Disclaimer: This proposed rule has been submitted to the Office of the Federal Register (OFR) for publication, and is currently pending placement on public inspection at the OFR and publication in the Federal Register. This draft version of the proposed rule may vary slightly from the published document if minor technical or formatting changes are made during the OFR review process. Only the version published in the Federal Register is the official proposed rule.

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DEPARTMENT OF LABOR

Occupational Safety and Health Administration

29 CFR Part 1910

Docket No. OSHA–2021–0009

RIN: 1218-AD39

Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings

AGENCY: Occupational Safety and Health Administration (OSHA), Labor.

ACTION: Notice of Proposed Rulemaking; request for comments.

SUMMARY:

OSHA is proposing to issue a new standard, titled *Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings*. The standard would apply to all employers conducting outdoor and indoor work in all general industry, construction, maritime, and agriculture sectors where OSHA has jurisdiction, with some exceptions. It would be a programmatic standard that would require employers to create a plan to evaluate and control heat hazards in their workplace. It would more clearly set forth employer obligations and the measures necessary to effectively protect employees from hazardous heat. OSHA requests comments on all aspects of the proposed rule.

DATES: Comments to this NPRM (including requests for a hearing) and other information must be submitted by [INSERT DATE 120 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].

Informal public hearing: OSHA will schedule an informal public hearing on the proposed rule if requested during the comment period. If a hearing is requested, the location and date of the hearing, procedures for interested parties to notify the agency of their intention to participate, and procedures for participants to submit their testimony and documentary evidence will be announced in the *Federal Register*.

ADDRESSES:

Written comments: You may submit comments and attachments, identified by Docket No. OSHA–2021–0009, electronically at *http://www.regulations.gov*, which is the Federal e-Rulemaking Portal. Follow the instructions online for making electronic submissions. After accessing ‘‘all documents and comments’’ in the docket (Docket No. OSHA–2021–0009), check the “proposed rule” box in the column headed “Document Type,” find the document posted on the date of publication of this document, and click the “Comment Now” link. When uploading multiple attachments to regulations.gov, please number all of your attachments because regulations.gov will not automatically number the attachments. This will be very useful in identifying all attachments. For example, Attachment 1—title of your document, Attachment 2—title of your document, Attachment 3—title of your document. For assistance with commenting and uploading documents, please see the Frequently Asked Questions on regulations.gov.

Instructions: All submissions must include the agency’s name and the docket number for this rulemaking (Docket No. OSHA–2021–0009). All comments, including any personal information you provide, are placed in the public docket without change and may be made available online at *http://www.regulations.gov*. Therefore, OSHA cautions commenters about submitting information they do not want made available to the public, or submitting materials that contain personal information (either about themselves or others), such as Social Security Numbers and birthdates.

Docket citations: This *Federal Register* document references material in Docket No. OSHA–2021–0009, which is the docket for this rulemaking.

Citations to documents: The docket referenced most frequently in this document is the docket for this rulemaking, docket number OSHA–2021–0009, cited as Document ID OSHA–2021–0009. Documents in the docket get an individual document identification number, for example ‘‘OSHA–2021–0009–0047.’’ Because this is the most frequently cited docket, the citation is shortened to indicate only the document number. The example is cited in the NPRM as ‘‘Document ID 0047.’’

Documents cited in this NPRM are available in the rulemaking docket (Docket ID OSHA–2021–0009). They are available to read and download by searching the docket number or document ID number at *https://www.regulations.gov*. Each docket index lists all documents in that docket, including public comments, supporting materials, meeting transcripts, and other documents. However, some documents (e.g., copyrighted material) in the dockets are not available to read or download from that website. All documents in the dockets are available for inspection at the OSHA Docket Office. This information can be used to search for a supporting document in the docket at *www.regulations.gov*. Contact the OSHA Docket Office at (202) 693–2350 (TTY number: 877–889–5627) for assistance in locating docket submissions.

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Copies of this Federal Register notice: Electronic copies are available at *http://www.regulations.gov*. This *Federal Register* notice, as well as news releases and other relevant information, also are available at OSHA's webpage at *http://www.osha.gov*.

The docket is available at *https://www.regulations.gov*, the Federal eRulemaking Portal. A "100-word summary" is also available on *https://www.regulations.gov*. For additional information on submitting items to, or accessing items in, the docket, please refer to the **"ADDRESSES"** section of this NPRM. Most exhibits are available at *https://www.regulations.gov*; some exhibits (e.g., copyrighted material) are not available to download from that webpage. However, all materials in the dockets are available for inspection and copying at the OSHA Docket Office.

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I. Executive Summary

Heat is the leading cause of death among all weather-related phenomena in the United States. Excessive heat in the workplace can cause a number of adverse health effects, including heat stroke and even death, if not treated properly. Yet, there is currently no Federal OSHA standard that regulates heat stress hazards in the workplace. Although several governmental and non-governmental organizations have published regulations and guidance to help protect workers from heat hazards, OSHA believes that a mandatory federal standard specific to heat-related injury and illness prevention is necessary to address the hazards posed by occupational heat exposure. OSHA has preliminarily determined that this proposed rule would substantially reduce the risk posed by occupational exposure to hazardous heat by clearly setting forth employer obligations and the measures necessary to effectively protect exposed workers.

OSHA is proposing this standard pursuant to the Occupational Safety and Health Act of 1970, 29 USC 651 et seq. (OSH Act or Act). The Act authorizes the agency to issue safety or health standards that are “reasonably necessary or appropriate” to provide safe or healthful employment and places of employment (29 USC 652(8)). A standard is reasonably necessary or appropriate when a significant risk of material harm exists in the workplace and the standard would substantially reduce or eliminate that workplace risk. Applicable legal requirements are more fully discussed in Section II., Pertinent Legal Authority.

Workers in both outdoor and indoor work settings without adequate climate controls are at risk of hazardous heat exposure. Certain heat-generating processes, machinery, and equipment (e.g., hot tar ovens, furnaces) can also cause heat hazards when cooling measures are not in place. Based on the best available evidence, as discussed in this preamble, OSHA has preliminarily determined that exposure to hazardous heat in the workplace poses a significant risk of serious injury and illness. This finding of a significant risk of material harm is based on the health consequences associated with exposure to heat (see Section IV., Health Effects) as well as the risk assessment (see Section V., Risk Assessment and Section VI., Significance of Risk). In Sections V.C., Risk Reduction, OSHA demonstrates the efficacy of the controls relied on in this proposed rule to reduce the risk of heat-related injury and illness in the workplace.

Employees working in workplaces without these controls are at higher risk of severe health outcomes from exposure to hazardous heat.

On October 27, 2021, OSHA published in the Federal Register an Advance Notice of Proposed Rulemaking (ANPRM) for Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings (86 FR 59309). The ANPRM outlined key issues and challenges in occupational heat-related injury and illness prevention and aimed to collect evidence, data, and information critical to informing how OSHA proceeds in the rulemaking process. The ANPRM included background information on injuries, illnesses, and fatalities due to heat, underreporting, scope, geographic region, and inequality in exposures and outcomes. The ANPRM also covered existing heat injury and illness prevention efforts including OSHA's efforts, the National Institute for Occupational Safety and Health (NIOSH) criteria documents, state standards, and other standards.

OSHA received 965 unique public comments, which largely supported the need for continued rulemaking. The agency then worked with the National Advisory Committee on Occupational Safety and Health (NACOSH) to assemble a Heat Injury and Illness Prevention Work Group. The Work Group was tasked with evaluating stakeholder input to the ANPRM and developing recommendations on potential elements of a proposed heat injury and illness prevention standard. The Work Group presented its recommendations on potential elements of a proposed heat injury and illness prevention standard for consideration by the full NACOSH committee. On May 31, 2023, NACOSH amended the report to ask OSHA to include a model written plan and then unanimously voted to submit the Work Group's recommendations to the Secretary of Labor.

In accordance with the requirements of the Small Business Regulatory Enforcement Fairness Act (SBREFA), OSHA next convened a Small Business Advocacy Review (SBAR) Panel in August 2023. The Panel, comprised of members from the Small Business Administration's (SBA) Office of Advocacy, OSHA, and OMB's Office of Information and Regulatory Affairs, heard comments directly from Small Entity Representatives (SERs) on the potential impacts of a heat-specific standard. The Panel received advice and recommendations from the SERs and reported its findings and recommendations to OSHA. OSHA has taken the SER's comments and the Panel's findings and recommendations into consideration in the development of this proposed rule (see section VIII.F., Initial Regulatory Flexibility Analysis).

In accordance with 29 CFR parts 1911 and 1912, OSHA also consulted with and considered feedback from the Advisory Committee on Construction Safety and Health (ACCSH). On April 24, 2024, the Committee unanimously passed a motion recommending that OSHA proceed expeditiously with proposing a standard on heat injury and illness prevention. In addition, in accordance with Executive Order 13175, Consultation and Coordination with Indian Tribal Governments, 65 FR 67249 (Nov. 6, 2000), OSHA held a listening session on May 15, 2024, with tribal representatives regarding this Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings rulemaking and provided an opportunity for the representatives to offer feedback.

The proposed rule is a programmatic standard that requires employers to create a heat injury and illness prevention plan to evaluate and control heat hazards in their workplace. It establishes requirements for identifying heat hazards, implementing engineering and work practice control measures at or above two heat trigger levels (i.e., an initial heat trigger and a high heat trigger), developing and implementing a heat illness and emergency response plan, providing training to employees and supervisors, and retaining records. The proposed rule would apply to all employers conducting outdoor and indoor work in all general industry, construction, maritime, and agriculture sectors, with some exceptions (see Section VII.A., Paragraph (a) Scope and Application). Throughout this document, OSHA seeks input on alternatives and potential exclusions.

Organizations affected by heat hazards vary significantly in size and workplace activities. Accordingly, many of the provisions of the proposed standard provide flexibility for affected employers to choose the control measures most suited to their workplace. The flexible nature of the proposed rule may be particularly beneficial to small organizations with limited resources.

Additionally, to determine whether the proposed rule is feasible for affected employers, and in accordance with Executive Orders 12866 and 13563, the Regulatory Flexibility Act (RFA), and the Unfunded Mandates Reform Act (2 U.S.C 1501 et seq.), OSHA has prepared a Preliminary Economic Analysis (PEA), including an Initial Regulatory Flexibility Analysis (see Section VIII., Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis). Supporting materials prepared by OSHA are available in the public docket for this rulemaking, Document ID OSHA-2021-0009, through regulations.gov.

II. Pertinent Legal Authority

A. Introduction.

In the Occupational Safety and Health Act, 29 USC 651 et seq., Congress authorized the Secretary of Labor ("the Secretary") "to set mandatory occupational safety and health standards applicable to businesses affecting interstate commerce" (29 USC 651(b)(3); see *Nat'l Fed'n of Indep. Bus. v. Dep't of Labor*, 595 U.S. 109, 117 (2022) (per curiam); see also 29 USC 654(a)(2) (requiring employers to comply with OSHA standards)). Section 6(b) of the Act authorizes the promulgation, modification or revocation of occupational safety or health standards pursuant to detailed notice and comment procedures (29 USC 655(b)).

Section 3(8) of the Act defines a safety or health standard as a standard which requires conditions, or the adoption or use of one or more practices, means, methods, operations, or processes "reasonably necessary or appropriate" to provide safe or healthful employment and places of employment (29 USC 652(8)). A standard is reasonably necessary or appropriate within the meaning of section 3(8) when a significant risk of material harm exists in the workplace and the standard would substantially reduce or eliminate that workplace risk (see *Indus. Union Dep't, AFL-CIO v. Am. Petroleum Inst.,* 448 U.S. 607 (1980) ("*Benzene*")). OSHA's authority extends to, for example, removing workers from environments where workplace hazards exist (see, e.g., *United Steelworkers of America v. Marshall*, 647 F.2d 1189, 1228-38 (D.C. Cir. 1981); 29 C.F.R. 1910.1028(i)(8); 29 C.F.R. 1910.1024(l); cf. *Whirlpool Corp. v. Marshall*, 445 U.S. 1, 12 (1980) (upholding regulation allowing employees to refuse dangerous work in certain circumstances because "[t]he Act does not wait for an employee to die or become injured.").

In addition to the requirement that each standard address a significant risk, standards must also be technologically feasible (see *UAW v. OSHA*, 37 F.3d 665, 668 (D.C. Cir. 1994)). A standard is technologically feasible when the protective measures it requires already exist, when available technology can bring the protective measures into existence, or when that technology is reasonably likely to develop (see *Am. Iron and Steel Inst. v. OSHA*, 939 F.2d 975, 980 (D.C. Cir. 1991)).

Finally, a standard must be economically feasible (see *Forging Indus. Ass'n v. Secretary of Labor*, 773 F.2d 1436, 1453 (4th Cir. 1985)). A standard is economically feasible if industry can absorb or pass on the costs of compliance without threatening its long-term profitability or competitive structure (see *American Textile Mfrs. Inst., Inc.*, 452 U.S. 490, 530 n.55 ("*Cotton Dust*")). Each of these requirements is discussed further below.

B. Significant Risk.

As noted above, OSHA's workplace safety and health standards must address a significant risk of material harm that exists in the workplace (see *Benzene,* 448 U.S. at 614-15). The agency's risk assessments are based on the best available evidence, and its final conclusions are made only after considering all information in the rulemaking record. Reviewing courts have upheld the Secretary's significant risk determinations where supported by substantial evidence and "a reasoned explanation for [their] policy assumptions and conclusions" (*Bldg & Constr. Trades Dep't v. Brock*, 838 F.2d 1258, 1266 (D.C. Cir. 1988) ("*Asbestos II*")).

The Supreme Court in *Benzene* explained that "[i]t is the agency's responsibility to determine, in the first instance, what it considers to be a 'significant' risk" (*Benzene*, 448 U.S. at 655). The Court declined to "express any opinion on the . . . difficult question of what factual determinations would warrant a conclusion that significant risks are present which make promulgation of a new standard reasonably necessary or appropriate" (*Benzene*, 448 U.S. at 659). The Court stated, however, that the substantial evidence standard applicable to OSHA's significant risk determination (see 29 USC 655(b)(f)) does not require the agency "to support its finding that a significant risk exists with anything approaching scientific certainty" (*Benzene*, 448 U.S. at 656). Rather, OSHA may rely on "a body of reputable scientific thought" to which "conservative assumptions in interpreting the data" may be applied, "risking error on the side of overprotection" (*Benzene*, 448 U.S. at 656). The D.C. Circuit has further explained that OSHA may thus act with a pronounced bias towards worker safety in making its risk determinations (*Asbestos II*, 838 F.2d at 1266). The Supreme Court also recognized that the determination of what constitutes "significant risk" is "not a mathematical straitjacket" and will be "based largely on policy considerations" (*Benzene*, 448 U.S. at 655 & n.62).

Once OSHA makes its significant risk finding, the standard it promulgates must be "reasonably necessary or appropriate" to reduce or eliminate that risk (29 U.S.C. 652(8)). In choosing among regulatory alternatives, however, "[t]he determination that [one standard] is appropriate, as opposed to a marginally [more or less protective] standard, is a technical decision entrusted to the expertise of the agency" (*Nat'l Mining*

Ass'n v. Mine Safety and Health Admin., 116 F.3d 520, 528 (D.C. Cir. 1997) (analyzing a Mine Safety and Health Administration standard under the *Benzene* significant risk standard)).

C. Feasibility.

The statutory mandate to consider the feasibility of the standard encompasses both technological and economic feasibility; OSHA has performed these analyses primarily on an industry-by-industry basis (*United Steelworkers of Am., AFL-CIO-CLC v. Marshall*, 647 F.2d 1189, 1264, 1301 (D.C. Cir. 1980) ("*Lead I*")). The agency has also used application groups, defined by common tasks, as the structure for its feasibility analyses (*Pub. Citizen Health Research Grp. v. OSHA*, 557 F.3d 165, 177-79 (3d Cir. 2009)). The Supreme Court has broadly defined feasible as "capable of being done" (*Cotton Dust*, 452 U.S. at 509-10).

I. Technological Feasibility.

A standard is technologically feasible if the protective measures it requires already exist, can be brought into existence with available technology, or can be created with technology that can reasonably be expected to be developed (*Lead I*, 647 F.2d at 1272; *Amer. Iron & Steel Inst. v. OSHA*, 939 F.2d 975, 980 (D.C. Cir. 1991) ("*Lead II*")). Courts have also interpreted technological feasibility to mean that a typical firm in each affected industry or application group will reasonably be able to implement the requirements of the standard in most operations most of the time (see *Public Citizen v. OSHA*, 557 F.3d 165, 170-71 (3d Cir. 2009); *Lead I*, 647 F.2d at 1272; *Lead II*, 939 F.2d at 990)). OSHA's standards may be "technology forcing," so long as the agency gives an industry a reasonable amount of time to develop new technologies to comply with the standard. Thus, OSHA is not bound by the "technological status quo" (*Lead I*, 647 F.2d at 1264).

II. Economic Feasibility.

In addition to technological feasibility, OSHA is required to demonstrate that its standards are economically feasible. A reviewing court will examine the cost of compliance with an OSHA standard "in relation to the financial health and profitability of the industry and the likely effect of such costs on unit consumer prices" (*Lead I*, 647 F.2d at 1265 (citation omitted)). As articulated by the D.C. Circuit in *Lead I*, "OSHA must construct a reasonable estimate of compliance costs and demonstrate a reasonable likelihood that these costs will not threaten the existence or competitive structure of an industry, even if it does portend disaster for some marginal firms" (*Lead I*, 647 F.2d at 1272). A reasonable estimate entails assessing "the likely range of costs and the likely effects of those costs on the industry" (*Lead I*, 647 F.2d at 1266). As with OSHA's consideration of scientific data and control technology, however, the estimates need not be precise (*Cotton Dust*, 452 U.S. at 528-29 & n.54), as long as they are adequately explained.

OSHA standards satisfy the economic feasibility criterion even if they impose significant costs on regulated industries so long as they do not cause massive economic dislocations within a particular industry or imperil the very existence of the industry (*Lead II*, 939 F.2d at 980; see also *Lead I*, 647 F.2d at 1272; *Asbestos I*, 499 F.2d. at 478). As with its other legal findings, OSHA "is not required to prove economic feasibility with certainty, but is required to use the best available evidence and to support its conclusions with substantial evidence" (*Lead II*, 939 F.2d at 980-81 (citing *Lead I*, 647 F.2d at 1267)).

In addition to determining economic feasibility, OSHA estimates the costs and benefits of its proposed and final rules to ensure compliance with other requirements such as those in Executive Orders 12866 and 13563.

D. High Degree of Employee Protection.

Safety standards must provide a high degree of employee protection to be consistent with the purpose of the Act (see Control of Hazardous Energy Sources (Lockout/Tagout) Final Rule, Supplemental Statement of Reasons, 58 FR 16612, 16614-15 (March 30, 1993)). OSHA has preliminarily determined that this proposed standard is a safety standard because the health effects associated with exposure to occupational heat are generally acute. As explained in Section IV., Health Effects, the proposed standard aims to address the numerous acute health effects of occupational exposure to hazardous heat. These include, among other things, heat stroke, heat exhaustion, heat syncope, and physical injuries (e.g., falls) due to fatigue or other heat-related impairments. These harms occur after relatively short-term exposures to hazardous heat and are typically apparent at the time of the exposure or shortly thereafter. Consequently, the link between these harms and heat exposures is also often apparent and they do not implicate the concerns about latent, hidden harms that underly health standards (see *Benzene*, 448 U.S. at 649 n. 54; *UAW v. OSHA*, 938 F.2d 1310, 1313 (D.C. Cir. 1991) ("*Lockout/Tagout I*");

National Grain & Feed Ass'n v. OSHA, 866 F.2d 717, 733 (5th Cir. 1989) ("*Grain Dust*")).

Finally, although OSHA acknowledges that there is growing evidence occupational exposure to hazardous heat may lead to some chronic adverse health outcomes like chronic kidney disease, much of the science in this area is still developing (see Section IV., Health Effects). In any event, the agency expects that addressing the acute hazards posed by heat would also protect workers from potential chronic health outcomes by reducing workers' overall heat strain.

III. Background

A. Introduction.

The Occupational Safety and Health Administration (OSHA) is proposing a new standard to protect outdoor and indoor workers from hazardous heat in the workplace. OSHA promulgates and enforces occupational safety and health standards under authority granted by the Occupational Safety and Health (OSH) Act of 1970 (29 U.S.C. 651 et seq.).

