

5.2.5 Participate in individual worker orientation and training before assignment.

5.2.6 Choose PPE for specific situations.

5.2.7 Medical services as described in 5.7 shall be arranged.

5.3 Engineering shall be responsible for the following:

5.3.1 With safety staff, regularly review heat exposures associated with foundry processes and seek ways to reduce heat exposure.

5.3.2 Provide feasible engineering control of process heat sources and ventilation of work areas.

NOTE 1—Portable cooling methods may be used, but could affect exhaust and other ventilation systems.

5.3.3 Research and implement feasible corrective actions recommended in investigative reports.

5.3.4 Provide ready access to cool-off areas and hydration stations.

5.4 Workers shall be responsible for:

5.4.1 Following their training,

5.4.2 Preparing themselves for work under heat stress conditions, and

5.4.3 Following established procedures for recognizing and reporting warning signs of the onset of excessive heat strain in themselves and in their coworkers.

5.5 Supervisors shall be responsible for the following:

5.5.1 Evaluate work conditions and worker heat exposure status, and take actions based on heat exposure levels.

5.5.2 Provide input to the worker training process and to employee evaluation before assignment.

5.5.3 Remove workers from their job assignments who experience signs of excessive heat strain and interface with response personnel.

5.5.4 Ensure employees have break periods to cool off and hydrate.

5.6 First aid responders shall be responsible for the following:

5.6.1 Respond promptly to situations where workers experience signs of excessive heat strain.

5.7 Medical services shall be responsible for the following:

5.7.1 Evaluate potential employees with respect to their capability to perform assigned work tasks without risk of heat-related illness.

NOTE 2—Workers at greater risk of heat stress include those who are 65 years of age or older, are overweight, have heart disease or high blood pressure, or take medications that may be affected by extreme heat.[3]

5.7.2 Be prepared to treat workers with signs of heat illness.

5.7.3 Participate in the process of clearing workers for return to work.

[3] "Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments," DHHS (NIOSH) Publication 2016-106, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 2016, pp. 33–40.

6. Heat Stress and Heat Strain Management Program Elements

6.1 For a program to be effective in controlling the heat exposure of workers, control measures shall be implemented to address the following needs:

6.1.1 *Worker Preparation*—Only assign workers to tasks involving heat exposure who are prepared for work in those environments and can tolerate the heat exposure associated with the assignments.

NOTE 3—This need may be addressed by conducting a job hazard evaluation to determine which of the following elements would apply:

(1) Worker Evaluation—To consider, among other things, medical and physical conditions, acclimatization, and history of issues with heat exposure.

(2) Task Evaluation—Take into account potentially elevated metabolic rate associated with tasks conducted during heat exposure and the use of personal protective equipment.

(3) Training—To train workers, supervisors, first responders, and others associated with work under heat exposure conditions in needed knowledge and skills associated with this work, including:

(a) Understanding the safety and health aspects of heat exposure and how to recognize the signs and symptoms of heat strain in themselves and in coworkers.

(b) Learning methods to be followed to maintain hydration and electrolyte balance.

(c) Agreeing to cooperate with established company procedures concerning needs such as acclimatization and communicating with one's supervisor should early warning signs of excessive heat strain be experienced in oneself or observed in coworkers.

(4) Acclimatization.

NOTE 4—Workers can be conditioned to become more heat tolerant over time, as their bodies adjust to working in heated environments.

(5) Encouraging workers to check themselves and one another for signs of excessive heat strain and report findings to the supervisor.

(6) Assigning additional and extended breaks.

(7) Encouraging workers to take breaks they feel are needed.

(8) Ensuring that breaks are taken.

6.1.2 *Workplace and Work Preparation*—Control heat stress sources in the workplace by:

6.1.2.1 Addressing process heat emissions and thermal conditions in work areas.

6.1.2.2 Establishing work regimens which take into account heat stress on workers from both the work environment and from heat buildup in the body created by the production of metabolic heat during work effort.

6.1.2.3 Accommodating workers in maintaining hydration and electrolyte balance, and providing locations where workers can obtain relief from heat stress.

NOTE 5—These needs may be addressed by the following action items:

(1) Process heat emission control.

(2) Ventilation of work areas.

(3) Scheduling of work under heat stress conditions.

(4) Providing heat relief crews.

(5) Personal protective equipment (PPE) such as cooling vests, reflective clothing, air-supplied hoods, etc.

(6) Employing personal and portable cooling devices.

(7) Ready availability of water, electrolytes, and cooled locations for work breaks.

6.1.3 *Ongoing Exposure Controls Based on Workplace Evaluation*—Accommodate workers in following the heat exposure control practices they are required to perform to control body core temperature.

NOTE 6—This need may be addressed by a combination of the following action items:

(1) Hydration and electrolyte balance.

(2) PPE.

(3) Cooling rooms and personal cooling provisions.

(4) Adjusting work schedules (for example, shorter shift).

(5) Reducing work time or working during cooler hours (for example, pour during night shift).

(6) Reducing workload or work pace.

(7) Providing heat relief crews (for example, crew rotation).

(8) Employing personal and portable cooling devices.

6.2 Ongoing tracking of heat stress and strain is required:

6.2.1 To check whether heat exposure control measures are functional and operating and whether workers are following assigned practices for working under heat stress conditions,

6.2.2 Through temperature measurements and work effort assessments to determine whether heat stress impacts have risen above acceptable limits, and

6.2.3 Through observation of workers and communication with them and through assessment of work conditions to assess the potential for the onset of excessive heat strain in workers.