In the absence of a federal occupational heat standard, five states have issued heat injury and illness prevention regulations to protect employees exposed to heat hazards in the workplace: Minnesota (Minn. R. 5205.0110 (1997)); California (Cal. Code of Regs. tit. 8, § 3395 (2005)); Oregon (Or. Admin. R. 437-002-0156 (2022); Or. Admin. R. 437-004-1131 (2022)); Colorado (7 Colo. Code Regs. § 1103-15 (2022)); and Washington (Wash. Admin. Code § 296-62-095 through 296-62-09560; § 296-307-097 through § 296-307-09760 (2023)). Although Minnesota was the first state to adopt a standard covering employees exposed to indoor environmental heat conditions, California was the first state to adopt a standard covering employees exposed to outdoor environmental heat conditions. Washington, Oregon, and Colorado have since enacted similar regulations to California's, requiring employers to implement controls and monitor for signs and symptoms of heat-related injury or illness, among other requirements. In 2023, California proposed a new standard that would cover indoor work environments (California, 2023). In 2024, Maryland published a proposed standard that would cover both outdoor and indoor work environments (Maryland, 2024).

Workers in many industries are at risk for heat-related injury and illness stemming from hazardous heat exposure (see Section V.A., Risk Assessment). While the general population may be able to avoid and limit prolonged heat exposure, workers across a wide range of indoor and outdoor settings often are required to work through shifts with prolonged heat exposure. Some workplaces have heat generation from industrial processes and expose workers to sources of radiant heat, such as ovens and furnaces. Additionally, employers may not take adequate steps to protect their employees from exposure to hazardous heat (e.g., not providing rest breaks in cool areas). Many work operations also require the use of personal protective equipment (PPE) that can reduce the worker's heat tolerance because it can decrease the body's ability to cool down. Workers may also face pressure, or incentivization through pay structures, to push through and continue working despite high heat exposure, which can increase the risk of heat-related injury and illness (Billikopf and Norton, 1992; Johansson et al., 2010; Spector et al., 2015; Pan et al., 2021).

OSHA uses several terms related to excessive heat exposure throughout this proposal. Heat stress is the combined load of heat that a person experiences from sources of heat (i.e., metabolic heat and the environment) and heat retention (e.g., from clothing or personal protective equipment). Heat strain refers to the body's response to heat stress (American Conference of Governmental Industrial Hygienists (ACGIH), 2023). Heat-related illness means adverse clinical health outcomes that occur due to heat exposure, such as heat exhaustion or heat stroke. Heat-related injury means an injury linked to heat exposure, such as a fall or cut. OSHA sometimes refers to these collectively as "heat-related injuries and illnesses."

B. Need for Proposal.

Occupational heat exposure affects millions of workers in the United States. Each year, thousands of workers experience heat-related injuries and illnesses, and some of these cases result in fatalities (BLS, 2023b; BLS, 2024c). OSHA has relied on the General Duty Clause of the OSH Act (discussed further below), as well as enforcement emphasis programs and hazard alerts and other guidance, to protect workers and inform employers of their legal obligations. However, a standard specific to heat-related injury and illness prevention would more clearly set forth enforceable employer obligations and the measures necessary to effectively protect employees from hazardous heat.

Workers in both outdoor and indoor work settings without adequate climate controls are at risk of hazardous heat exposure. In addition to weather-related heat, certain heat-generating processes, machinery, and equipment (e.g., hot tar ovens, furnaces) can cause hazardous heat exposure when cooling measures are not in place. An evaluation of 66 heat-related illness enforcement investigations from 2011–2016 found heat-related injuries and illnesses, including fatalities, occurring in both outdoor (n=34) and indoor (n=29) work environments (Tustin et al., 2018a). Excessive heat exacerbates existing health conditions like asthma, diabetes, kidney failure, and heart disease, and can cause heat stroke and death if not treated properly and promptly. Some groups may be more likely to experience adverse health effects from heat, such as pregnant workers (NIOSH, 2024), while others are disproportionately exposed to hazardous levels of heat, such as workers of color in essential jobs, who are more often employed in work settings with a high risk of hazardous heat exposure (Gubernot et al., 2015).

The Bureau of Labor Statistics (BLS), in its Census of Fatal Occupational Injuries, documented 1,042 U.S. worker deaths due to occupational exposure to environmental heat from 1992–2022, with an average of 34 fatalities per year during that period (BLS, 2024c). In 2022 alone, BLS reported 43 work-related deaths due to environmental heat exposure (BLS, 2024c). The BLS Annual Survey of Occupational Injuries and Illnesses (SOII) estimates 33,890 work-related heat injuries and illnesses involving days away from work from 2011–2020, which is an average of 3,389 injuries and illnesses occurring each year during this period (BLS, 2023b).

Workers across hundreds of industries are at risk for hazardous heat exposure and resulting heat-related injuries and illnesses. From January 1, 2017, to December 31, 2022, 1,054 heat-related injuries, illnesses, and fatalities were reported to and investigated by OSHA, including 625 heat-related hospitalizations and 211 heat-related fatalities, as well as 218 heat-related injuries and illnesses that did not result in hospitalization. During this time, hospitalizations occurred most frequently in construction, manufacturing, and postal and delivery service. Fatalities were most frequently reported in construction, landscaping, agriculture, manufacturing, and postal and delivery service (as identified by 2-digit NAICS codes).

However, as explained in Section V.A., Risk Assessment, these statistics likely do not capture the true magnitude and prevalence of heat-related injuries, illnesses, and fatalities. Recent studies demonstrate significant undercounting of occupational injuries and illnesses by both the BLS SOII and OSHA's enforcement data. One reason for this undercounting is that the BLS SOII only reports the number of heat-related injuries and illnesses involving days away from work and thus does not capture the full picture of heat-related injuries and illnesses. An examination of workers' compensation claims in California, which include more than only cases involving days away from work, identified 3 to 6 times the number of annual heat-related illness and injury cases than reported by BLS SOII (Heinzerling et al., 2020). In addition, evidence has shown significant underreporting as employers and employees are disincentivized from reporting injuries and illnesses due to several factors, including potential increases in workers' compensation costs or impacts on the employer's reputation, or an employee's fear of retaliation or lack of awareness of their right to speak out about workplace conditions (BLS, 2020b).

Heat-related injuries and illnesses may present unique challenges to surveillance efforts. As the nature of heat-related symptoms (e.g., headache, fatigue) vary, some cases may be attributed to other illnesses rather than heat (as discussed in Section IV., Health

Effects). Furthermore, heat is not always identified as a contributing factor to fatality, as heat exposure may exacerbate existing medical conditions and medical professionals may not witness the symptoms and events preceding death (Luber et al., 2006).

Finally, exposure to heat can interfere with routine occupational tasks and impact workers' psychomotor and mental performance, which can lead to workplace injuries. Particularly, heat can impair performance of job tasks related to complex cognitive function (Hancock and Vasmatzidis, 2003; Piil et al., 2017) and reduce decision making abilities (Ramsey et al., 1983; Xiang et al., 2014a) and productivity (Foster et al., 2021). A growing body of evidence has demonstrated that heat-induced impairments may result in significant occupational injuries that are not currently factored into official statistics for heat-related cases (Spector et al., 2016; Calkins et al., 2019; Dillender, 2021; Park et al., 2021). See Section V.A., Risk Assessment, for further discussion on underreporting of heat-related injuries, illnesses, and fatalities.

While a significant percentage of heat-related incidents are unreported, OSHA’s investigations of reported heat-related fatalities point to many gaps in employee protections. OSHA has identified the following circumstances in its review of 211 heat-related fatality investigations from 2017-2022: employees left alone by employers after symptoms started; employers not providing adequate medical attention to employees with symptoms; employers preventing employees from taking rest breaks; employers not providing water on-site; employers not providing on-site access to shade; employers not providing cooling measures on-site; and employers not having programs to acclimatize employees to hot work environments (*https://www.osha.gov/fatalities*). OSHA has relied on multiple mechanisms to protect employees from hazardous heat, however, OSHA's efforts to prevent the aforementioned circumstances have been met with challenges without a heat-specific standard (as discussed in Section C.III).

Many U.S. states run their own OSHA-approved State Plans (e.g., state heat standards, voluntary consensus standards) (see Section III.D), however OSHA has preliminarily determined that this standard is still needed to protect workers from the persistent and serious hazards posed by occupational heat exposure. As explained in Section VI., Significance of Risk, OSHA has preliminarily determined that a significant risk of material harm from occupational exposure to hazardous heat exists, and issuance of this standard would substantially reduce that risk. Therefore, to more clearly set forth employer obligations and the measures necessary to more effectively protect employees from hazardous heat, and reduce the number and frequency of occupational injuries, illness, and fatalities caused by exposure to hazardous heat, OSHA is proposing a federal standard for Heat Injury and Illness Prevention for Outdoor and Indoor Work Settings.

C. Events Leading to the Proposal.

I. History of Heat as a Recognized Occupational Hazard.

Heat exposure has long been recognized as an occupational hazard. For example, in the United States, the occupational hazards associated with the construction of the Hoover Dam between 1931 and 1935 brought attention to the effects of heat on worker health. The Bureau of Reclamation reported that 14 dam workers and two others residing in the work area died from "heat prostration" in 1931 (Bureau of Reclamation, 2015). According to a local newspaper, temperatures at the dam site that summer reached 140°F in the sun and 120°F in the shade (Turk, 2018; Rogers, 2012). In response to the extreme heat of the summer and other unsafe working conditions, the Industrial Workers of the World convinced Hoover Dam workers to strike over safety concerns (Turk, 2018; Rogers, 2012). Six Companies, the conglomerate of companies hired by the Bureau of Reclamation to construct most of the dam, was forced to make concessions, including protections against HRI such as providing potable water in dormitories, bringing ice water to workers at their work sites, and adding first aid stations closer to the job site (Rogers, 2012). The heat-related deaths that occurred during 1931 also prompted Harvard University researchers from the Harvard Fatigue Laboratory to travel to the Hoover Dam and study the relationship between hot, dry temperatures, physical performance, and heart rate (Turk, 2018).

Heat-related illnesses were identified as a major concern for the U.S. military in the 1940s and 1950s. Between 1942 and 1944, 198 soldiers died of heat stroke at U.S.-based training camps, 157 of which did not have a known history of cardiac diseases or other conditions that may predispose them to heat illness (Schickele, 1947, p. 236). This led to investigations of the environmental conditions at the time of these deaths, and eventually to the development of wet bulb globe temperature (WBGT) to measure heat stress (Yaglou and Minard, 1957; Minard, 1961; Department of the Army, 2022; Department of the Navy, 2023).

Research on the effects of occupational heat exposure continued in the 1960s, as researchers conducted trials examining the physiological effects of work at various temperatures (e.g., Lind, 1963). Findings from these trials would eventually underpin the

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), as well as the National Institute of Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL) (Dukes-Dobos and Henschel, 1973). ACGIH first proposed guidelines for a TLV in 1971, which were later adopted in 1974.

Heat was recognized as a preventable workplace hazard in the legislative history of the OSH Act. Senator Edmund Muskie submitted a letter in support of the OSH Act into the Congressional record on behalf of "a distinguished group of citizens, including a former Secretary of Labor and several noted scientists." (Senate Debate on S. 2193, Nov. 16, 1970), *reprinted in* Legislative History of the Occupational Safety and Health Act of 1970, pp. 513-14 (1971) (Committee Print) ("Leg. Hist."). The letter states, "Most industrial diseases and accidents are preventable. Modern technological and medical sciences are capable of solving the problems of noise, dust, heat, fumes, and toxic substances in the plants. However, existing legislation in this area does not begin to meet the problems" (Leg. Hist., pp. 513-14).

In 1972, just two years after promulgation of the OSH Act, NIOSH first recommended a potential OSHA heat standard in its *Criteria for a Recommended Standard* (NIOSH, 1972). This criteria document, issued under the authority of section 20(a) of the OSH Act, recommended an OSHA standard based on a critical review of scientific and technical information. In response, an OSHA Standards Advisory Committee on Heat Stress was appointed in 1973 and presented recommendations for a standard for work in hot environments in 1974. At the time, 12 of 15 members of the advisory committee agreed that occupational heat stress warranted a standard (Ramsey, 1975).

NIOSH's criteria document for a recommended standard has since been updated in 1986 (NIOSH, 1986) and again in 2016 (NIOSH, 2016). The 2016 criteria document recommends various provisions to protect workers from heat stress, including rest breaks, hydration, shade, acclimatization plans, and worker training (NIOSH, 2016). The 2016 criteria document also recommends that no worker be "exposed to combinations of metabolic and environmental heat greater than" the recommended alert limit (RAL) for unacclimatized workers or the recommended exposure limit (REL) for acclimatized workers). The document recommends that environmental heat be assessed with measurements of WBGT (NIOSH, 2016).

A detailed report of the history of heat as a recognized occupational hazard is available in the docket (ERG, 2024a). The report summarizes historical documentation of occupational heat-related illness beginning in ancient times and from the eighteenth century through the regulatory interest in the twentieth century.

II. OSHA's Heat Injury and Illness Prevention Efforts.

In 2011, OSHA issued a memorandum to inform regional administrators and State Plan designees of inspection guidance for heat-related illnesses (OSHA, 2011). That same year, OSHA launched the Heat Illness Prevention Campaign (*https://www.osha.gov/heat*) to build awareness of prevention strategies and tools for employers and workers to reduce occupational heat-related illness. In its original form, the Campaign delivered a message of "Water. Rest. Shade." The agency updated

Campaign materials in 2021 to recognize both indoor and outdoor heat hazards, as well as the importance of protecting new and returning workers from hazardous heat with an acclimatization period.

In addition, OSHA maintains on its website a Heat Topics page on workplace heat exposure (*https://www.osha.gov/heat-exposure/*), which provides additional information and resources. The page provides information on planning and supervision in hot work environments, identification of heat-related illness and first aid, information on prevention such as training, calculating heat stress and controls, personal risk factors, descriptions of other heat standards and case study examples of situations where workers developed heat-related illness. OSHA and NIOSH also co-developed a Heat Safety Tool Smartphone App for both Android and iPhone devices (see *www.osha.gov/heat/heat-app*). The app provides outdoor, location-specific temperature, humidity, and heat index (HI) readings. Measurements for indoor work sites must be collected and manually entered into the app by the user for accurate calculations. The app also provides relevant information on identifying signs and symptoms of heat-related illness and steps to prevent heat-related injuries and illnesses. Despite the strengths and reach of the Campaign, Heat Topics page, and Heat Safety Tool App, these guidance and communication materials are not legally enforceable requirements.

III. OSHA's Heat-Related Enforcement.

Without a specific standard governing hazardous heat conditions at workplaces, the agency currently enforces Section 5(a)(1) (the General Duty Clause) of the OSH Act against employers that expose their workers to this recognized hazard. Section 5(a)(1) states that employers have a general duty to furnish to each of their employees "employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm" to employees (29 U.S.C. 654(a)(1)). To prove a violation of the General Duty Clause, OSHA must establish—in each individual case—that: (1) the employer failed to keep the workplace free of a hazard to which its employees were exposed; (2) the hazard was recognized; (3) the hazard was causing or likely to cause death or serious injury; and (4) a feasible means to eliminate or materially reduce the hazard existed (see, e.g., A.H. Sturgill Roofing, Inc., 2019 O.S.H. Dec. (CCH) ¶ 33712, 2019 WL 1099857 (No. 13-0224, 2019)).

OSHA has relied on the General Duty Clause to cite employers for heat-related hazards for decades (see, e.g., Duriron Co., 11 BNA OSHC 1405, 1983 WL 23869 (No. 77-2847, 1983), aff'd, 750 F.2d 28 (6th Cir. 1984)). According to available OSHA enforcement data, between 1986 and 2023, Federal OSHA issued at least 348 hazardous heat-related citations under the General Duty Clause. Of these citations, 85 were issued between 1986-2000 (OSHA, 2024b). Citations were identified using multiple queries of OSHA enforcement data and then manually reviewed to ensure the inclusion of only citations due to heat exposure and no other exposures (e.g., burns or explosions). Several keywords were utilized to filter the data for inclusion (e.g., "heat," "heat stress," "heat illness," "WBGT") and exclusion (e.g., "explosion," "flash," "electrical burn," "fire"). Due to limitations of the data set on which OSHA relied, OSHA did not have access to violation text descriptions of citations issued before the mid-1980s and thus did not determine how many are related to heat exposure prior to this time period. Additionally, over half of the citations from 1986-1989 are missing violation text descriptions, which likely resulted in an undercount of heat-related citations.

OSHA has used its general inspection authority (29 U.S.C. 657) to target heat-related injuries and illnesses in various Regional Emphasis Programs (REPs). OSHA enforcement emphasis programs focus the agency's resources on particular hazards or high-hazard industries (see Marshall v. Barlow's, Inc., 436 U.S. 307, 321 (1978) (affirming OSHA's use of an administrative plan containing specific neutral criteria to focus inspections)). OSHA's Region VI regional office, located in Dallas, TX, has a heat-related special REP (OSHA, 2019). This region covers Texas, New Mexico, Oklahoma, Arkansas, and Louisiana. OSHA's Region IX regional office, located in San Francisco, CA, also has a heat-related REP (OSHA, 2022). This region covers American Samoa, Arizona, California, Guam, Hawaii, Nevada, and the Northern Mariana Islands. These REPs allow field staff to conduct heat illness inspections of outdoor work activities on days when the high temperature is forecasted to be above 80°F.

On September 1, 2021, OSHA issued updated Inspection Guidance for Heat-Related Hazards, which established a new enforcement initiative to protect employees from heat-related injuries and illnesses while working in hazardous hot indoor and outdoor environments (OSHA, 2021). The guidance provided that days when the heat index exceeds 80°F would be considered heat priority days. It announced that enforcement efforts would be increased on heat priority days for a variety of indoor and outdoor industries, with the aim of identifying and mitigating potential hazards and preventing heat-illnesses before they occur.

In April 2022, OSHA launched a National Emphasis Program (NEP) to protect employees from heat-related hazards and resulting injuries and illnesses in outdoor and indoor workplaces. The NEP expanded the agency's ongoing heat-related injury and illness prevention initiatives and campaign by setting forth a targeted enforcement component and reiterating its compliance assistance and outreach efforts. The NEP targets specific industries expected to have the highest exposures to heat-related hazards and resulting illnesses and deaths. This approach is intended to encourage early interventions by employers to prevent illnesses and deaths among workers during high heat conditions (CPL 03-00-024). As of June 26, 2024, OSHA has conducted 5,038 Heat NEP Federal inspections. More than 1,229 of these were initiated by complaints and 117 were due to the occurrence of a fatality or catastrophe. As a result of these inspections, OSHA issued 56 General Duty Clause citations and 736 Hazard Alert Letters (HALs). Inspections occurred across various industries (as identified by 2-digit NAICS codes) including construction, which had the highest number of inspections, as well as manufacturing, maritime, agriculture, transportation, warehousing, food services, waste management, and remediation services.

On July 27, 2023, OSHA issued a heat hazard alert to remind employers of their obligation to protect workers against heat injury and illness in outdoor and indoor workplaces. The alert highlights what employers can and should be doing to protect employees. It also serves to remind employees of their rights, including protections against retaliation. In addition, the alert highlights steps OSHA is currently taking to protect workers and directs employers, employees, and the public to OSHA resources, including guidance and fact sheets on heat.

OSHA's efforts to protect employees from hazardous heat conditions using the General Duty Clause, although important, have limitations leaving many workers vulnerable to heat-related hazards. For example, the Commission has struggled to determine exactly what conditions create a recognized heat hazard under the General Duty Clause, and has therefore suggested the necessity of a standard (see, A.H. Sturgill Roofing, Inc., 2019 OSHD (CCH) ¶ 33712, 2019 WL 1099857, at *2-5 and n.8 (No. 13-0224, 2019) ("The Secretary's failure to establish the existence of an excessive heat hazard here illustrates the difficulty in addressing this issue in the absence of an OSHA standard."); U.S. Postal Service, 2023 OSHD (CCH) ¶ 33908, 2023 WL 2263313, at *3 n.7 (Nos. 16-1713, 16-1872, 17-0023,17-0279, 2023) (noting Commissioner Laihow's opinion that "A myriad of factors, such as the geographical area where the work is being performed and the nature of the tasks involved, can impact" whether excessive heat is present, and indicating that a standard is therefore necessary to define the hazard).

Under the General Duty Clause, OSHA cannot require abatement before proving in an enforcement proceeding that specific workplace conditions are hazardous; whereas a standard would establish the existence of the hazard at the rulemaking stage, thus allowing OSHA to identify and require specific abatement measures without having to prove the existence of a hazard in each case (see Sanderson Farms, Inc. v. Perez, 811 F.3d 730, 735 (5th Cir. 2016) ("Since OSHA is required to determine that there is a hazard before issuing a standard, the Secretary is not ordinarily required to prove the existence of a hazard each time a standard is enforced.")). Given OSHA's burden under the General Duty Clause, it is currently difficult for OSHA to ensure necessary abatement before employee lives and health are unnecessarily endangered. Further, under the General Duty Clause OSHA must largely rely on expert witness testimony to prove both the existence of a hazard and the availability of feasible abatement measures that will materially reduce or eliminate the hazard in each individual case (see, e.g., Industrial Glass, 15 BNA OSHC 1594, 1992 WL 88787, at *4-7 (No. 88-348, 1992)).

Moreover, as OSHA has noted in similar contexts, standards have the advantage of providing greater clarity to employers and employees of the measures required to protect employees and are developed with the benefit of information gathered in the notice and comment process (see 86 FR 32376, 32418 (Jun. 21, 2021) (COVID-19 Healthcare ETS); 56 FR 64004, 64007 (Dec. 6, 1991) (Bloodborne Pathogens Standard)).

OSHA currently has other existing standards that, while applicable to some issues related to hazardous heat, have not proven to be adequate in protecting workers from exposure to hazardous heat. For example, OSHA's Recordkeeping standard (29 CFR 1904.7) requires employers to record and report injuries and illnesses that meet recording criteria. Additionally, the agency's Sanitation standards (29 CFR 1910.141, 29 CFR 1915.88, 29 CFR 1917.127, 29 CFR 1926.51, and 29 CFR 1928.110) require employers to provide potable water readily accessible to workers. While these standards require that drinking water be made available in “sufficient amounts,” they do not specify quantities, and employers are not required to encourage workers to frequently hydrate on hot days.

OSHA's Safety Training and Education standard (29 CFR 1926.21) requires employers in the construction industry to train employees in the recognition, avoidance, and prevention of unsafe conditions in their workplaces. OSHA's PPE standards (29 CFR 1910.132, 29 CFR 1915.152, 29 CFR 1917.95, and 29 CFR 1926.28) require employers to conduct a hazard assessment to determine the appropriate PPE to be used to protect employees from the hazards identified in the assessment. However, hazardous heat is not specifically identified as a hazard for which workers need training or PPE, complicating the application of these requirements to hazardous heat.

IV. Rulemaking Activities Leading to this Proposal.

OSHA has received multiple petitions to promulgate a heat injury and illness prevention standard, including in 2018 from Public Citizen, on behalf of approximately 130 organizations (Public Citizen et al., 2018). OSHA has also been urged by members of Congress to initiate rulemaking for a federal heat standard, as well as by the Attorneys General of several states in 2023.

On October 27, 2021, OSHA published an Advance Notice of Proposed Rulemaking (ANPRM) for Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings in the Federal Register (86 FR 59309) (referred to as "the ANPRM" hereafter). The ANPRM outlined key issues and challenges in occupational heat-related injury and illness prevention and aimed to collect evidence, data, and information critical to informing how OSHA proceeds in the rulemaking process. The ANPRM included background information on injuries, illnesses, and fatalities due to heat, underreporting, scope, geographic region, and inequality in exposures and outcomes. The ANPRM also covered existing heat injury and illness prevention efforts, including OSHA's efforts, the NIOSH criteria documents, state standards, and other standards. The initial public comment period was extended and closed on January 26, 2022. In response to the ANPRM, OSHA received 965 unique comments. The comments covered several topics, including the scope of a standard, heat stress thresholds for workers across various industries, heat acclimatization planning, and heat exposure monitoring, as well as the nature, types, and effectiveness of controls that may be required as part of a standard.

Following the publication of the ANPRM, OSHA presented topics from the ANPRM and updates on the heat rulemaking to several stakeholders, including several trade associations, the Office of Advocacy of the Small Business Administration's (SBA's Office of Advocacy) Labor Safety Roundtable (November 19, 2021), and NIOSH National Occupational Research Agenda (NORA) councils, including the Construction Sector Council (November 17, 2021), Landscaping Safety Workgroup (January 12, 2022), and Oil and Gas Extraction Sector (April 7, 2022).

On May 3, 2022, OSHA held a virtual public stakeholder meeting on the agency's "Initiatives to Protect Workers from Heat-Related Hazards." A total of over 1,300 people attended the virtual meeting, and the recorded video has been viewed over 3,500 times (see *www.youtube.com/watch?v=Ud29WsnsOw8*) as of June 2024. The six-hour meeting provided stakeholders an opportunity to learn about and comment on efforts OSHA is taking to protect workers from heat-related hazards and ways the public can participate in the agency's rulemaking process.

OSHA also established a Heat Injury and Illness Prevention Work Group of the National Advisory Committee on Occupational Safety and Health (NACOSH) to support the agency's rulemaking and outreach efforts. The Work Group was tasked with reviewing and developing recommendations on OSHA's heat illness prevention guidance materials, evaluating stakeholder input, and developing recommendations on potential elements of any proposed heat injury and illness prevention standard. On May 31, 2023, the Work Group presented its recommendations on potential elements of a proposed heat injury and illness prevention standard for consideration by the full NACOSH committee. The Work Group recommended that any proposed heat injury and illness prevention standard include: a written exposure control plan/heat illness prevention plan; training; environmental monitoring; workplace control measures; acclimatization; worker participation; and emergency response (Document ID OSHA-2023-0003-0007). After deliberations, NACOSH amended the report to ask OSHA to include a model written plan and then submitted its recommendations to the Secretary of Labor (Document ID OSHA-2023-0003-0012).

As an initial rulemaking step, OSHA convened a Small Business Advocacy Review Panel (SBAR Panel) on August 25, 2023, in accordance with the Regulatory Flexibility Act (RFA) (5 U.S.C. 601 et seq.), as amended by the Small Business Regulatory Enforcement Act (SBREFA) of 1996. This SBAR Panel consisted of members from OSHA, SBA's Office of Advocacy, and the Office of Information and Regulatory Affairs (OIRA) in the White House Office of Management and Budget (OMB). The SBAR Panel identifies individual representatives of affected small entities, termed small entity representatives (SERs), which includes small businesses, small local government entities, and non-profits. This process enabled OSHA, with the assistance of SBA's Office of Advocacy and OIRA, to obtain advice and recommendations from SERs about the potential impacts of the regulatory options outlined in the regulatory framework and about additional options or alternatives to the regulatory framework that may alleviate those impacts while still meeting the objectives and requirements of the OSH Act.

The SBAR Panel hosted six online meetings on September 9, 12, 13, 14, 18, and 19, 2023, with participation from a total of 82 SERs from a wide range of industries. A final report containing the findings, advice, and recommendations of the SBAR Panel was submitted to the Assistant Secretary of Labor for Occupational Safety and Health on November 3, 2023, to help inform the agency's decision making with respect to this rulemaking (Document ID OSHA-2021-0009-1059).

In accordance with 29 CFR parts 1911 and 1912, OSHA presented to the Advisory Committee on Construction Safety and Health (ACCSH) on its framework for a proposed rule for heat injury and illness prevention in outdoor and indoor work settings on April 24, 2024. The Committee then passed unanimously a motion recommending that OSHA proceed expeditiously with proposing a standard on heat injury and illness prevention. The Committee also recommended that OSHA consider the feedback and questions discussed by Committee members during the meeting in formulating the proposed rule (see the minutes from the meeting, Docket No. 2024-0002). OSHA has considered the Committee's feedback in the development of this proposal.

In accordance with Executive Order 13175, Consultation and Coordination with Indian Tribal Governments, 65 FR 67249 (Nov. 6, 2000), OSHA held a listening session with tribal representatives regarding this Heat Injury and Illness Prevention in Outdoor and Indoor Work Settings rulemaking on May 15, 2024. OSHA provided an overview of the rulemaking effort and sought comment on what, if any, tribal implications would result from the rulemaking. A summary of the meeting and list of attendees can be viewed in the docket (DOL, 2024a).

D. Other Standards.

Various other organizations have also either identified the need for standards to prevent occupational heat-related injury and illness or published their own standards. In 2024, the American National Standards Institute/American Society of Safety Professionals A10 Committee (ANSI/ASSP) published a consensus standard on heat stress management in construction and demolition operations. The International Organization for Standardization (ISO) also has a standard for evaluating heat stress: ISO 7243: Ergonomics of the thermal environments – Assessment of heat stress using the WBGT (wet bulb globe temperature) index (ISO, 2017). ISO 7243 uses WBGT values, along with metabolic rate, to assess hot environments, similar to ACGIH and NIOSH recommendations. Additional ISO standards address predicting sweat rate and core temperature (ISO 7933), and determining metabolic rate (ISO 8996), physiological strain (ISO 9886), and thermal characteristics for clothing (ISO 9920). In 2021, the American Society for Testing and Materials (ASTM) finalized its Standard Guide for Managing Heat Stress and Heat Strain in Foundries (E3279-21) which establishes "best practices for recognizing and managing occupational heat stress and heat strain in foundry environments." The standard outlines employer responsibilities and recommends elements for a "Heat Stress and Heat Strain Management Program" (ASTM, 2021).

ACGIH has identified TLVs for heat stress (ACGIH, 2023). The TLVs utilize WBGT and take into consideration metabolic rate or workload categories. Additionally, ACGIH provides clothing adjustment factors which are added to the measured WBGT for certain types of work clothing to account for the impaired thermal regulation.

The U.S. Armed Forces has developed extensive heat-related illness prevention and management strategies. The Warrior Heat and Exertion Related Events Collaborative is a tri-service group of military leaders focused on clinical, educational, and research efforts related to exercise and exertional heat-related illnesses and medical emergencies (HPRC, 2023). The U.S. Army has a Heat Center at Fort Benning which focuses on management, research, and prevention of heat-related illness and death (Galer, 2019). In 2023, the U.S. Army updated its Training and Doctrine Command (TRADOC) Regulation 350-29 addressing heat and cold casualties. The regulation includes requirements for rest and water consumption according to specific WBGT levels and work intensity (Department of the Army, 2023). The U.S. Navy has developed Physiological Heat Exposure Limit curves that are based on metabolic and environmental heat loads and represent the maximum allowable heat exposure limits, which were most recently updated in 2023. The Navy monitors WBGT and has guidelines based on these measurements, with physical training diminishing as WBGTs increase and all nonessential outdoor activity stopped when WBGTs exceed 90 °F (Department of the

Navy, 2023). The U.S. Marine Corps follows the Navy's guidelines for implementation of the Marine Corps Heat Injury Prevention Program (Commandant of the Marine Corps, 2002). In 2022, the U.S. Army and U.S. Air Force issued an update to their technical heat stress bulletin, which outlines measures to prevent indoor and outdoor heat-related illness in soldiers. The bulletin includes recommended acclimatization planning, work-rest cycles, fluid and electrolyte replacement, and limitations on work based on WBGT (Department of the Army, 2022).

As of April 2024, five states have promulgated heat standards requiring employers in various industries and workplace settings to implement protections to reduce the risk of heat-related injuries and illnesses for their employees: California, Minnesota, Oregon, Washington, and Colorado. In addition, Maryland and California are currently engaged in rulemaking. State standards differ in the scope of coverage (see Tables III-1 and 2). For example, Minnesota's standard covers only indoor workplaces. California and Washington standards cover only outdoor workplaces, although California’s proposal would include coverage of indoor workplaces. Oregon's rule covers both indoor and outdoor workplaces. State rules also differ in the methods used for triggering protections against hazardous heat. Minnesota's standard considers the type of work being performed (light, moderate, or heavy) and provides WBGT trigger levels based on the type of work activity. California's heat-illness prevention protections go into effect at an ambient temperature of 80 °F. Washington's rule also relies on ambient temperature readings combined with considerations for the breathability of workers' clothing. Oregon's rule uses a heat index 80 °F as a trigger.

California, Washington, Colorado, and Oregon all have additional protections that are triggered by high heat. However, they differ as to the trigger for these additional protections. In California, high heat protections are triggered at an ambient temperature reading of 95 °F (and only apply in certain industries). In Washington, high heat protections are triggered at an ambient temperature reading of 90 °F. In Colorado, additional protections are triggered at an ambient temperature reading of 95 °F or by other factors such as unhealthy air quality, length of workday, heaviness of clothing or gear, and acclimatization status. These additional protections only apply to the agricultural industry. Finally, in Oregon, high heat protections are triggered at a heat index of 90 °F.

All the state standards require training for employees and supervisors. All the state standards, except for Minnesota, require employers to provide at least one quart of water per hour for each employee, require some form of emergency response plan, include provisions related to acclimatization for workers, and require access to shaded break areas. Washington and Oregon require that employers provide training in a language that the workers understand. Similarly, California's standard requires that employers create a written heat-illness prevention plan in English as well as in whatever other language is understood by the majority of workers at a given workplace. California also requires close monitoring of new employees for the first fourteen days and monitoring of all employees during a heat wave. Table III-1 below provides an overview of the provisions included in the existing and proposed state standards on heat injury and illness prevention. Table III-2 provides an overview of the additional provisions required when the high heat trigger is met or exceeded.

Table III-1 Initial heat triggers and provisions in state heat standards

			General							
		Threshold	Provision of water	Shade or cool-down means	Rest breaks if needed	Emergency response	Acclimatization	Training	Heat Illness Prevention Plan	Observation /supervision
California	Outdoor	80°F (Ambient)[1]	•	•	•	•	•	•	•	
Washington	Outdoor	80°F (Ambient), All other clothing; 52°F, Non-breathable clothes	•	•	•	•	•	•	• (accident prevention)	
Colorado	Agriculture	80°F (Ambient)	•	•	•	•	•	•		•
California (proposal)	Indoor	82°F (Ambient)	•	•	•	•	•	•	•	
Maryland (proposal)	Indoor & Outdoor	80°F (Heat Index)	•	•		•	•	•	•	
Minnesota[2]	Indoor	86°F (WBGT), Light work; 80°F, Moderate work; 77°F, Heavy work						•		
Oregon	Indoor & Outdoor	80°F (Heat Index)	•	•		•	•	•	•	

[1] Some provisions, including water, emergency response, training, and heat illness prevention plan, apply to covered employers regardless of the temperature threshold.

[2] Minnesota uses a 2-hour time-weighted average permissible exposure limit rather than a trigger.

Table III-2 High heat triggers and additional provisions in state heat standards

			Additional High Heat Provisions			
		Threshold	Work-rest schedule	Observation/supervision	Pre-shift meetings	Assessment and control measures[1]
California	Outdoor[2]	95°F (Ambient)	• (only agriculture)	•	•	
Washington	Outdoor	90°F (Ambient)	•	•		
Colorado	Agriculture	95°F (Ambient) or other conditions[3]	•	covered in general provisions above	•	
California (proposal)	Indoor	87°F (Ambient or Heat Index) or other conditions[4]				•
Maryland (proposal)	Indoor & Outdoor	90°F (Heat Index)	•	•		
Oregon	Indoor & Outdoor	90°F (Heat Index)	•	•		

[1] Assessment and control measures include measuring temperature and heat index, identifying and evaluating all other environmental risk factors for heat illness, and using specified control measures to minimize the risk of heat illness.

[2] High heat procedures apply in agriculture; construction; landscaping; oil and gas extraction; transportation or delivery of agricultural products, construction materials or other heavy materials, except for employment that consists of operating an air-conditioned vehicle and does not include loading or unloading.

[3] Other conditions include unhealthy air quality, shifts over 12 hours, heavy clothing or gear required, or the employee is new or returning from absence.

[4] Other conditions include wearing clothing that restricts heat removal, or working in a high radiant heat area, when the ambient temperature is at or above 82°F.

IV. Health Effects

A. Introduction.

I. Health Effects of Occupational Heat Exposure.

Exposure to workplace heat can be seriously detrimental to workers' health and safety and, in some cases, can be fatal. Workplace heat contributes to heat stress, which is a person’s total heat load (NIOSH, 2016) from the following sources combined: 1) heat from the environment, including heat generated by equipment or machinery; 2) metabolic heat generated through body movement, which is proportional to one’s relative level of exertion (Sawka et al., 1993; Astrand 1960); and 3) heat retained due to clothing or personal protective equipment (PPE), which is highly dependent on the breathability of the clothing and PPE worn (Bernard et al., 2017). Heat is routinely an occupation-specific risk because, for example, workers may experience greater heat stress than non-workers, particularly when they are required to work through shifts with prolonged heat exposure, complete tasks that require physical exertion, and/or their employers do not take adequate steps to protect them from exposure to hazardous heat. In addition, many work operations require the use of PPE. PPE can increase heat stress and can reduce workers’ heat tolerance by decreasing the body’s ability to cool down. Workers may also face pressure, or incentivization through pay structures (e.g., piece-rate, bonuses), to work through hazardous heat. Pressure to produce results and be seen as a good worker can have a direct impact on worker self-care choices that impact health (Wadsworth et al., 2019). Pay structures and production quotas intended to motivate workers may also compromise worker safety (Iglesias-Rios et al., 2023). These pressures can increase their risk of heat-related injury and illness (Billikopf and Norton, 1992; Johansson et al., 2010; Spector et al., 2015; Pan et al., 2021). The body's response to heat stress is called heat strain (NIOSH, 2016). As the heat stress a person experiences increases, the body attempts to cool itself by releasing heat into the surrounding environment. If the body begins to acquire heat faster than it can release it, the body will store heat. As stored heat accumulates, the body can show signs of excessive heat strain, such as increased core temperature and heart rate, as well as symptoms of heat strain, such as sweating, dizziness, or nausea.

Two large meta-analyses (n=2,409 and n=11,582).[1] have confirmed that occupational heat exposure is associated with both signs and symptoms of heat strain (Ioannou et al., 2022; Flouris et al., 2018). In one, the authors found a high prevalence of heat strain (35%) among workers in hot conditions, defined by the authors as WBGT greater than 26°C (78.8°F); they also found that workers in hot conditions were four times more likely to experience signs and symptoms of heat strain than workers in more moderate conditions (Flouris et al., 2018).

II. Literature Review for Health Effects Section.

OSHA conducted a non-systematic review of the medical and scientific literature to identify evidence on the relationship between heat exposure and illnesses and death. OSHA's literature review focused on meta-analyses, systematic reviews, and studies

[1] In the Health Effects section, OSHA refers to statistics that were reported by authors when describing results from their research studies. These include the sample size (n), the odds ratio (OR), the confidence interval (CI), and the p-value (p). These statistics provide information about effect size, error, and statistical significance.

cited in NIOSH's *Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments*, published in 2016. OSHA separately searched for additional meta-analyses and systematic reviews that were not cited in the NIOSH Criteria document, including those that were published after the document was released (i.e., 2016 and on).

OSHA also reviewed sentinel epidemiological evidence including observational, experimental, and randomized controlled studies. OSHA primarily reviewed epidemiological studies focusing on worker populations, athletes, and military members, but also included studies in non-worker populations where appropriate. For example, when there was limited occupation-specific research or data for some heat-related health effects, OSHA sometimes considered general population studies as they relate to understanding physiological mechanisms of heat-related illness, severity of an illness, and prognosis. In addition to the evidence of heat-related illnesses and deaths, OSHA reviewed a large body of evidence that evaluated the association of occupational heat exposure with workplace injuries such as falls, collisions, and other accidents. OSHA also reviewed evidence regarding individual factors such as age, medication use, and certain medical conditions that may affect one's risk for heat-related health effects.

III. Summary.

The best available evidence in the scientific and medical literature, as summarized in this Health Effects section, demonstrates that occupational heat exposure can result in death; illnesses, including heat stroke, heat exhaustion, heat syncope, rhabdomyolysis, heat cramps, hyponatremia, heat edema, and heat rash; and heat-related injuries, including falls, collisions, and other workplace accidents.

B. General Mechanisms of Heat-Related Health Effects.

This section briefly describes the mechanisms of heat-related health effects, i.e., how the body's physiological responses to heat exposure can lead to the heat-related health effects identified in OSHA's literature review. More detailed information about the mechanisms underpinning each specific heat-related health effect is described in the relevant subsections that follow.