6.2.4 Evaluate information gathered to provide a basis for initiating actions that can address the issues identified.

NOTE 7—In a heat exposure control program, ongoing status of heat stress levels and the effects of heat strain on workers are not constant because:

(1) The amount of heat energy created within the body by the work effort as well as heat energy received from outside the body can vary widely, and

(2) The worker's tolerance to heat can vary due to chronic or temporary health-related reasons or any issues that prevent workers from being fully prepared for exposure to heat.[4]

Given the possible range of variations in heat stress, heat strain, and heat tolerance of workers, the basic heat exposure control measures implemented in 6.1 may not be capable of protecting workers from excessive heat strain under all circumstances.

NOTE 8—Actions which foundries can take to track conditions that can affect the heat stress and heat strain status of workers include the following:

(1) Observe workers regarding following assigned work practices.

(2) Check whether heat exposure control measures are being performed.

(3) Measure the workplace thermal environment (temperature, humidity, radiant heat, etc.).

(4) Evaluate work conditions and worker heat exposure status, and take advantage of biometric information where available.

(5) Establish triggering points for initiating actions based on tracking results requiring follow-up action.

6.3 Heat exposure control actions shall be taken in response to tracking results, and preplanned strategies shall be initiated when situations are occurring or may occur where:

6.3.1 Heat stress conditions are rising or are expected to rise,

6.3.2 Onset of excessive heat strain is being recognized in workers,

6.3.3 Heat exposure controls may not be functioning properly,

6.3.4 Process upsets may be occurring, and

6.3.5 Workers may not be following the heat exposure control practices assigned to them.

NOTE 9—Action items which foundries may take, or be prepared to

[4] DHHS (NIOSH) Publication 2016-106, pp. 88–89.

take, in response to information gathered to address situations that may place workers at increased risk of acquiring heat-related illness include the following:

(1) Encourage workers to self-evaluate for signs and symptoms of excessive heat strain and to report those occurrences to their supervisors.

(2) Encourage workers to evaluate others in their work group for signs and symptoms of excessive heat strain and to report those occurrences to their supervisors.

(3) Reduce heat stress levels by having workers take more frequent and longer breaks.

(4) Reduce heat stress levels by altering work pace or assignments.

(5) Provide additional air movement and cooling at workstations.

6.4 The heat exposure management program of a foundry must have a response protocol in place for responding to reports of warning signs of the onset of excessive heat strain by the worker involved or by coworkers and supervisors.

NOTE 10—Actions that foundries can take as part of their heat exposure response effort include the following:

(1) Train first responders.

(2) Respond to an affected worker after a report has been received of excessive heat strain.

(3) After evaluating and treating the worker, take follow-up actions to remedy the situation so the worker is cleared to return to work or to be reassigned.

(4) Identify and correct conditions responsible for the occurrence.

7. Keywords

7.1 acclimatization; foundries; heat; heat strain; heat stress; occupational heat stress; temperature

APPENDIX

(Nonmandatory Information)

X1. ADDITIONAL INFORMATION

X1.1 Sources of Heat Exposure to the Human Body

X1.1.1 Discussion of the ability of the human body to work under heated conditions without encountering heat-related illness needs to begin with the identification of sources of heat that can impact the internal temperature of the body. Sources of heat energy that can cause body temperature to rise are located both inside and outside the body and include:

X1.1.1.1 Heat generated inside the body as a by-product of the body's system of converting food nutrients to provide fuel sources required for bodily functions and physical exertion (metabolic heat), and

X1.1.1.2 Thermal heat transferred to the body from heat sources external to the body (environmental heat).

X1.1.2 Thermal energy can be transferred to the body or removed from the body by:

X1.1.2.1 *Convective Heat Transfer*—Liquids or gases hotter than or cooler than body surfaces moving across body surface and transferring heat to or from the body,

X1.1.2.2 *Conductive Heat Transfer*—Objects hotter or cooler than body surfaces, including clothing, contacting body surfaces and transferring heat to or from the body, and

X1.1.2.3 *Radiant Heat Transfer*—Objects hotter or cooler than body surfaces transferring heat along the line-of-sight via radiation.

X1.1.3 Clothing and personal protective devices which cover the body alter the manner and extent to which thermal heat sources affect the body. Environmental heat energy can be transmitted through, absorbed by, or reflected off clothing or personal protective devices covering body surfaces. Clothing and personal protective equipment can also trap heat near the body, preventing evaporation and causing warming.

X1.2 Examples of Potential Sources of Heat Exposure in Foundries

X1.2.1 Foundries have been melting metals at high temperatures for more than 5000 years. To melt and pour metal into molds, iron and steel must be heated and held to working temperatures above 1300 °C (~2372 °F). Aluminum alloys have a working temperature above 620 °C (~1148 °F) and copper alloys above 1100 °C (~2012 °F).

X1.2.2 Metalcasting is typically conducted in process operations that have the potential for heat exposure to workers. Metal ingots and scrap metal are melted in furnaces to high temperatures and the molten metal is then treated with additives to meet metallurgical specifications. Slag is removed from molten metal surfaces (slagging) before being transferred as molten metal into preheated transfer ladles (tapping), and then the molten metal is poured into molds to produce castings. Once poured, molds are left to cool, and the molten metal solidifies. Molds are subsequently transferred to shakeout stations, usually while castings are still hot. Gates and risers (that is, casting appendages required for flow of molten metal into the mold) are removed after shakeout. Castings then begin the finishing process, which typically starts with the shot blasting of castings followed by manual finishing work such as chipping and grinding on casting surfaces using portable tools. In many foundries, the above manufacturing steps, along with other foundry-related activities such as mold preparations, core preparation, sand processing, and sand reclamation are all conducted in the same facility.

X1.3 Causes and Challenges of Heat Stress

X1.3.1 Proper body function requires body core temperature to be maintained at approximately 98.6 °F (37 °C).