As explained above, occupational heat exposure contributes to heat stress. The resulting bodily responses are collectively referred to as heat strain (Cramer and Jay, 2016). The bodily responses included in heat strain serve to decrease stored heat by increasing heat loss to the environment to maintain a stable body temperature (NIOSH, 2016). When the brain recognizes that the body is storing heat, it activates the autonomic nervous system to initiate cooling (Kellogg et al., 1995; Wyss et al., 1974). Blood is shunted towards the skin and vasodilation begins, meaning that the blood vessels near the skin's surface become wider, thereby increasing blood flow near the surface of the skin (Kamijo et al., 2005; Hough and Ballantyne, 1899). The autonomic nervous system also triggers the body's sweat response, in which sweat glands release water to wet the skin (Roddie et al., 1957; Grant and Holling, 1938). These processes allow the body to cool in four ways: 1) radiation, i.e., when heat is released directly into the surrounding air; 2) convection, i.e., when there is air movement that moves heat away from the body; 3) evaporation, i.e., when sweat on the skin diffuses into surrounding air (as clothing/PPE permits) and 4) conduction, i.e., when heat is directly transferred through contact with a cooler surface (e.g., wearing an ice-containing vest (Cramer and Jay, 2016; Leon and Kenefick, 2012).

Importantly, the extent of heat release through radiation, convection, and evaporation depends on environmental conditions such as the speed of air flow, temperature, and relative humidity (Clifford et al., 1959; Brebner et al., 1958). For example, when relative humidity is high, sweat is less likely to evaporate off the skin, which significantly reduces the cooling effect of evaporation. Additionally, when sweat remains on the skin and irritates the sweat glands, it can cause a condition known as heat rash*,* whereby itchy red clusters of pimples or blisters develop on the skin (DiBeneditto and Worobec, 1985; Sulzberger and Griffin, 1968).

While the purpose of the sweat response is to cool the body, in doing so, it can deplete the body's stores of water and electrolytes (e.g., sodium [Na], potassium [K], chloride [Cl], calcium [Ca], and magnesium [Mg]) that are essential for normal bodily function (Shirreffs and Maughan, 1997). The condition resulting from abnormally low sodium levels is known as hyponatremia. When stores of electrolytes are depleted, painful muscle spasms known as heat cramps can occur (Kamijo and Nose, 2006). Additionally, depletion of the body's stored water causes dehydration, which is known to reduce the body's circulating blood volume (Trangmar and Gonzalez-Alonso, 2017; Dill and Costill, 1974).

During vasodilation that happens as the body attempts to cool, blood can pool in areas of the body that are most subject to gravity, and fluid can seep from blood vessels causing noticeable swelling under the skin (known as heat edema). Upright standing would further encourage blood to pool in the legs, and thus, the heart has an even lower blood volume available for circulation (Smit et al., 1999). A large reduction in circulating blood volume will lead to 1) a continued rise in core body temperature, and 2) reduced blood flow to the brain, muscles, and organs. A rise in core body temperature and reduced blood flow to the brain can cause neurological disturbances, such as loss of consciousness, which are characteristic of heat stroke and heat syncope (Wilson et al., 2006; Van Lieshout et al., 2003). A rise in core body temperature and reduced blood flow to muscles can also cause extreme muscle fatigue (to the point of collapse) and muscle cell damage during exertion, which are characteristic of heat exhaustion and rhabdomyolysis, respectively (Torres et al., 2015; Nybo et al., 2014). Finally, a rise in core body temperature and reduced blood flow to organs can damage multiple vital organs (such as the heart, liver, and kidneys), which is often observed in heat stroke (Crandall et al., 2008; O'Donnell and Clowes, 1972). Heat stroke and rhabdomyolysis can lead to death if not treated properly and promptly.

C. Identifying Cases of Heat-Related Health Effects.

In its review of the scientific and medical literature on the health effects of occupational heat exposure, OSHA found several studies that relied upon coding systems, in which medical providers or other public health professionals identify fatalities and non-fatal cases of various illnesses and injuries, including heat-related illnesses and injuries (HRIs). The medical and scientific communities use data from these coding systems to study the incidence and prevalence of illnesses and injuries, including HRIs.

In both this Health Effects section and Section V., Risk Assessment, OSHA relied on several studies that make use of data from these coding systems. A brief summary of each of the major coding systems is provided below.

I. International Statistical Classification of Diseases and Related Health Problems (ICD) Codes.

The International Statistical Classification of Diseases and Related Health Problems (ICD) System is under the purview of the World Health Organization (WHO), an international agency that, as the leading authority on health and disease, regularly publishes evidence-based guidelines to advance clinical practice and public health policy. The ICD System harmonizes the diagnosis of disease across many countries, and ICD codes are used routinely in the U.S. healthcare system by medical personnel to record diagnoses in patients' medical records, as well as to identify cause of death. These codes are utilized as part of a standardized system for recording diagnoses, as well as organizing and collecting data into public health surveillance systems. Each ICD code is a series of letters and/or numbers that corresponds to a highly specific medical diagnosis. Healthcare providers may record multiple ICD codes if an individual presents with multiple diagnoses. The ICD system has multiple codes that medical personnel can use when diagnosing HRIs.

The ICD system was first developed in the 18th century and was adopted under the purview of the World Health Organization (WHO) in 1948 (Hirsch et al., 2016). Since then, the ICD system has been revised 11 times—ICD-11 was released in 2022. However, because the ICD-11 system has not yet been implemented in the United States, many of the epidemiological studies cited throughout this Health Effects section used the ICD-9 and ICD-10 systems to survey heat-related deaths and HRIs. Table IV-1 provides a list of heat-related ICD-9 and ICD-10 codes.

Table IV-1 ICD-9 and ICD-10 Codes for Heat-Related Health Effects*

ICD-9 Code	ICD-10 Code Equivalent
992 *Effects of heat and light*	T67 *Effects of heat and light*
992.0 *Heatstroke and sunstroke*	T67.0 *Heatstroke and sunstroke*
992.1 *Heat syncope*	T67.1 *Heat syncope*
992.2 *Heat cramps*	T67.2 *Heat cramp*
992.3 *Heat exhaustion, anhydrotic*	T67.3 *Heat exhaustion, anhydrotic*
992.4 *Heat exhaustion due to salt depletion*	T67.4 *Heat exhaustion due to salt depletion*
992.5 *Heat exhaustion, unspecified*	T67.5 *Heat exhaustion, unspecified*
992.6 *Heat fatigue, transient*	T67.6 *Heat fatigue, transient*
992.7 *Heat edema*	T67.7 *Heat edema*
992.8 *Other effects of heat and light*	T67.8 *Other effects of heat and light*
992.9 *Effects of heat and light, unspecified*	T67.9 *Effects of heat and light, unspecified*
E900 *Accident caused by excessive heat*	NA
E900.0 *Accident caused by excessive heat due to weather conditions*	X30 *Exposure to excessive natural heat*
E900.1 *Accidents due to excessive heat of man-made origin*	W92 *Exposure to excessive heat of man-made origin*
E900.9 *Accidents due to excessive heat of unspecified origin*	X30 *Exposure to excessive natural heat*

Note: The above heat-related codes exclude X32 *Exposure to sunlight* and W89 *Exposure to man-made radiation*, among others.
*These ICD codes are specific to heat as indicated by the names of the codes. There are additional codes that can be associated with diagnosed heat illness but may not be specific to heat-related illness which are not included here but may be included in text where relevant (e.g., *M62.82* for rhabdomyolysis and E87.1 for hypo-osmolality and hyponatremia).

Various surveillance systems exist to track documentation of ICD codes. For example, the CDC leverages ICD-10 codes to collect nearly real-time data on heat-related deaths and HRIs through the National Syndromic Surveillance System (NSSP). The CDC also uses ICD-10 codes to collect annual data on heat-related deaths and HRIs, then reports these data via the National Vital Statistics System (NVSS) and National Center for Health Statistics (NCHS). Additionally, all branches of the U.S. Armed Forces (i.e., Army, Navy, Air Force, and Marine Corps) use ICD-10 codes to document HRIs among service members in the Defense Medical Surveillance System (DMSS). The US Army also uses ICD-10 codes to document HRIs in the Total Army Injury and Health Outcomes Database (TAIHOD) (Bell et al., 2004).

II. Occupational Illness and Injury Classification System (OIICS) Codes.

The U.S. Bureau of Labor Statistics (BLS) is a federal agency, housed in the Department of Labor, that collects and analyzes data on the U.S. economy and workforce. In 1992, BLS developed the Occupational Illness and Injury Classification System (OIICS) to harmonize reporting of injuries and illnesses that affect U.S. workers. The OIICS is similar to the ICD system. Each OIICS code is a series of numbers that specifies a diagnosis (referred to as the nature of an illness or injury, or a “nature code”) and event(s) leading to an illness or injury (referred to as an “event code”). OIICS was updated in 2010 (Version 2.0), and again in 2022 (Version 3.0); Version 3.0 is the most up to date version (*https://www.bls.gov/iif/definitions/occupational-injuries-and-illnesses-classification-manual.htm;* BLS, 2023e). The OIICS system has multiple codes that can be used when identifying occupational HRIs. Table IV-2 provides a list of heat-related OIICS codes (nature and event codes).

Table IV-2 OIICS Codes (Version 3.0) for Heat-Related Health Effects †

Nature Codes
172 *Effects of heat and light*
1720 *Effects of heat – unspecified*
1721 *Heat stroke, syncope*
1722 *Heat exhaustion, fatigue*
1729 *Effects of heat – not elsewhere classified*

2893 *Prickly heat, heat rash, and other disorders of the sweat glands including "miliaria rubra"*
Event Codes
53 *Exposure to temperature extremes*
530 *Exposure to temperature extremes – unspecified*
531 *Exposure to environmental heat*
5310 *Exposure to environmental heat – unspecified*
5311 *Exposure to environmental heat – indoor*
5312 *Exposure to environmental heat – outdoor*

† Some of the data OSHA relies on uses older versions of OIICS codes (Versions 1 and 2) but the major categories for heat-related incidents did not change significantly between versions.

Through a combination of survey staff and a specialized automated coding system, BLS applies OIICS codes to data collected through their worker safety and health surveillance systems, the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII), to identify and document occupational heat-related deaths and occupational HRIs, respectively. Researchers have also relied on this system for identifying occupational HRIs (e.g., Spector et al., 2016). However, BLS data does not currently specify discrete codes for all HRIs described in this health effects section. The CFOI is a cooperative program between the federal government and the states that relies on various administrative records, including death certificates, to accurately produce counts of fatal work injuries (BLS, 2012). The CFOI examines all cases marked "At work" on the death certificate, and the CFOI database relies on the death certificate (among other sources) to ascertain the cause(s) of death. Further details about BLS reporting using OIICS codes, as well as rates of HRIs, can be found in Section V., Risk Assessment.

III. Limitations.

A limitation to relying on these coding systems to identify heat-related fatalities and HRIs is underreporting. Numerous studies have found that HRIs are likely vastly underreported (see Section V., Risk Assessment). Reasons for the likely underreporting include underreporting of illness and injuries by workers to their employers (Kyung et al., 2023), underreporting of injuries and illnesses by employers to BLS and OSHA (Wuellner and Phipps, 2018; Fagan and Hodgson, 2017), underutilization of workers' compensation insurance (Fan et al., 2006; Bonauto et al., 2010), influence of structural factors and work culture on workers perceptions about seeking help (Wadsworth et al., 2019; Iglesias-Rios, 2023), and difficulties with determining heat-related causes of death (e.g., Luber et al., 2006; Pradhan et al., 2019). As a result, there are likely many heat-related fatalities and cases of HRIs that are not captured in these coding systems. For a more detailed discussion of underreporting, see Section V., Risk Assessment.

IV. Summary.

As demonstrated by these coding systems, in which medical providers or other public health professionals assign one or more codes to identify a heat-related fatality or HRI, it is well accepted in the medical and scientific communities that heat exposure, including occupational heat exposure, can result in death and HRIs. Indeed, in its review of the best available scientific and medical literature on the health effects of occupational heat exposure, OSHA identified several studies that relied upon data from these coding systems to determine the incidence or prevalence of heat-related deaths and HRIs in workers. OSHA relies on these studies in both this Health Effects section and Section V., Risk Assessment, of this preamble to the proposed rule.

D. Heat-Related Deaths.

I. Introduction.

Heat is the deadliest weather phenomenon in the United States (NWS, 2022). Heat as a cause of death is widely recognized in the medical and scientific communities. Studies investigating relationships between heat and mortality have long demonstrated positive associations between heat exposure and increased all-cause mortality (e.g., Weinberger et al., 2020; Basu and Samet, 2002; Whitman et al., 1997). As explained below, the connection between heat exposure, the body's physiological responses, and death (i.e., heat-related death mechanisms) is clearly established. Exposure to occupational heat can be fatal. According to BLS's CFOI, occupational heat exposure has killed 1,042 U.S. workers between 1992-2022 (BLS, 2024c).

II. Physiological Mechanisms.

Death caused by exposure to heat can occur in occupational settings if the worker's body is not able to adequately cool in response to heat exposure or if treatment for symptoms of heat-related illness is not provided promptly. Nearly all body systems can be negatively affected by heat exposure. Mora et al. (2017) systematically reviewed mechanistic studies on heat-related deaths and identified five harmful physiological mechanisms triggered by heat exposure that can lead to death: ischemia (inadequate blood flow), heat cytotoxicity (damage to and breakdown of cells), inflammatory response (inflammation that disrupts cell and organ function), disseminated intravascular coagulation (widespread dysfunction of blood clotting mechanisms), and rhabdomyolysis (breakdown of muscle tissue). These mechanisms, with the exception of rhabdomyolysis, are associated with the development of heat stroke. Rhabdomyolysis, which is a potentially fatal illness resulting from the breakdown of muscle tissue, can also occur in conjunction with or in the absence of heat stroke. For a more detailed discussion on rhabdomyolysis, see Section IV.H., Rhabdomyolysis. Mora et al. (2017) also identified seven vital organs that can be critically impacted by heat exposure—the brain, heart, kidneys, lungs, pancreas, intestines, and liver. Across the five identified mechanisms and seven vital organs, Mora et al. (2017) found medical evidence for twenty-seven pathways whereby physiological mechanisms triggered by heat exposure could lead to organ failure and fatality.

The most common cause of heat-related occupational deaths is heat stroke. Heat stroke is a potentially fatal dysregulation of multiple physiological processes and organ systems resulting in widespread organ damage. Heat stroke is typically marked by significant elevation in core body temperature and cognitive impairment due to central nervous system damage. The physiological mechanisms involved in the development and progression of heat stroke are discussed in more detail in Section IV.E., Heat Stroke.

III. Determining Heat as a Cause of Death.

The identification of deaths caused by heat exposure can take place in a few different ways. Healthcare professionals may identify heat-related deaths in medical settings. For example, a heat-related death may be identified if an individual experiencing heat stroke presents to an emergency room and then later dies. The heat-related nature of the death should be documented by the healthcare professional in the chief complaint field during medical history taking and selection of relevant ICD diagnosis codes. The

ICD system allows for identification of heat as either an underlying cause of death or a significant contributing condition. The ICD-10 instruction manual defines underlying cause as "(a) the disease or injury which initiated the train of morbid events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury" (WHO, 2016, p. 31). A significant contributing condition is defined as a condition that "contributed to the fatal outcome, but was not related to the disease or condition directly causing death" (WHO, 2004, p. 24).

Medical examiners or coroners can also identify heat as a cause of death or significant condition contributing to death during death investigations, which should be noted on the deceased individual's death certificate. The National Association of Medical Examiners (NAME), a professional organization for medical examiners, forensic pathologists, and medicolegal affiliates and administrators, defines "heat-related death" as "a death in which exposure to high ambient temperature either caused the death or significantly contributed to it" (Donoghue et al., 1997). This definition was developed in an effort to standardize the way in which heat-related deaths were identified and documented on death certificates. According to the NAME definition, cause is ascertained based on circumstances of the death, investigative reports of high environmental temperature (e.g., a known heat wave), or a pre-death temperature ≥105°F. Cause is also indicated in cases where the person may have a lower body temperature due to attempted cooling measures, but where the individual had a history of mental status changes and specific toxicological findings of elevated muscle and liver enzymes. Heat may be designated as a "significant contributing condition" if: 1) "antemortem body temperature cannot be established but the environmental temperature at the time of collapse was high"; and/or 2) heat stress exacerbated a pre-existing disease, in which case heat and the pre-existing disease would be listed as the cause and significant contributing condition, respectively, or vice versa. Importantly, Donoghue et al. note "The diagnosis of heat-related death is based principally on investigative information; autopsy findings are nonspecific." (Donoghue et al., 1997). While this definition is the official definition of this professional organization, other definitions or processes for determining whether or not a death is heat-related may be used.

Additionally, there are processes in place to identify and document deaths that are work-related. Death certificates include a field that can be checked for "injury at work" (Russell and Conroy, 1991). Further, work-related fatalities due to heat are identified and documented through the CFOI (for more details, see Section IV.C., Overview of ICD and OIICS Codes for Heat-Related Health Effects).

IV. Occupational Heat-Related Deaths.

Occupational heat exposure has led to worker fatalities in both indoor and outdoor work settings and across a variety of industries, occupations, and job tasks (Petitti et al., 2013; Arbury et al., 2014; Gubernot et al., 2015; NIOSH, 2016; Harduar Morano and Watkins, 2017). BLS's CFOI identified 1,042 U.S. worker deaths due to heat exposure between 1992 and 2022, with an average of 34 fatalities per year during that period (BLS, 2024c). Between 2011 and 2022, BLS reports 479 worker deaths (BLS, 2024c). During the latest three years for which BLS reports data (2020-2022), there was an average of 45 work-related deaths due to exposure to environmental heat per year (BLS, 2024c).

However, for the reasons explained in Section V., Risk Assessment, these statistics likely do not capture the true magnitude and prevalence of heat-related fatalities because of underreporting.

There are numerous case studies documenting the circumstances under which occupational heat exposure led to death among workers. For example, in three NIOSH Fatality Assessment and Control Evaluations (FACE) investigations of worker fatalities, workers died of heat stroke after not receiving prompt treatment upon symptom onset (NIOSH, 2004; NIOSH, 2007; NIOSH, 2015). Another case report of a farmworker who died due to heat stroke indicates that confusion the worker experienced as a result of heat exposure may have played a role in his ability to seek help (Luginbuhl et al., 2008). Additional case reports show workers have collapsed and later died while working alone, such as in mail delivery (Shaikh, 2023), and that worker distress has been interpreted as drug use as opposed to symptoms of heat illness (Alsharif, 2023).

V. Summary.

OSHA's review of the scientific and medical literature indicates that occupational heat exposure can and does cause death. The physiological mechanisms by which heat exposure can result in death are clearly established in the literature, and heat exposure being a cause of death is widely recognized in the medical and scientific communities. Indeed, occupational surveillance data demonstrates that numerous work-related deaths from occupational heat exposure occur every year.

E. Heat Stroke.

I. Introduction.

Among HRIs, the most serious and deadly illness from occupational heat exposure is heat stroke. NIOSH (2016) defines heat stroke as “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 [body’s] temperature-regulating mechanism.” When this happens, an individual’s central nervous system is affected, which can result in a sudden and sustained loss of consciousness preceded by symptoms including vertigo, nausea, headache, cerebral dysfunction, bizarre behavior, and excessive body temperature (NIOSH 2016).

Because progression of symptoms varies and involves central nervous system function, it may be difficult for individuals, or those they are with, to know when they are experiencing serious heat illness or to understand that they need urgent medical care (Alsharif, 2023). If not treated promptly, early symptoms of heat stroke may progress to seizures, coma, and death (Bouchama et al., 2022). Thus, heat stroke is often referred to as a life-threatening form of hyperthermia (i.e., elevated core body temperature) because it can cause damage to multiple organs such as the liver and kidneys. Of note, the term “stroke” in “heat stroke” is a misnomer in that it does not involve a blockage or hemorrhage of blood flow to the brain.

There are two types of heat stroke: classic heat stroke (CHS) and exertional heat stroke (EHS). CHS can occur without any activity or physical exertion, whereas EHS occurs as a result of physical activity. CHS typically occurs in environmental conditions where ambient temperature and humidity are high and is most often reported during heat waves (Bouchama et al., 2022). It is most likely to affect young children and the elderly (Laitano et al., 2019). Studies have found that EHS can occur with any amount of physical exertion, even within the first 60 minutes of exertion (Epstein and Yanovich, 2019; Garcia et al., 2022). Additionally, EHS can occur in healthy individuals who would otherwise be considered low risk performing physical activity, regardless of hot or cool environmental conditions (Periard et al., 2022; Epstein et al., 1999).

Cases of heat stroke can be identified in a few ways. Medical personnel who make a formal diagnosis of heat stroke record the corresponding ICD code in the patient’s medical record. Medical examiners also identify heat stroke as a cause of death or significant condition contributing to death and note it on the deceased individual’s death certificate.

II. Physiological Mechanisms.

Heat stroke happens when the body is under severe heat stress and is unable to dissipate excessive heat to keep the body temperature at 37°C (98.6°F), resulting in an elevated core body temperature (Epstein and Yanovich, 2019). The hallmark characteristics of heat stroke are: 1) central nervous system (CNS) dysfunction, including encephalopathy (i.e., brain dysfunction manifesting as irrational behavior, confusion, coma, or convulsions); and 2) damage to multiple organs, including the kidneys, liver, heart, pancreas, gastrointestinal tract, as well as the circulatory system. There are three accepted mechanisms through which heat exposure can cause CNS dysfunction and/or multi-organ damage (Bouchama et al., 2022; Garcia et al., 2022; Iba et al., 2022). All three mechanisms share a common origin: heat exposure contributes to excessive heat stress, which results in hyperthermia.

One mechanism of heat stroke is reduced cerebral blood velocity (CBV) (an indicator of blood flow to the brain) that results in orthostatic intolerance (i.e., the inability to remain upright without symptoms) (Wilson et al., 2006). As individuals experience whole body heating, CBV is reduced and cerebral vascular resistance (the ratio of carbon dioxide stimulus to cerebral blood flow) increases. These changes ultimately contribute to reduced cerebral perfusion (flow of blood from the circulatory system to cerebral tissue) and blood flow, as well as orthostatic intolerance (Wilson et al., 2006).

Another mechanism is damage to the vascular endothelium. Hyperthermia can damage or kill cells in the lining of blood vessels, known as the vascular endothelium. The body responds to vascular endothelium damage through a process called disseminated intravascular coagulation (DIC). DIC is characterized by two processes: 1) tiny clots form in the tissues of multiple organs, and 2) bleeding occurs at the sites of those tiny clots. DIC is extremely damaging and results in injury to organs (Bouchama and Knochel, 2002). Namely, DIC limits the delivery of oxygen and nutrients to several organs including the brain, heart, kidneys, and liver. Thus, DIC can result in both CNS dysfunction and multi-organ damage. Additionally, damage to the vascular endothelium makes it more permeable and creates an imbalance in the substances that control blood clotting, which promotes abnormal and increased blood clotting (Bouchama and Knochel, 2002; Wang et al., 2022).

A third mechanism is damage to the cells in the lining of the gut, known as the gut epithelium. Hyperthermia can alter the cell membranes' permeability (Roti Roti et al., 2008), or directly cause cells to die (Bynum et al., 1978). In either case, cells in the gut epithelium will leak endotoxins into the blood, a process known as endotoxemia. When these endotoxins circulate throughout the body, the immune system aggressively responds by activating cells to fight infection and inflammation, known as systemic inflammatory response syndrome (SIRS) (Leon and Helwig, 2010). The presence of endotoxins, as well as the body's aggressive immune response, can cause serious multi-organ damage (Epstein and Yanovich, 2019; Wang et al., 2022). In particular, the liver is usually one of the first organs to be damaged and is often what causes a heat stroke death (Wang et al., 2022).

III. Occupational Heat Stroke.

Heat stroke is life-threatening and can severely impair workers' safety and health (Lucas et al., 2014). A study of work-related HRIs in Florida using hospital data reported that, during the warm seasons from May through October between 2005 through 2012, heat stroke was the primary diagnosis in 91% (21 of 23) of deaths. In total, they reported 160 cases of work-related heat stroke (Harduar Morano and Watkins, 2017). Analyses of heat stroke among military members indicate that roughly 73% of EHS patients require hospitalization for at least two days (Carter et al., 2007).

IV. Treatment and Recovery.

Heat stroke is a serious medical emergency that requires immediate rest, cooling, and usually hospitalization. Prognosis for heat stroke is highly dependent on how quickly heat stroke is recognized and how quickly an affected worker can be cooled. When an affected person can be diagnosed early and cooled rapidly, the prognosis is generally good. For example, rapid cooling within one hour of presentation of symptoms of CHS was found to reduce the mortality rate from 33% to 15% (Vicario et al., 1986). For EHS, cooling the body below 104°F within 30 minutes of collapse is associated with very good outcomes (Casa et al., 2012; Casa et al., 2015). The authors also reported that they were unaware of any cases of fatalities among EHS victims where it was recorded that the body was cooled below 104°F within 30 minutes of collapse (Casa et al., 2012).

Comparably, others have found that the risk of morbidity and mortality from heat stroke increases as treatment is delayed (Demartini et al., 2015; Schlader et al., 2022). Schlader et al. (2022) found that a delay in cooling can result in tissue damage, multi-organ dysfunction, and eventually death. Similarly, Zeller et al. (2011) found in their retrospective cohort study that patients who did not receive early or immediate cooling had worse outcomes, such as more severe forms of disease or death, although their study design does not allow for conclusions regarding causality (Zeller et al., 2011). Khogali and Weiner's (1980) case study report on 18 cases of heat stroke found that 72% of the patients took between 30-90 minutes to cool, whereas the other 28% were resistant to cooling, taking two to five hours to reach 38°C (100.4°F). This means that there is variation in how individuals respond to heat stroke treatment and that some individuals will respond quicker to treatment than others. Prompt treatment is likely even more critical for the individuals who take longer to cool.

Data from the general population also demonstrate the serious nature of heat stroke. One analysis of nationwide data estimated that nearly 55% of emergency department visits for heat stroke required hospitalization and roughly 3.5% of patients died in the emergency department or at the hospital (Wu et al., 2014). This study also found that heat stroke medical emergencies are more severe than other non-heat-related emergencies, with a 2.6-fold increase in admission rate and a 4.8-fold increase in case fatality compared to those other conditions (Wu et al., 2014).

Complete recovery for individuals who are affected by heat stroke may require time away from work. Some research suggests the length of recovery time and the need for time away from work is based on how long a person was at or above the critical core body temperature of 41°C (105.8°F), and how long it takes for biomarkers in blood to normalize (McDermott et al., 2007). Relevant biomarkers include those for acute liver dysfunction, myolysis (the breakdown of muscle tissue), and other organ system biomarkers (Ward et al., 2020; Schlader et al., 2022).

Guidelines for military personnel and athletes suggest that it may be weeks or months before a worker who has suffered heat stroke can safely return to work or perform the same level of work they did before suffering heat stroke. U.S. military members have clear return-to-work protocols post-heat stroke where members are assigned grades of functional capacity in six areas: physical capacity or stamina, upper extremities, lower extremities, hearing and ears, eyes, and psychiatric functioning (O’Connor et al., 2007). For example, when a soldier/airman experiences heat stroke, they automatically receive a reduced function capacity grade status in physical capacity.

This also results in an automatic referral to a medical examination board. Soldiers and airmen are not cleared to return to duty until their laboratory results normalize, and even then, their status remains a trial of duty. If the individual has not exhibited any heat intolerance after three months, they are returned to a normal work schedule. However, maximal exertion and significant heat exposure remains prohibited for these individuals. If a military member experiences any heat intolerance during the period of restriction, or subsequent resumption to normal duty, a referral to the physical examination board for a hearing regarding their health status is required (O'Connor et al., 2007).

The U.S. Navy has its own set of guidelines, which does not distinguish between heat exhaustion and heat stroke, but uses laboratory tests, especially liver function tests, to determine when sailors are allowed to return to duty. For those who have suffered heat stroke, full return to duty is usually not granted until somewhere between two days to three weeks later (O'Connor et al., 2007).

In 2023, the American College of Sports Medicine (ACSM) published their consensus statement which provides evidence-based strategies to reduce and eliminate HRIs, including a return to activity protocol for athletes recovering from EHS (Roberts et al., 2023). Of note, ACSM names athletes (whether elite, recreational, or tactical) and occupational laborers as groups who are active and regularly perform exertional activities that could lead to EHS. Specifically, ACSM recommendations include refraining from exercise for at least seven days following release from the initial medical care for EHS treatment. Once all laboratory results and vital signs have normalized, ACSM recommends an individual can exercise in cool environments and gradually increase duration, intensity, and heat exposure over a two to four-week period to initiate environmental acclimatization (Roberts et al., 2023). If the affected athlete does not return to pre-EHS activity levels within four to six weeks, further medical evaluation is needed. ACSM recommends a full return to activity between two to four weeks after the individual has demonstrated exercise acclimatization and heat tolerance with no abnormal symptoms or test results during the re-acclimatization period (Roberts et al., 2023). Similarly, the National Athletic Trainer's Association proposes that individuals who experience EHS should complete a 7 to 21-day rest period, be asymptomatic, have normal blood-work values, and obtain a physician's clearance prior to beginning a gradual return to activity (Casa et al., 2015).

In the military setting it is accepted that returning to work too early and/or without adequate work restrictions can result in incomplete recovery from heat stroke, which may necessitate a prolonged restricted work status (McDermott et al., 2007). About 10-20% of people who have had heat stroke have been shown to experience heat intolerance roughly two months after having the heat stroke (Binkley et al., 2002). In some instances, this has lasted for five years and has increased the risk for another heat stroke (Binkley et al., 2002; McDermott et al., 2007). Similarly, a case study report of EHS cases amongst the U.S. Army found that in one of the ten cases examined, the person was heat intolerant for 11.5 months post-EHS (Armstrong et al., 1989).

Only a limited number of studies have focused on the long-term effects of heat stroke. This includes research by Wallace et al. (2007), whose retrospective review of military service members found that those who suffered an EHS event earlier in life were more likely to die due to cardiovascular disease and ischemic heart disease. Similarly, Wang et al. (2019) report that prior exertional heat illness was associated with a higher prevalence of acute ischemic stroke, acute myocardial infarction, and an almost three-fold higher prevalence of chronic kidney disease. Other research in mice support these claims and indicate that epigenetic effects post-EHS result in immunosuppression and an altered heat shock protein response as well as development of metabolic disorders that could negatively impact long-term cardiovascular health (Murray et al., 2020; Laitano et al., 2020).

V. Summary.

OSHA's review of the scientific and medical literature indicates that occupational heat exposure can cause heat stroke, a medical emergency. The physiological mechanisms by which heat exposure can result in heat stroke are well-established in the literature, and heat exposure as a cause of heat stroke is well-recognized in the medical and scientific communities. The best available research demonstrates that heat stroke must be treated as soon as possible and that prolonged time between experiencing heat stroke and seeking treatment increases the likelihood of death and may result in long-term health effects.

F. Heat Exhaustion.

I. Introduction.

NIOSH defines heat exhaustion as "[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" (NIOSH, 2016). Heat exhaustion can progress to heat stroke if not treated properly and promptly, and may require time away from work for a full recovery.

Signs and symptoms of heat exhaustion typically include profuse sweating, changes in mental status, dizziness, nausea, headache, irritability, weakness, decreased urine output and elevated core body temperature up to 40°C (104°F) (NIOSH, 2016; Kenny et al., 2018). Collapse may or may not occur. Significant injury to the central nervous system, and significant inflammatory response do not occur during heat exhaustion. However, there appears to be a fine line between heat exhaustion and heat stroke. Kenny et al. 2018 state that it can be difficult to clinically differentiate between heat exhaustion and early heat stroke. NIOSH also states that heat exhaustion “may signal impending heat stroke” (NIOSH, 2016). Armstrong et al. (2007) recommend that rectal temperature be taken to distinguish between heat exhaustion and heat stroke.

II. Physiological Mechanisms.

Heat exhaustion occurs when heat stress results in elevated body temperature between 98.6°F and 104°F (37°C and 40°C) and physiological changes occur (Kenny et al., 2018). Under these significant heat stress conditions, heavy sweating occurs, tissue perfusion is reduced, and inflammatory mediators are released. Electrolyte imbalances can occur due to fluid and electrolyte losses through sweating paired with inadequate replenishment. Voluntary and involuntary dehydration can exacerbate this process (Hendrie et al., 1997; Brake and Bates, 2003). “Voluntary dehydration,” as used by Brake and Bates, refers to the circumstance where a dehydrated worker does not adequately rehydrate, despite the availability of water. Upon review of several studies, Kenny et al.

(2018) report that dehydration among workers is common, even when water is readily available. There is also evidence that even when water intake increases, as sweat rate and dehydration increase, intake may not be adequate to fully replace losses (Hendrie et al., 1997).

Brake and Bates (2003) summarized various hypothesized reasons for voluntary and involuntary dehydration. One hypothesized reason for voluntary dehydration is a delayed or decreased thirst response (Brake and Bates, 2003). Other reasons include mechanisms that affect fluid retention, such as the dependence of fluid retention on solutes such as sodium, which may be in imbalance under heat stress (Brake and Bates, 2003). Lack of adequate hydration could also be due to workplace pressures or concerns about sanitation (Rao, 2007; Iglesias-Rios, 2023).

The combination of heat stress, upright posture, and low vascular fluid volume (hypovolemia) can further dysregulate the circulatory system and affect clotting mechanisms (Kenny et al., 2018). Heat stress reduces blood flow to the abdominal organs, kidneys, muscles, and brain and increases blood flow to the skin to aid in cooling. These changes in the circulatory system and blood flow to the brain can potentially lead to dizziness or faintness upon standing (orthostatic intolerance), or collapse. Other factors that affect the development of heat exhaustion include individual health status, preparedness (such as acclimatization level), individual characteristics, knowledge, access to fluids, environmental factors, personal protective equipment use and work pacing and intensity (Kenny, 2018).

III. Occupational Heat Exhaustion.

Heat exhaustion is one of the more common heat-related illnesses (Armstrong et al., 2007; Harduar Morano and Watkins, 2017; Lewandowski and Shaman, 2022). In their study of heat-illness hospitalizations in Florida during May to October from 2005-2012, Harduar Morano and Watkins (2017) reported that there were 2,659 cases of work-related heat exhaustion that resulted in emergency department visits or hospitalization, versus 181 cases of work-related heat stroke that resulted in emergency department visits, hospitalization, or death. Similar results have been reported in studies of heat-related illness among the United States Armed Forces and miners showing the frequency of heat exhaustion (Dickinson, 1994; Armed Forces Health Surveillance Division, 2022b; Lewandowski and Shaman, 2022; Donoghue et al., 2000; Donoghue, 2004). While in some studies heat exhaustion is not specifically diagnosed, several qualitative studies describe self-reported symptoms in workers that may be indicative of heat exhaustion (e.g., Mirabelli et al., 2010; Fleischer et al., 2013; Kearney et al., 2016; Mutic et al., 2018). These symptoms included headache, nausea, vomiting, feeling faint, and heavy sweating.

IV. Treatment and Recovery.

Heat exhaustion may require treatment beyond basic first aid to prevent progression to heat stroke (Kenny et al., 2018). In cases where the degree of severity of heat illness is unclear, the individual should be treated as if they have heat stroke (Armstrong, 1989). For a worker experiencing heat exhaustion, NIOSH recommends the following steps to ensure the worker receives proper and adequate treatment: “Take worker to a clinic or emergency room for medical evaluation and treatment; If medical care is unavailable, call 911; Someone should stay with worker until help arrives; Remove worker from hot area and give liquids to drink; Remove unnecessary clothing, including shoes and socks; Cool the worker with cold compresses or have the worker wash head, face, and neck with cold water; Encourage frequent sips of cool water" (NIOSH, 2016).

Complete recovery from heat exhaustion may require a restricted work status (or limited work duties). Donoghue et al. (2000) reported that following heat exhaustion, 29% (22 of 77) of miners included in the study required a restricted work status for at least one shift. The military has specific protocols for return to duty following heat exhaustion. For example, the U.S. Army and Air Force follow the protocol outlines in AR 40-501 (O'Connor et al., 2007). Three instances of heat exhaustion in less than 24 months can result in referral to a Medical Evaluation Board before a full return to service. Some military units have additional or more specific guidelines. For example, one military unit, at Womack Army Medical Center in North Carolina, has guidelines that allow individuals who are considered to have mild illness, fully recovered in the emergency room, and have no abnormal laboratory findings to return to light duty the following day and limited duty the day after that. However, they also indicate that some effects of heat illness may be subtle or delayed and recommend individuals avoid strenuous exercise for several days and remain under observation (O'Connor et al., 2007).

V. Summary.

The scientific and medical literature presented here clearly demonstrate that heat exhaustion is a recognized health effect of occupational heat exposure. The best available evidence on the symptoms, treatment, and recovery of heat exhaustion demonstrates that heat exhaustion can progress to heat stroke, a medical emergency, if not treated promptly and that heat exhaustion may require time away from work for a full recovery.

G. Heat Syncope.

I. Introduction.

Occupational heat exposure can result in heat syncope. Syncope is the medical term for "fainting," and heat syncope is defined as "fainting, dizziness, or light-headedness after standing or suddenly rising from a sitting/lying position" due to heat exposure (NIOSH, 2023a). Heat syncope may sometimes be referred to as "exercise-associated collapse" (EAC), but heat syncope can happen without significant levels of exertion (Asplund et al., 2011; Pearson et al., 2014). As explained below, heat syncope is an acknowledged and documented health effect of occupational heat exposure.

II. Physiological Mechanisms.

There are two mechanisms for how heat exposure can cause heat syncope (Schlader et al., 2016; Jimenez et al., 1999). One mechanism for heat syncope is reduced blood flow to the brain. Elevated core temperature induces vasodilation, sweating, and may result in blood pooling in certain areas of the body (see Section IV.B., General Mechanisms of Heat-Related Health Effects). Thus, there is a lower circulating blood volume, which can reduce blood flow to the brain and cause loss of consciousness (Wilson et al., 2006; Van Lieshout et al., 2003).

A second mechanism for heat syncope is reduced cerebral blood velocity (CBV) (indicative of reduced blood flow to the brain) that results in orthostatic intolerance (the inability to remain upright without symptoms) during a heat stress episode (Wilson et al., 2006). As individuals experience whole body heating, CBV is reduced and cerebral vascular resistance (the ratio of carbon dioxide stimulus to cerebral blood flow) increases. These changes ultimately contribute to reduced cerebral perfusion and blood flow, as well as orthostatic intolerance (Wilson et al., 2006). The orthostatic response to heat stress during "rest" (i.e., standing/sitting) is essentially equivalent to the orthostatic response to heat stress after exercise if skin temperature is similarly elevated (Pearson et al., 2014). While core temperature is not always elevated in cases of heat syncope, skin temperature typically is (Department of the Army, 2022; Noakes et al., 2008).

Differentiating between heat syncope, heat exhaustion, and heat stroke is a critical step in proper diagnosis (Santelli et al., 2014; Coris et al., 2004). As stated above, heat syncope always involves loss of consciousness, but it does not require elevated core body temperature (Santelli et al., 2014; Holtzhausen et al., 1994). Conversely, heat exhaustion and stroke do not require loss of consciousness. Though central nervous system (CNS) disturbances are possible in heat stroke and heat stroke is always characterized by significantly elevated core temperature. Further, recovery of mental status is faster in heat syncope than in exhaustion and heat stroke, since cooling may not be required for treatment of heat syncope (Howe and Boden, 2007).

III. Occupational Heat Syncope.

Workers have experienced heat syncope when exposed to heat. A survey-based study in southern Georgia found that 4% of 405 farmworkers experienced fainting within the previous week (Fleischer et al., 2013). Another survey-based study in North Carolina asked 281 farmworkers if they had ever experienced heat-related illness and found that 3% of workers had fainted (Mirabelli et al., 2010). While these cases were not formally diagnosed as heat syncope, Fleischer reported temperatures ranging from 34-40°C (94-104°F) and a heat index of 37-42°C (100-108°F) at the time workers fainted, and Mirabelli described the working conditions at the time of fainting as being in “extreme heat.”

IV. Treatment and Recovery.

NIOSH recommends treating heat syncope by having the worker sit down in a cool environment and hydrate with either water, juice, or a sports drink (NIOSH, 2016). The Department of the Army recommends that "victims of heat/parade syncope will recover rapidly once they sit or lay supine, though complete recovery of stable blood pressure and heart rate (resolution of orthostasis or ability to stand without fainting) in some individuals may take 1 to 2 hours” (Department of the Army, 2022). Treatment recommendations for athletes consist of moving the athlete to a cool area and laying them supine with elevated legs to assist in venous return, possibly with oral or intravenous rehydration (Peterkin et al., 2016; Howe and Boden, 2007; Seto et al., 2005; Lugo-Amador et al., 2004).

An episode of heat syncope may require time away from work for a thorough evaluation to ascertain one’s risk for recurrent/future episodes of heat syncope. No studies have evaluated recurring episodes of syncope among workers specifically, but a study found that, for the general population, 1-year syncope recurrence (any type) was 14% in working-age people (18-65 years) (Barbic et al., 2019). The U.S. Army has a requirement to "obtain a complete history to rule out other causes of syncope, including an exertional heat illness or other medical diagnosis (for example, cardiac disorder)" (Department of the Army, 2022). Recommendations for athletes include thorough evaluation "for injury resulting from a fall, and all cardiac, neurologic, or other potentially serious causes for syncope" (Howe and Boden, 2007; Lugo-Amador et al., 2004; Binkley et al., 2002). Indeed, if an injury (e.g., fall, collision) is sustained because of heat syncope, treatment beyond first aid (including hospitalization) may be necessary. Supporting this point, more general syncope has been linked to occupational accidents requiring hospitalizations (Nume et al., 2017).

V. Summary.

The scientific and medical literature presented in this section demonstrate that heat syncope is a recognized health effect of occupational heat exposure. Studies suggest that heat syncope may require time away from work for further evaluation. Additionally, heat syncope can lead to injuries (e.g., injury from a fall), some of which may require hospitalization.

H. Rhabdomyolysis.

I. Introduction.

Rhabdomyolysis is a life-threatening illness that can affect workers exposed to occupational heat. NIOSH defines rhabdomyolysis as "a medical condition associated with heat stress and prolonged physical exertion, resulting in the rapid breakdown of muscle and the rupture and necrosis of the affected muscles" (NIOSH, 2016). This definition is specific to exertional rhabdomyolysis. Another form of rhabdomyolysis, called traumatic rhabdomyolysis, is caused by direct muscle trauma (e.g., from a fall or crush injury). Workers can experience such injuries, and consequently suffer from traumatic rhabdomyolysis, because of occupational heat exposure (see Section IV.P., Heat-Related Injuries). However, this section will focus only on exertional rhabdomyolysis. Unless otherwise specified, all references to rhabdomyolysis are shorthand for exertional rhabdomyolysis.

Signs and symptoms of rhabdomyolysis include myalgia (muscle pain), muscle weakness, muscle tenderness, muscle swelling, and/or dark-colored urine (Armed Forces Health Surveillance Division, 2023b; Dantas et al., 2022; O'Connor et al., 2008; Cervellin et al., 2010). Notably, the onset of these symptoms may be delayed by 24-72 hours (Kim et al., 2016). Rhabdomyolysis commonly affects individuals who are exposed to heat during physical exertion. For example, the Centers for Disease Control and Prevention (CDC) investigated an incident in which an entire cohort of 50 police trainees were diagnosed with rhabdomyolysis after the first 3 days of a 14-week training program; the trainees had engaged in heavy physical exertion outdoors with limited access to water. The CDC concluded that adequate hydration is particularly important when the HI approaches 80°F (Goodman et al., 1990).

Rhabdomyolysis has long been recognized as a heat-related illness by NIOSH, the U.S. Armed Forces, and national athletic organizations such as the American College of

Sports Medicine (Armstrong et al., 2007). Specifically, NIOSH lists rhabdomyolysis as an “acute heat disorder” in its *Criteria for a Recommended Standard* (2016) and provides detailed recommendations for recognition and treatment of rhabdomyolysis. NIOSH also conducted case studies and retrospective analyses to identify cases of rhabdomyolysis among workers exposed to heat, including firefighter cadets and instructors, as well as park rangers (Eisenberg et al., 2019; Eisenberg J et al., 2015; Eisenberg and Methner, 2014).

Similarly, the U.S. Armed Forces developed a case definition that specifies rhabdomyolysis can be heat-related (Armed Forces Health Surveillance Board, 2017), and this definition is applied in their annual surveillance reports of HRIs. From 2018 to 2022, most rhabdomyolysis cases (75.9%) occurred during warmer months (i.e., May to October) (Armed Forces Health Surveillance Division, 2023b). In a retrospective study of hospital admissions for rhabdomyolysis in military members (2010-2013), 60.1% (193 out of 321) cases were deemed to be associated with exertion and exposure to heat (Oh et al., 2022).

Many studies have also found that rhabdomyolysis often coincides with exertional heat stroke and other HRIs such as heat exhaustion, heat cramps, hyponatremia, and dehydration. The frequent co-occurrence of rhabdomyolysis and other HRIs has been reported among workers, including police and firefighters (Eisenberg et al., 2019; Goodman et al., 1990), workers included in OSHA enforcement investigations (Tustin et al., 2018a), military members (Oh et al., 2022; Carter et al., 2005), athletes (Thompson et al., 2018), and in the general population (Thongprayoon et al., 2020).

II. Physiological Mechanisms.

Studies have identified two interrelated mechanisms through which heat exposure, combined with exertion, can cause rhabdomyolysis. Both mechanisms share a common origin: occupational heat exposure and exertion both contribute to excessive heat stress, which in turn causes an elevated core temperature. Both mechanisms also share a common outcome: the breakdown and death of muscle tissue, which is the hallmark characteristic of rhabdomyolysis. The first mechanism is thermal injury to muscle cells. When the body's core temperature is elevated, it creates a toxic environment that can directly injure or kill muscle cells. The temperature at which this occurs, known as the thermal maximum, is estimated to be about 107.6 °F (42°C) (Bynum et al., 1978). At the thermal maximum, the structural components of the cells' membranes are liquified and the membrane breaks down. Proteins in the cells' mitochondria, which are key to energy production, change shape and no longer function properly. Calcium, which is normally maintained at a low level inside muscle cells, will rush into the cells and activate inflammatory processes that accelerate the death of those cells (Torres et al., 2015; Khan, 2009).

The second mechanism is lack of oxygen to muscle cells. When the body attempts to cool itself, it can lose high volumes of sweat. Sweat loss can deplete the body's stores of water and electrolytes, leading to low blood volume (see Section IV.B., General Mechanisms of Heat-Related Health Effects). Low blood volume, and low potassium in the blood (known as hypokalemia), can both contribute to muscle cell death. An adequate supply of blood is necessary to deliver oxygen to muscles, and an adequate supply of potassium is needed to support vasodilation (to support increased blood flow to the muscles during exertion). When neither blood volume nor potassium are sufficient, the muscle cells do not receive enough oxygen (known as ischemia). When this occurs, the muscle cells produce less energy and eventually will die if exertion continues (Knochel and Schlein, 1972).

III. Occupational Rhabdomyolysis.

While OSHA is not aware of surveillance data on the incidence of rhabdomyolysis in the worker population in the United States, there are surveillance data on the incidence of rhabdomyolysis among active military members in the Army, Navy, Air Force, and Marine Corps. These data have been reported for the U.S. Army from 2004 to 2006 (Hill et al., 2012) and for all military branches from 2008 through 2022 (Armed Forces Health Surveillance Division, 2023b; Armed Forces Health Surveillance Division, 2018; U.S. Armed Forces, 2013). These surveillance data and the studies described above by NIOSH and others indicate that workers performing strenuous tasks in the heat are at risk of developing rhabdomyolysis. The U.S. Armed Forces has successfully identified many cases of heat-related rhabdomyolysis by searching medical records for the presence of either the ICD-10 code for rhabdomyolysis and/or the ICD-10 code for myoglobinuria, along with any other heat-related codes (Table IV-1) (Armed Forces Health Surveillance Division, 2023b; Oh et al., 2022).

IV. Treatment and Recovery.

Rhabdomyolysis is a serious heat-related illness that can cause life-threatening complications. Many cases of rhabdomyolysis may require hospitalization. For example, A CDC investigation into a police training program in Massachusetts found that 26% of police trainees (13 out of 50) were hospitalized for rhabdomyolysis only three days into their training (Goodman et al., 1990). The mean length of hospitalization was 6 days, with a range of 1 to 20 days (Goodman et al., 1990). Similarly, a military surveillance study identified 473 rhabdomyolysis cases among military members in 2022, with 35.3% of cases (167 out of 473) requiring hospitalization (Armed Forces Health Surveillance Division, 2023b). In a retrospective study of 193 military trainees hospitalized for rhabdomyolysis, the mean length of hospitalization was 2.6 days, with a range of 0 to 25 days (Oh et al., 2022).

The focus of treatment for rhabdomyolysis during hospitalization is to reduce levels of creatine kinase (CK) and myoglobin in the blood, as well as correct electrolyte imbalances, through aggressive administration of intravenous fluids (generally normal saline) (O'Connor et al., 2020; Luetmer et al., 2020; Manspeaker et al., 2016; Torres et al., 2015). Monitoring is used to repeatedly measure CK levels until a peak concentration is reached (often within 1-3 days), and then to ensure that CK levels are consistently trending downwards before discharge from the hospital (Kodadek et al., 2022; Oh et al., 2022).

Complications of rhabdomyolysis are also possible. When muscle cells die, they release several electrolytes and proteins into the bloodstream that can cause severe health complications. For example, the release of potassium from muscle cells can cause hyperkalemia (high level of potassium in the blood), which then leads to heart arrhythmias (abnormal heart rhythms) (Mora et al., 2017; Sauret et al., 2002). Also, the release of myoglobin into the bloodstream can be toxic for the kidneys. When blood is filtered by nephrons (functional units of the kidneys) to produce urine, the presence of even small amounts of myoglobin can obstruct and damage the nephrons (Mora et al., 2017; Sauret et al., 2002). In some cases, these complications from rhabdomyolysis can be life-threatening (Wesdock and Donoghue, 2019) and in fact fatalities have been reported (Gardner and Kark, 1994; Goodman et al., 1990). A more detailed discussion of how rhabdomyolysis can cause acute kidney injury or other kidney damage can be found in Section IV.M., Kidney Health Effects.

Guidelines for return to work among workers diagnosed with rhabdomyolysis are limited. In the U.S. military, soldiers deemed to be at low risk for recurrence of rhabdomyolysis are restricted to light, indoor duty and encouraged to rehydrate for at least 72 hours to allow for normalization of CK levels. If CK levels do not normalize, they must continue indoor, light duty; if CK levels do normalize, they can proceed to light, outdoor duty for at least 1 week and must show no return of clinical symptoms before they can gradually return to full duty. In contrast, soldiers deemed to be at high risk for recurrence of rhabdomyolysis must undergo additional diagnostic tests, with consultation from experts, and can be given an individualized, restricted exercise program while they await clearance for full return to duty (O’Connor et al., 2020; O’Connor et al., 2008). These guidelines have been adopted by the Armed Forces and restated in their surveillance reports of rhabdomyolysis (Armed Forces Health Surveillance Division, 2023b).

V. Summary.

The available scientific literature indicates that rhabdomyolysis can result from physical exertion in the heat. Based on plausible mechanistic data, studies by NIOSH and others, and surveillance data indicating incidence of rhabdomyolysis among active military members, OSHA preliminarily determines that workers performing strenuous tasks in the heat are at risk of rhabdomyolysis.

I. Hyponatremia.

I. Introduction.

Workers in hot environments may experience hyponatremia, a condition that occurs when the level of sodium in the blood falls below normal levels (<135 milliequivalents per liter (mEq/L)) (NIOSH, 2016). Hyponatremia is often caused by drinking too much water or hypotonic fluids, such as sports drinks, over a prolonged period of time. Without sodium replacement, the high water intake can result in losses of sodium in the blood as more sodium is lost due to increased sweating from heat exposure and urination (Korey Stringer Institute (KSI), n.d.). Mild forms of hyponatremia may not produce any signs or symptoms, or may present with symptoms including muscle weakness and/or twitching, dizziness, lightheadedness, headache, nausea and/or vomiting, weight gain, and swelling of the hands or feet (KSI, n.d.; NIOSH, 2016). In severe cases, hyponatremia may cause altered mental status, seizures, cerebral edema, pulmonary edema, and coma, which may be fatal (KSI, n.d.; NIOSH, 2016; Rosner and Kirven, 2007). NIOSH and the U.S. Army classify hyponatremia as a heat-related illness (NIOSH, 2016; Department of the Army, 2022).

II. Physiological Mechanisms.

When exposed to heat, the autonomic nervous system triggers the body's sweat response, in which sweat glands release water to wet the skin (Roddie et al., 1957; Grant and Holling, 1938). The purpose of the sweat response is to cool the body. However, in doing so, it can deplete the body's stores of water and electrolytes (e.g., sodium, potassium, chloride, calcium, and magnesium) that are essential for normal bodily function (Shirreffs and Maughan, 1997). As the body's store of sodium is lessening and high quantities of water are consumed, hyponatremia may develop as sodium in the blood becomes diluted (<135 mEq/L). In some cases, this dilution may cause an osmotic disequilibrium—an imbalance in the amount of sodium inside and outside the cell resulting in cellular swelling—which can lead to the serious and fatal health outcomes discussed above.

III. Occupational Hyponatremia.

Surveillance of hyponatremia among workers is limited. However, a recent case study demonstrates the potential severity and life-threatening nature of hyponatremia. After a seven-day planned absence from work, a 34-year-old male process control operator in an aluminum smelter pot room was hospitalized due to a variety of HRI symptoms including hyponatremia, with serum (the liquid portion of blood collected without clotting factors) sodium level of 114 millimoles per liter (mmol/L) (reference range: 136-145 mmol/L) (Wesdock and Donoghue, 2019). After 13 days in the hospital, the patient was discharged with a diagnosis of "severe hyponatremia likely triggered by heat exposure" (Wesdock and Donoghue, 2019). The patient was still out of work 32 weeks after the incident. While no temperature data for the pot room were available, an exposure assessment used outdoor temperatures that day and pot room temperatures from the literature to estimate that the WBGT could have been as high as 33°C, which the authors state exceeds the ACGIH TLV for light work for acclimatized workers (Wesdock and Donoghue, 2019).

The relationship of heat exposure and hyponatremia was examined among male dockyard workers in Dubai, United Arab Emirates (Holmes et al., 2011). This population performed long periods of manual work in the heat and consumed a diet low in sodium. A first round of plasma (i.e., the liquid part of blood collected that contains water, nutrients and clotting factors) samples were taken at the end of the summer (n=44), with a second round taken at the end of the winter among volunteers still willing to participate (n=38). In the summer, 55% of participants were found to be hyponatremic (<135 millimolar (mM)), whereas only 8% were hyponatremic in the winter. Although ambient temperature conditions were not reported, the authors indicate that hyponatremia was highest during the summer because of sodium losses through sweat and inadequate sodium replacement (Holmes et al., 2011).

Hyponatremia among the military population has been well documented by the Annual Armed Forces Health Surveillance Division, which releases annual reports on exertional hyponatremia among active duty component services members, each with surveillance data for the previous 15 years (e.g., Armed Forces Health Surveillance Division, 2023a; Armed Forces Health Surveillance Division, 2022a; Armed Forces Health Surveillance Division, 2021; Armed Forces Health Surveillance Division, 2020). Cases come from the Defense Medical Surveillance System and include both ambulatory medical visits and hospitalizations in both military and civilian facilities. During the period of 2004 through 2022, the number of cases of hyponatremia among U.S. Armed Forces peaked in 2010 with 180 cases. The lowest number during that time period was 2013, when 72 cases were reported. During the last 15 years in which data were reported (2007-2022), 1,690 cases of hyponatremia occurred. Of these 1,690 cases, 86.8% (1,467) were diagnosed and treated during an ambulatory care visit (Armed Forces Health Surveillance Division, 2023a). As the diagnostic code for hyponatremia may include cases that are not heat-related, these data may be overestimates. However, such overestimation is reduced in this study as the authors controlled for many other related diagnoses (e.g., kidney diseases, endocrine disorders, alcohol/illicit drug abuse), which can cause hyponatremia.

IV. Treatment and Recovery.

Treatment and recovery for hyponatremia can vary depending on severity and symptoms. Workers presenting with mild symptoms should increase salt intake by consuming salty foods or oral hypertonic saline and restrict fluid until symptoms resolve or sodium levels return to within normal limits (KSI, n.d.). Medical attention may be required in severe cases, which may be life-threating, and may be sought to address symptoms and personal risk factors (e.g., history of heart conditions, on a low sodium diet) (NIOSH, 2016).

V. Summary.

The available evidence in the scientific literature indicates that hyponatremia can result from occupational heat exposure. The evidence on treatment and recovery demonstrates that hyponatremia can require medical attention and, in some cases, may be life-threatening.

J. Heat Cramps.

I. Introduction.

Workers exposed to environmental or radiant heat can experience sudden muscle cramps known as “heat cramps.” NIOSH defines heat cramps as “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” (NIOSH, 2016). Someone can experience heat cramps even if they are frequently hydrating with water, but they are not replenishing electrolytes. Heat cramps are recognized as a “heat-related illness” by numerous organizations, including NIOSH, U.S. Army, U.S. Navy, National Athletic Trainers’ Association (NATA), American College of Sports Medicine (ACSM), and World Medicine (formerly known as IAAF).

II. Physiological Mechanisms.

It is recognized in the medical and scientific communities that heat cramps result from heat exposure. However, the exact physiological mechanism is not known. In an early study of heat cramps, investigators included the following as the diagnostic criteria for heat cramps: exposure to high temperatures at work; painful muscle cramps; rapid loss of salt in the sweat that is not replaced (which may cause hyponatremia); diminished concentration of chloride in the blood and in the body tissues (also known as hypochloremia); and rapid amelioration of symptoms after appropriate treatment (Talbott and Michelsen, 1933).

The following mechanism has been proposed for the development of heat cramps: profuse sweating can deplete electrolyte stores (e.g., sodium (Na), potassium (K), calcium (Ca)), which exacerbates muscle fatigue and can cause heat cramps (Bergeron, 2003; Horswill et al., 2009; Schallig et al., 2017; Derrick, 1934). The U.S. Army further posits that "intracellular calcium is increased via a reduction in the sodium concentration gradient across the cell membrane. The increased intracellular calcium accumulation then stimulates actin-myosin interactions (that is, filaments propelling muscle filaments) causing the muscle contractions" (Department of the Army, 2022). Heat cramps are sometimes referred to, more broadly, as exercise-associated muscle cramps (EAMCs) (Bergeron et al., 2008). However, heat cramps are distinct in that they only occur in hot conditions, which exacerbate electrolyte depletion, and may or may not be associated with exercise.

III. Occupational Heat Cramps.

Surveillance data and survey study data demonstrate that workers exposed to environmental or radiant heat frequently experience heat cramps in the United States. In a study of heat-related illness hospitalizations and deaths for the U.S. Army from 1980-2002, 8% of heat-related illness hospitalizations recorded were due to heat cramps (Carter et al., 2005). Similarly, in studies of self-reported heat-related illness, workers frequently cite heat cramps as a common symptom of heat exposure. Specifically, in several studies of self-reported heat-related symptoms among farmworkers in multiple states, participants reported experiencing sudden muscle cramps in the prior week in Georgia (33.7% of 405 respondents) (Fleischer et al., 2013), North Carolina (35.7% of 158 respondents) (Kearney et al., 2016), and Florida (30% of 198 respondents) (Mutic et al., 2018). In another study of self-reported symptoms among 60 migrant farmworkers in Georgia, heat-related muscle cramps were reported by 25% of participants, the second most frequently reported HRI symptom (Smith et al., 2021). In a study examining exertional heat illness and corresponding wet bulb globe temperatures in football players at five southeastern U.S. colleges from August to October 2003, the authors found that the highest incidences of exertional heat illness (EHI) occurred in August (88%, EHI rate= 8.95/1000 athlete-exposures (Aes)) and consisted of 70% heat cramps (6.13/1000 Aes) (Cooper et al., 2016).

IV. Treatment and Recovery.

Treatment for heat cramps includes electrolyte-containing fluid replacement (also known as isotonic fluid replacement), stretching, and massage (Gauer and Meyers, 2019; Peterkin et al., 2016). In some cases, sodium replacement may be a treatment for heat cramps (Talbott and Michelsen, 1933; Sandor, 1997; Jansen et al., 2002). In severe cases, it is recommended that magnesium levels of the patient are obtained and if necessary, magnesium replacement through IV therapy is provided (O'Brien et al., 2012). The ACSM recommends rest, prolonged stretching in targeted muscle groups, oral sodium chloride ingestion in fluids or foods, or intravenous normal saline fluids in severe cases (ACSM, 2007). NIOSH recommends that medical attention is needed if the worker has heart problems, is on a low sodium diet, or if cramps do not subside within 1 hour

(NIOSH, 2016). If treated early and effectively, individuals may return to activity after heat cramps have subsided (Bergeron, 2007; Savioli et al., 2022; Gauer and Meyers, 2019). However, severe heat cramps may require an emergency department visit or hospitalization (Harduar Morano and Waller, 2017; Carter et al., 2005). While most cases of heat cramps do not require restricted work status or time away from work, guidelines for military personnel suggest some cases may require light workload the next day and limited workload the following day, with observation of the affected patient because some additional deficits may be delayed or subtle (O'Connor et al., 2007). In addition, guidelines for military personnel advise that strenuous exercise be avoided for several days in some cases of heat cramps (O'Connor et al., 2007). Severe heat cramps may also elicit soreness for several days which can lead to a longer recovery period (Casa et al., 2015).

V. Summary.

OSHA's review of the scientific and medical literature indicates that heat cramps are a recognized health effect of occupational heat exposure. Indeed, several studies of self-reported symptoms of HRI among farmworkers in multiple states have indicated that heat cramps are quite common. The best available evidence on treatment and recovery indicates that heat cramps can, in some cases, require medical attention and may require time away from work or an adjusted workload.

K. Heat Rash.

I. Introduction.

Workers in hot environments may experience heat rash. Heat rash is defined by NIOSH as "a skin irritation caused by excessive sweating during hot, humid weather" (NIOSH, 2022). NIOSH, the U.S. Army, and the U.S. Navy classify heat rash as a heat-related illness (NIOSH, 2016; Department of the Army, 2022; Department of the Navy, 2023). Also known as miliaria rubra or prickly heat, workers with heat rash develop red clusters of pimples or small blisters, which can produce itchy or prickly sensations that become more irritating as sweating persists in the affected area. Heat rash can last for several days and tends to form in areas where clothing is restrictive and rubs against the skin, most commonly on the neck, upper chest, groin, under the breasts, and in elbow creases (OSHA, 2011; NIOSH, 2022; OSHA, 2024a). If left untreated, heat rash can become infected, and more severe cases can lead to high fevers and heat exhaustion (Wenzel and Horn, 1998). In some cases, heat rash can lead to hypohidrosis (i.e., the reduced ability to sweat) in the affected area, even weeks after the heat rash is no longer visible, which impairs thermoregulation and can cause predisposition for heat stress (Sulzberger and Griffin, 1969; Pandolf et al., 1980; DiBeneditto and Worobec, 1985). This can impair an employee's ability to work and prevent resumption of normal work activities in hot environments to allow for the area to heal, which in some cases can take 3-4 weeks for heat intolerance to subside (Pandolf et al., 1980).

II. Physiological Mechanisms.

The development of heat rash has been studied for centuries (Renbourn, 1958). While working in hot environments with a high relative humidity, the body's ability to cool itself is greatly reduced, as sweat is less likely to evaporate from the skin

(Sulzberger and Griffin, 1969; DiBeneditto and Worobec, 1985). Heat rash occurs when sweat remains on the skin and causes a blockage of sweat (eccrine) glands and ducts (Wenzel and Horn, 1998). Since the sweat ducts are blocked, sweat secretions can leak and accumulate beneath the skin, causing an inflammatory response and resulting in clusters of red bumps or pimples (Dibeneditto and Worobec, 1985). If left untreated, heat rash may become infected (Holzle and Kligman, 1978). Depending on the level of blockage, this can manifest as various types of miliaria, with miliaria rubra being the most common form of heat rash (Wenzel and Horn, 1998).

III. Occupational Heat Rash.

Surveillance of heat rash in worker populations is limited. However, farmworkers have reported cases of skin rash or skin bumps while working in summer months (Bethel and Harger, 2014; Kearney et al., 2016; Luque et al., 2020). From these studies, the percentage of participants surveyed or interviewed that report experiencing skin rash or skin bumps in the previous week were 10% (n=100, Beth and Harger, 2014), 12.1% (n=158, Kearney et al., 2016) and 5% (n=101, Luque et al., 2020). Although these studies do not purport a diagnosis, presentation of skin rash or skin bumps while working in hot environments with reported average high temperatures ranging to the mid-90s°F indicates respondents may have developed heat rash.

Similar findings with diagnosis of heat rash or related symptoms have been recorded outside of the U.S. among workers in the following professions: 17% of indoor electronics store employees in air-conditioned (4%) and non-air-conditioned (13%) areas in Singapore (n=52, Koh, 1995); 2% of underground miners at a site in Australia (n=1,252, Donoghue and Sinclair, 2000); 34% of maize farmers in Nigeria (n=396, Sadiq et al., 2019); 68% of sugarcane cutters and 23% of sugarcane factory workers in Thailand (n=183, Boonruksa et al., 2020); 41% of sugarcane farmers in Thailand (n=200, Kiatkitroj et al., 2021); 17% of autorickshaw drivers (n=78), 23% of outdoor street vendors (n=75), 16% of street sweepers (n=75) in India (n=228, Barthwal et al., 2022); and 13% of underground and open pit miners across Australia (n=515, Taggart et al., 2024). Although these studies illustrate the prevalence of heat rash in various worker populations, OSHA notes that differences in study methodologies and the populations studied mean that the results of these studies are not necessarily directly comparable to each other or to similar industries or worker populations in the United States.

The type of clothing worn may also contribute to formation of heat rash while working in higher temperatures. Heat rash was formally diagnosed among U.S. military personnel wearing flame resistant army combat uniforms in hot and arid environments (102.2°F to 122°F (39°C to 50°C), 5% to 25% relative humidity) (Carter et al., 2011). In this case series, 18 patients with heat rash presented with moderate to severe skin irritation, which was worsened by reactions to chemical additives not removed from the laundering process and increased heat retention from sweat-soaked clothing, as well as the friction from the fabric and the occlusive effect of the clothing, which allowed sweat to accumulate on the skin despite the lower humidity (Carter et al., 2011). This study calls attention to the effect of clothing on the development of heat rash and factors that may influence its severity.

IV. Treatment and Recovery.

Although most cases of heat rash can be self-treated without seeking medical attention, symptoms typically last for several days (Wenzel and Horn, 1998). It is important that heat rash is kept dry and cool to avoid possible infection. Workers experiencing heat rash should move to a cooler and less humid work environment and avoid tight-fitting clothing, when possible (NIOSH, 2022). The affected area should be kept dry, and ointments and creams, especially if oil-based, should not be used (NIOSH, 2022). However, powder may be used for relief.

V. Summary.

The available evidence in the scientific literature indicates that heat rash can result from occupational heat exposure. Although heat rash usually resolves on its own without medical attention, symptoms often persist for several days and more severe cases can impair an employee's ability to work and lead to infection if left untreated.

L. Heat Edema.

I. Introduction.

Workers in hot environments may experience heat edema. Heat edema is the swelling of soft tissues, typically in the lower extremities (feet, ankles, and legs) and hands, and may be accompanied by facial flushing (Gauer and Meyers, 2019). Surveillance systems and the U.S. Army classify heat edema as a heat-related illness (Department of the Army, 2022). Workers who are sitting or standing for prolonged periods may be at higher risk for heat edema (Barrow and Clark, 1998). Workers who are not fully acclimatized to the work site may be more prone to developing heat edema as the body adjusts to hotter temperatures (Howe and Boden, 2007).

II. Physiological Mechanism.

When exposed to heat, the body increases blood flow and induces vasodilation to cool itself and thermoregulate. This means, as blood is shunted towards the skin and vasodilation begins, the blood vessels near the skin's surface become wider (Hough and Ballantyne, 1899; Kamijo et al., 2005). However, blood can pool in areas of the body that are most subject to gravity (e.g., legs), and fluid can seep from blood vessels causing noticeable swelling under the skin – this is known as heat edema (Gauer and Meyers, 2019).

III. Occupational Heat Edema.

Surveillance of heat edema is limited. Many studies include heat edema as one of many HRIs that contributed to an aggregate measure of HRI in worker, military, or general populations, but very few were found to quantify heat edema alone.

Multiple studies outside of the U.S. have examined HRIs among farm and factory workers in the sugarcane industry through surveys and interviews (Crowe et al., 2015; Boonruksa et al., 2020; Kiatkitroj et al., 2021; Debela et al., 2023). Respondents in the studies were asked if they experienced swelling of the feet or hands (with varying degrees of frequency) during periods of heat exposure, which could indicate presentation of heat edema. In different samples of sugarcane workers in two provinces of Thailand, two studies found incidence of swelling of the hands and feet. Among sugarcane cutters, 16.7% self-reported ever experiencing swelling of the hands or feet and 5.6% self-reported experiencing these symptoms (mean 30.6°C WBGT) (n=90, Boonruksa et al., 2020). In another province, 10.5% self-reported swelling of the hands/feet while working one summer (n=200, Kiatkitroj et al., 2021).

While comparing HRI symptoms among sugarcane harvesters and non-harvesters in Costa Rica, 15.1% of harvesters (n=106) and 7.9% of non-harvesters (n=63) self-reported having ever experienced swelling of hands/feet (p=0.173) (n=169, Crowe et al., 2015). While 7.5% of harvesters, who worked outdoors in the field, self-reported experiencing this symptom at least once per week, no non-harvesters self-reported swelling with this level of frequency (p=0.026) (Crowe et al., 2015). The sample of non-harvesters included both workers that were intermediately exposed to heat (e.g., in the processing plant or machinery shop) and workers not exposed to heat (e.g., in offices).

In a sample of sugarcane factory workers (n=1,524) in Ethiopia, 72.4% (1,104) were considered exposed to heat defined as conditions exceeding the ACGIH's TLV (Debela et al., 2023). Of the total sample (including workers considered exposed to heat and not), 78% (1,189) self-reported having experienced swelling of hands and feet at least once per week, which was the most commonly reported HRI symptom (Debela et al., 2023). Although these studies do not purport a diagnosis, presentation of swelling of the hands and feet while working in hot environments suggests respondents may have developed heat edema.

IV. Treatment and Recovery.

Although most cases of heat edema can be self-treated without seeking medical attention, symptoms can last for days and reoccurrence is less likely if individuals are properly acclimatized (Howe and Boden, 2007; Department of the Army, 2023). It is important that the affected individual moves out of the heat and elevates the swollen area. Diuretics are not typically recommended for treatment (Howe and Boden, 2007; Gauer and Meyers, 2019; CDC, 2024a).

V. Summary.

The available evidence in the scientific literature indicates that heat edema can result from occupational heat exposure, causing swelling of the lower extremities (feet, ankles, and legs) and hands. It may be difficult to move swollen body parts, thereby impeding an employee's ability to perform their job. The need for medical attention can typically be avoided if the condition is properly treated.

M. Kidney Health Effects.

I. Introduction.

The kidneys perform many functions in the body, including filtering toxins out of the blood and balancing the body's water and electrolyte levels (NIDDK, 2018). Working in the heat places a lot of demand on the kidneys to conserve water and regulate electrolytes, like sodium, lost through sweat. A growing body of experimental and observational literature suggests that intense heat strain can cause damage to the kidneys in the form of acute kidney injury (AKI), even independent of conditions like heat stroke and rhabdomyolysis. An epidemic of chronic kidney disease in Central America and other regions around the world has placed additional attention on the potential of recurrent heat stress-related AKI to cause chronic kidney disease (CKD) over time (Johnson et al., 2019; Schlader et al., 2019). Working in the heat has also been associated with the development of kidney stones among workers outside the U.S., likely a result of decreased urine volume leading to increased concentration of minerals in the urine that crystallize into stones.

Each kidney is comprised of hundreds of thousands of functional units called nephrons. Each nephron has multiple parts, including the glomerulus (a cluster of blood vessels that conduct the initial filtering of large molecules) and the tubules (tubes that reabsorb needed water and minerals and secrete waste products). The fluid that remains after traveling through the glomeruli and tubules becomes urine and is eliminated from the body (NIDDK, 2018).

This section will discuss three kidney-related health effects associated with heat exposure: kidney stones, AKI, and CKD.

II. Kidney Stones.

A. Introduction.

Kidney stones are hard objects that form in the kidney from the accumulation of minerals. They range in size from a grain of sand to a pea (NIDDK, 2017a). Symptoms include sharp pain in the back, side, lower abdomen, or groin; pink, red, or brown blood in the urine; a constant need to urinate; pain while urinating; inability to urinate or only able to urinate a small amount; and cloudy or foul-smelling urine (NIDDK, 2017b). Nausea, vomiting, fever, and chills are also possible, and symptoms may be brief, prolonged, or come in waves (NIDDK, 2017b). In rare cases or when medical care is delayed, kidney stones can lead to complications including severe pain, urinary tract infections (UTI), and loss of kidney function (NIDDK, 2017a). Risk factors for kidney stones include being male, a family history of kidney stones, having previously had kidney stones, not drinking enough liquids, other medical conditions (e.g., chronic inflammation of the bowel, digestive problems, hyperparathyroidism, recurrent UTIs), drinking sugary beverages, and working in the heat, especially if unacclimatized (NIDDK, 2017a; Maline and Goldfarb, 2024). NIOSH has also cautioned workers that experiencing chronic dehydration can increase the risk of developing kidney stones (NIOSH, 2017a).

B. Physiological Mechanisms.

Kidney stones form when concentrations of minerals are high enough to the point of forming crystals, which then aggregate into a stone in either the renal tubular or interstitial fluid (Ratkalkar and Kleinman, 2011). Reduced urine volume, altered urine pH, diet, genetics, or many other factors may cause this concentration of minerals (Ratkalker and Kleinman, 2011). Heat exposure has the potential to cause kidney stones through heat-induced sweating and dehydration. Loss of extracellular fluid increases osmolality (i.e., increased concentration of solutes, like sodium and glucose) which leads to increased secretion of vasopressin, an antidiuretic hormone. Vasopressin signals to the kidneys to conserve water by reducing urine volume, leading to increased concentration of relatively insoluble salts, like calcium oxalate, in the urine. These salts can eventually form crystals which can develop into stones (Fakheri and Goldfarb, 2011).

C. Occupational Heat Exposure and Kidney Stones.

Epidemiological studies conducted outside the U.S. have documented the association between working in heat and developing kidney stones. One of the earliest publications on occupational heat and kidney stones was a small study of beach lifeguards in Israel (Better et al., 1980). Eleven of 45 randomly selected lifeguards (24%) were found to have had kidney stones, which Better et al. noted was approximately 20 times the incidence rate of the general Israeli population at the time. The authors attributed this finding to low urine output due to dehydration, hyperuricemia (elevated levels of uric acid in the blood), and absorptive hypercalciuria (elevated levels of calcium in the urine), among other factors. In 1992, Pin et al. compared outdoor workers exposed to hot environmental conditions to indoor workers exposed to cooler conditions (Pin et al., 1992). This study of 406 men in Taiwan included quarry, postal, and hospital engineering support workers. The prevalence of kidney stones was found to be significantly higher in the outdoor workers than the indoor workers (5.2% versus 0.85%, $p<0.05$). The authors posited that chronic dehydration from working outdoors in a tropical environment might explain the higher prevalence of kidney stones among outdoor workers (Pin et al., 1992).

Several studies have also considered occupational exposure to indoor heat sources. Borghi et al. studied machinists who had been working in the blast furnaces of a glass plant in Parma, Italy for five or more years, excluding those who had kidney stones before working at the plant (Borghi et al., 1993). The prevalence of kidney stones was significantly higher among machinists exposed to heat (n=236) than among those working in cooler temperatures (n=165) (8.5% vs. 2.4%, p=0.03) (Borghi et al., 1993). An analysis of risk factors revealed that workers in the heat lost substantially more water to sweat and that their urine had higher concentrations of uric acid, higher specific gravity, and lower pH than workers in normal temperatures (Borghi et al., 1993).

In a large study in Brazil, the prevalence of at least one episode of kidney stones was 8.0% among the 1,289 workers in hot areas, which was significantly higher than the 1.75% prevalence found among the 9,037 people working in room temperature conditions ($p<0.001$) (Atan et al., 2005). An analysis of a subset of workers demonstrated that workers in hot temperatures had significantly less citrate in their urine ($p=0.03$) and lower urinary volume ($p=0.01$) compared to room-temperature workers.

Venugopal et al. studied 340 steel workers in southern India engaged in moderate to heavy labor with three or more years of heat exposure (Venugopal et al., 2020). Of the 340 participants, 91 workers without other risk factors for kidney disease, but who had reported a symptom of kidney or urethral issues, underwent renal ultrasounds, which revealed that 27% had kidney stones. 84% of the participants with kidney stones were occupationally exposed to heat, as defined as working in conditions above the ACGIH TLV. Having five or more years of heat exposure was significantly associated with risk of kidney stones, while controlling for smoking (OR: 3.6, 95% CI: 1.2, 10.7).

Most recently, Lu et al. studied 1,681 steel workers in Taiwan, 12% of whom had kidney stones, compared to the age-adjusted prevalence among men in Taiwan of 9% (Lu et al., 2022). Heat exposure was found to be positively associated with prevalence of stones, particularly among workers ≤ 35 years old (OR: 2.7, 95% CI: 1.2, 6.0) (Lu et al., 2022).

Overall, the peer-reviewed literature supports occupational heat exposure as a risk factor for kidney stones, in both indoor and outdoor environments, across multiple countries, and in several industries.

D. Treatment and Recovery.

Treatment of kidney stones depends on their size, location, and type. Someone with a small kidney stone may be able to pass it by drinking plenty of water and taking pain medications as prescribed by a doctor (NIDDK, 2017c). Larger kidney stones can block the urinary tract, cause intense pain, and may require medical intervention such as shock wave lithotripsy, cystoscopy, ureteroscopy, or percutaneous nephrolithotomy to remove or break up the stone (NIDDK, 2017c). Percutaneous nephrolithotomy, whereby kidney stones are removed through a surgical incision in the skin, requires several days of hospitalization, but the other interventions typically do not require an overnight hospital stay (NIDDK, 2017c). One study found that among working aged adults, approximately one third of people treated for kidney stones miss work and that they miss, on average, 19 hours of work per person (Saigal et al., 2005). With monitoring or treatment, people typically recover from kidney stones. However, over the long term, individuals who develop kidney stones are at increased risk of chronic kidney disease and end-stage renal disease, particularly if kidney stones are recurrent (Uribarri, 2020).

E. Summary.

The available peer-reviewed scientific literature demonstrates occupational heat exposure as a risk factor for kidney stones, in both indoor and outdoor environments. Kidney stones may require medical treatment and in some cases hospitalization. Finally, individuals who develop kidney stones are at increased risk of other kidney diseases.

III. Acute Kidney Injury.

A. Introduction.

Acute kidney injury (AKI) can affect workers exposed to occupational heat. AKI is an abrupt decline in kidney function in a short period (e.g., a few days). As normally functioning kidneys filter blood and maintain fluid balance in the body, AKI events can disrupt this fluid balance, which can impact major organs like the heart. AKI can also have metabolic consequences, like a build-up of too much potassium in the blood (hyperkalemia) (Goyal et al., 2023). AKI is not always accompanied by symptoms and is typically diagnosed with blood and/or urine tests (e.g., increase in serum creatinine). While damage to the kidneys is one potential consequence of heat stroke (such as in the context of multi-organ failure, as mentioned in Section IV.E., Heat Stroke), this section is focused on AKI that is not necessarily preceded by clinical heat stroke.

B. Physiological Mechanisms.

There are three categories of AKI used to distinguish the location of the cause(s) of AKI—prerenal, intrarenal, and postrenal (Goyal et al., 2023). Prerenal AKI represents a reduction in blood volume being delivered to the kidneys (i.e., renal hypoperfusion). This can be the result of heat-induced sweating that leads to reduced circulating blood volume. Prerenal AKI that is reversed (e.g., dehydration is quickly reversed) is typically not associated with impairment to the kidney glomeruli or tubules, however prolonged exposure can lead to direct injury to renal cells through ischemia (inadequate blood and oxygen supply to cells). Intrarenal AKI is when the function of the glomeruli, tubules, or interstitium are affected, such as in the case of nephrotoxic exposures (e.g., heavy metals) or prolonged ischemia. Rhabdomyolysis, which was previously discussed in Section

IV.H., Rhabdomyolysis, is one potential cause of necrosis of tubular cells resulting from myoglobin precipitation and direct iron toxicity (Sauret et al., 2002, Patel et al., 2009). Postrenal AKI is when there is an obstruction to the flow of urine, such as kidney stones, pelvic masses, or prostate enlargement. Postrenal AKI is less relevant to a discussion of heat-related health effects, apart from kidney stones, which is discussed in Section IV.M.II., Kidney Stones.

Researchers have written specifically about potential mechanisms leading from occupational heat exposure to AKI (Roncal-Jiménez et al., 2015; Johnson et al., 2019; Schlader et al., 2019; Hansson et al., 2020), often in the context of chronic kidney disease. As previously discussed in Section IV.B., General Mechanisms of Heat-Related Health Effects, working in the heat can lead to increases in core temperature and reductions in circulating blood volume. Researchers hypothesize that elevated core temperature could directly injure renal tissue or that injury could be mediated through subclinical (mild and asymptomatic) rhabdomyolysis or increases in intestinal permeability that can cause inflammation. Reductions in blood volume could inflame or injure the kidneys through reduced renal blood flow that leads to ischemia and/or local reductions in adenosine triphosphate (ATP) availability. Reduced blood flow and increased blood osmolality also trigger physiologic pathways (e.g., renin-angiotensin-aldosterone system, polyol-fructokinase pathway) which are energy-intensive and may lead to oxidative stress and inflammation. Other mechanistic pathways under investigation include urate crystal-induced injury (Roncal-Jiménez et al., 2015) and increased reabsorption of nephrotoxicants (Johnson et al., 2019).

C. Identifying Cases of Acute Kidney Injury.

Serum creatinine levels are used in clinical settings to estimate kidney function (glomerular filtration rate, or GFR), as it is typically produced in the body at a relatively stable rate and is removed from circulation by the kidneys. Multiple criteria exist for defining AKI based on increases in serum creatinine over hours or days, such as the KDIGO criteria published by a non-profit organization that produces recommendations on kidney disease (KDIGO, 2012). There are multiple factors that could affect the reliability of using serum creatinine to estimate GFR, including the increased production of creatinine during exercise. As a result of the limitations of serum creatinine, there is growing use of alternative biomarkers to identify cases of AKI, which may be more reliable and specific to AKI, such as neutrophil gelatinase-associated lipocalin, or NGAL.

D. Experimental Evidence.

Researchers have documented an association between heat strain and biomarkers of AKI in controlled experimental conditions. In 2013, Junglee et al. documented elevations in urine and plasma NGAL and reductions in urine flow rate in participants after a heat stress trial that induced elevations in core temperature and reductions in body mass (an indication of hydration status) (Junglee et al., 2013). These increases in NGAL were higher in an experimental group that underwent a muscle damaging, downhill (-10% gradient) run (compared to a non-muscle damaging run on a 1% gradient) prior to the heat stress trial, providing support for the argument that subclinical rhabdomyolysis may be a pathway from heat stress to kidney injury. Schlader et al. conducted a trial in which participants wearing firefighting gear completed two separate exercise trials in hot conditions of different durations. The longer duration trial was intended to induce higher levels of heat strain, while the shorter duration was intended to induce lower levels (Schlader et al., 2017). The researchers found that the longer trial was associated with elevated core temperature and reduced blood volume, as well as increases in serum creatinine and plasma NGAL, suggesting the magnitude of kidney injury may be proportional to the magnitude of heat strain. McDermott et al. tested longer durations of exercise in the heat (5.7 ± 1.2 hours) and similarly found elevations in serum creatinine and serum NGAL from before the trial to after (McDermott et al., 2018). To determine whether it is elevated core temperature or reduced blood volume that primarily drives heat-induced AKI, Chapman et al. conducted four trials in which subjects exercised for two hours in the same conditions, but received different interventions (water, cooling, water plus cooling, and no intervention) (Chapman et al., 2020). The group with no intervention had the highest levels of urinary AKI biomarkers in the recovery period, whereas the water and cooling groups each experienced reductions in AKI biomarker levels relative to the control group. The researchers concluded that limiting hyperthermia and/or dehydration reduces the risk of AKI.

The relationship between AKI and hyperthermia and/or dehydration has also been demonstrated in animal models (Hope and Tyssebotn 1983; Miyamoto 1994; Roncal-Jiménez et al., 2014; Sato et al., 2019).

E. Cases of Occupational Heat-Related AKI.

In addition to experimental evidence, heat-related AKI has also been observed in "real world" conditions going back to the 1960s. In 1967, Schrier et al. documented evidence of military recruits developing AKI (referred to as "acute renal failure") following training exercises in the heat (Schrier et al., 1967). It was soon after reported that AKI cases linked to exercise in the heat represented a sizeable portion (approximately 10%) of all AKI cases treated at Walter Reed General Hospital in the early 1960s (Schrier et al., 1970).

More recently, serum creatinine-defined AKI has been observed in agricultural workers in both Florida and California. Among a cohort of field workers from the Central Valley of California, Moyce et al. report a post-work shift incidence of AKI of 12.3% (35 of 283 workers) (Moyce et al., 2017). Workers with heat strain, characterized by increased core temperature and heart rate, were significantly more likely to have AKI (OR: 1.34, 95% CI: 1.04, 1.74). Among a cohort of agricultural workers in Florida, Mix et al. found that heat index (based on nearest weather monitor) was positively associated with the risk of AKI - 47% increase in the odds of AKI for every 5°F increase in heat index. The authors reported an incidence of AKI of 33% (i.e., 33% of workers had AKI on at least one day of monitoring) in this study (Mix et al., 2018).

OSHA researchers have also identified cases of heat-related AKI among workers in the agency's own databases: the Severe Injury Reports (SIR) database and case files from consultations by the Office of Occupational Medicine and Nursing (OOMN) (Shi et al., 2022). Shi et al. identified 22 cases of heat-related AKI between 2010 and 2020 in the OOMN consultation records (based on serum creatine elevations meeting the KDIGO requirements) after excluding cases related to severe hyperthermia, multi-organ failure, or death. Using inclusion criteria of a heat-related OIICS code (172*) and a mention of AKI in the narrative, they also identified 57 cases of probable heat-related AKI between 2015 and 2020 in the SIR database.

Studies conducted among workers outside the U.S. have also reported a relationship between working in the heat and acute elevations in serum creatinine or increased risk of AKI (García-Trabanino et al., 2015; Wegman et al., 2018; Nerbass et al., 2019; Sorensen et al., 2019).

There are a few limitations to these observational studies, such as the use of serum creatinine to characterize AKI, as described above. An additional limitation is the inability to determine from these studies whether the AKI observed is due to prerenal or intrarenal causes. As discussed in *Physiological Mechanisms*, prerenal AKI may be due to reductions in renal blood flow (which would be expected in cases of dehydration) and is not necessarily indicative of clinically significant structural injury. Another limitation may be the use of serum creatinine measures taken over relatively short spans of time, which may be too short to see true reductions in GFR (Waikar and Bonventre, 2009). However, there are a growing number of studies that find a relationship between short-term fluctuations in serum creatinine and longer-term declines in kidney function among outdoor workers (see discussion in Section IV.M.IV., Chronic Kidney Disease).

F. Treatment and Recovery.

There is a spectrum of severity for AKI. For example, some individuals may not know they are experiencing AKI without a serum or urine test. There is also a spectrum of time and medical treatment needed for recovery, dependent on whether the AKI is quickly reversed or sustained for longer periods of time. In Schlader et al. 2017, researchers noted that the biomarkers of AKI for participants in their trial returned to baseline the following day. However, intrarenal causes of AKI may require longer periods of time for recovery and may potentially require the need for medication or dialysis (Goyal et al., 2023). AKI can be severe, which can be the case when resulting from heat stroke, where it may represent irreversible damage to the kidneys and can be fatal (Roberts et al., 2008; King et al., 2015; Wu et al., 2021). Recurrent AKI may also lead to chronic kidney disease (as discussed in Section IV.M.IV., Chronic Kidney Disease).

G. Summary.

The available peer-reviewed scientific literature, both experimental and observational studies, suggests that occupational heat exposure causes AKI among workers. However, there are limitations in the case definitions used to define AKI in observational settings.

IV. Chronic Kidney Disease.

A. Introduction.

Chronic kidney disease (CKD) is a progressive disease characterized by a gradual decline in kidney function over months to years. It is typically asymptomatic or mildly symptomatic until later stages of the disease, when symptoms such as edema, weight loss, nausea, and vomiting can occur (NIDDK 2017d). People with CKD can be at a greater risk for other health conditions, like AKI, heart attacks, hypertension, and stroke. The diagnosis typically requires multiple blood and urine tests taken over time (NIDDK 2016). Typical risk factors for CKD include hypertension and diabetes.

Epidemics of CKD in Central America and other pockets of the world, such as India and Sri Lanka, that appear to be afflicting mostly young, outdoor workers with no history of hypertension or diabetes have raised questions about whether working in hot conditions can cause the development of CKD (Johnson et al., 2019). Researchers have been investigating this question and the cause of the epidemic over the past 20 years, including other potential exposures, such as heavy metals, agrichemicals, silica, and infectious agents (Crowe et al., 2020).

B. Physiological Mechanisms.

Researchers have proposed that working in the heat could lead to the development of CKD through repetitive AKI events (see discussion of heat-related mechanisms in Section IV.M.III., Acute Kidney Injury). However, some researchers acknowledge the possibility that the unexplained CKD cases observed in Central America and elsewhere may instead represent a chronic disease process that begins earlier in life which places workers at increased risk of AKI (Johnson et al., 2019; Schlader et al., 2019). Additionally, as discussed above in Section IV.M.III., Acute Kidney Injury, some occupational cases of AKI could be transient, the result of prerenal causes, and possibly unrelated to the development of CKD.

Independent of the epidemic of unexplained CKD, frequent and/or severe AKI has been identified as a risk factor for developing CKD (Ishani et al., 2009; Coca et al., 2012; Chawla et al., 2014; Hsu and Hsu 2016; Heung et al., 2016). The relationship between heat-related AKI and risk of developing CKD is untested in the experimental literature because of the ethical implications (Schlader et al., 2019; Hansson et al., 2020).

As discussed in Section IV.E., Heat Stroke, there is also evidence that experiencing heat stroke may increase an individual's risk of developing CKD (Wang et al., 2019; Tseng et al., 2020).

C. Identifying Cases of Chronic Kidney Disease.

As discussed previously in the context of AKI, serum creatinine is commonly used to estimate glomerular filtration rate (GFR), the indicator of kidney function. When measures of serum creatinine (and therefore estimates of GFR) are taken over periods of months to years, medical professionals can determine if an individual's kidney function is declining. CKD is typically diagnosed when the estimated GFR is below a rate of 60 mL/min/1.73m^2 for at least 3 months, although there are other indicators, like a high albumin-to-creatinine ratio. There are various stages of CKD; the final stage is called end-stage renal disease (ESRD) and represents a point at which the kidneys can no longer function on their own and require dialysis or transplant.

D. Observational Evidence.

There is a growing body of evidence that suggests that heat-exposed workers who experience AKI (or short-term fluctuations in serum creatinine) are at greater risk of experiencing declines in kidney function over a period of months to years. For instance, sugarcane workers in Nicaragua who experienced cross-shift increases (i.e., increase from pre-shift to post-shift) in serum creatinine at the beginning of the harvest season were more likely to experience declines in estimate GFR nine weeks later (Wesseling et al., 2016). Another study conducted among Nicaraguan sugarcane workers found that approximately one third of workers who experienced AKI during the harvest season had newly decreased kidney function (greater than 30% decline) and a measure of estimated GFR of less than 60 mL/min/1.73m2 one year later (Kupferman et al., 2018). In an analysis among Guatemalan sugarcane workers, Dally et al. found that workers with severe fluctuations in serum creatinine over a period of 6 workdays had greater declines in estimated GFR (-20% on average) (Dally et al., 2020). In a separate study conducted in Northwest Mexico, researchers observed declines in estimated GFR among migrant and seasonal farm workers from March to July that were not observed in a reference group of office workers in the same region (López-Gálvez et al., 2021).

Further support for the hypothesis that working in the heat may lead to declines in GFR and increased risk of CKD comes from intervention studies in Central America, in which workers were given water-rest-shade interventions and observed longitudinally for kidney outcomes. In these studies, implementation of the heat stress controls was associated with reductions in the declines in kidney function and reduced rates of kidney injury (Glaser et al., 2020; Wegman et al., 2018).

While much of the literature is focused on Central American workers, OSHA did identify one paper conducted among a cohort of U.S. firefighters. Pinkerton et al. (2022) found lower than expected rates of ESRD in the cohort (relative to the general U.S. population) despite high levels of occupational exposure to heat. However, as the authors point out, this may be due to the healthy worker effect (i.e., a phenomenon in occupational epidemiology by which workers appear to be healthier than the general population due to individuals with health conditions leaving the workforce) (Pinkerton et al., 2022). The authors also examined associations between proxies for heat exposure and risk of developing ESRD and found non-significant associations between the number of exposed days and all-cause ESRD, systemic ESRD, and hypertensive ESRD. Very few of the ESRD cases identified in this cohort were due to interstitial nephritis (which would be most consistent with the CKD cases observed in Central America), limiting the authors' ability to examine associations between those cases and exposure.

There may be differences between the heat-exposed worker populations in Central America and the U.S. that could limit the ability to extrapolate findings from that region, such as differences in other potentially nephrotoxic exposures (e.g., agrichemicals, infectious agents). There is also evidence that children in regions with epidemics of unexplained CKD have signs of kidney injury (Leibler et al., 2021). Unfortunately, surveillance of CKD in the U.S. (namely the U.S. Renal Data System) may be missing cases among susceptible workers, such as migrant agricultural workers, limiting the ability to detect a potential epidemic of heat-related CKD in this country.

In addition to the general lack of studies conducted among U.S. workers, there may be other limitations with these observational studies, such as limited data on longer-term follow-up (i.e., years instead of months) and the potential for reverse causality (i.e., undetected CKD is causing AKI).

E. Treatment and Recovery.

Often kidney disease gets worse over time and function continues to decline as scarring occurs (NIDDK 2017d). As discussed above, late-stage CKD (or ESRD) requires dialysis or a kidney transplant for an individual to survive. Kidney failure is permanent. Having even early-stage CKD may impair workers' urine concentrating ability, which could increase their heat strain and risk of HRIs while working (Petropoulos et al., 2023).

F. Summary.

There is growing evidence suggesting that heat stress and dehydration may be contributing to an epidemic of CKD among workers in Central America and other parts of the world, although the cause is still being investigating by researchers. There is currently limited information as to whether this type of CKD is affecting U.S. workers and if so, to what extent. Experiencing heat stroke has been identified in the literature as a risk factor for developing CKD.

N. Other Health Effects.

I. Introduction.

In addition to the health effects discussed in the previous sub-sections, heat exposures have also been linked to reproductive health effects. Additionally, health effects have been associated with prior episodes of heat illness.

II. Reproductive and developmental health effects.

There is mixed evidence that heat affects reproductive and developmental health outcomes. NIOSH reported two mechanisms by which heat may affect reproductive and developmental health: infertility (e.g., such as through damaged sperm) and teratogenicity (harm to the developing fetus, e.g., spontaneous abortion or birth defects) (NIOSH, 2016). NIOSH concluded that while human data about reproductive risks at exposure limits (see NIOSH, 2016, Table 5-1, p. 70) were limited, results of research and animal experiments support the conclusion heat-related infertility and teratogenicity are possible (NIOSH, 2016, p. 91).

More recent evidence, although also limited, continues to provide support of a reproductive risk to people who are pregnant and developmental risk to their children. Numerous epidemiological studies have reported that heat exposure during pregnancy is associated with poor outcomes, such as pre-term labor and birth and low-birth weight babies (e.g., Kuehn and McCormick, 2017; Basu et al., 2018; Chersich et al., 2020; Rekha et al., 2023). While most studies assess this relationship in the general population of pregnant women and do not specifically address occupational exposures, Rekha et al. show that occupational exposures to heat were associated with adverse pregnancy and fetal outcomes, as well as adverse outcomes during birth in a cohort of pregnant women in Tamil Nadu, India (Rekha et al., 2023). Although the mechanisms for these outcomes are unclear, a study of pregnant women conducting agricultural work or similar activities for their homes in The Gambia reported an association between heat exposure and fetal strain (through measures of fetal heart rate and umbilical artery resistance) (Bonell et al., 2022). Further, a recent longitudinal prospective cohort study in Germany found that heat exposure was associated with vascular changes in the uterine artery. This study reports that changes of increased placental perfusion and decreased peripheral resistance in the uterine artery indicate blood redistribution to the fetus during the body’s response to heat stress. They also report increased maternal cardiovascular strain. This data may support a mechanistic role for uterine and placental blood flow changes during heat exposures in resultant birth outcomes, such as pre-term birth (Yuzen et al., 2023; Bonell et al., 2022).

There is evidence that occupational heat exposures can affect male reproductive health (e.g., Mieusset and Bujan, 1995). Some research studies report associations between occupational heat exposure and time to conceive (e.g., Rachootin and Olsen, 1983; Thonneau et al., 1997), sperm velocity (Figa-Talamanca et al., 1992), and measures of semen quality such as sperm abnormalities (Rachootin and Olsen, 1983; Bonde, 1992; Figa-Talamanca et al., 1992; De Fleurian et al., 2009). Effects of heat on sperm have also been demonstrated in experiments in animal models (Waites, 1991). Cao et al. report that in their study of heat stress in mice, heat stress reduced sperm count and motility (Cao et al., 2023). In this study, the heat exposed mice were exposed to 38°C (100.4°F) temperatures for 2 hours per day for two weeks. When the mice were not being exposed to heat, they were kept at 25°C (77°F). Control mice were kept at 25°C for the duration of the study. Their study results indicate that reduced sperm quality may be a result of disrupted testicular microbial environment and disruption in retinol metabolism that occurs during heat stress. Although, the authors note that the heat exposure does not accurately mimic real world heat exposures in humans.

While it is accepted that heat impairs spermatogenesis, or development of sperm (e.g., MacLeod and Hotchkiss, 1941; Mieusset et al., 1987; Thonneau et al., 1997), some studies of occupational heat exposure find no relationship between heat and semen quality (Eisenberg ML et al., 2015). Another study found observable but not statistically significant associations between heat and semen quality (Jurewicz et al., 2014). Many studies of the effects of occupational heat exposure on reproductive outcomes are cross-sectional in nature and measure exposures through occupation categories or self-report answers on questionnaires (e.g., Figa-Talamanca et al., 1992; Thonneau et al., 1997; Jurewicz et al., 2014). These methods can be susceptible to recall bias and misclassification errors, which can reduce accuracy in characterizing the association between occupational heat exposures and reproductive health outcomes, and they are also unable to determine causality on their own. Additional research that quantifies occupational heat exposures directly (e.g., through measures of heat strain or on-site temperatures) would help to clarify the impacts of occupational heat exposures on male reproductive outcomes.

III. Health effects associated with prior episodes of heat illness.

A limited number of studies have focused on a variety of long-term effects following a prior episode of heat illness. This includes research by Wallace et al., also reviewed by NIOSH in the 2016 *Criteria for a Recommended Standard Occupational Exposure to Heat and Hot Environments*, whose retrospective case control study of military members found that those who experienced an exertional heat illness event earlier in life were more likely to die due to cardiovascular or ischemic heart disease (Wallace et al., 2007). Similarly, Wang et al. reports that, in their retrospective cohort study in Taiwan, prior heat stroke was associated with a higher incidence of acute ischemic stroke, acute myocardial infarction, and an almost three-fold higher incidence of chronic kidney disease compared to patients who had other forms of heat illness or compared to the control group that had no prior heat illness, over the study's 14 year follow-up period (Wang et al., 2019). They also found significantly higher incidence of cardiovascular events, cardiovascular disease, and chronic kidney disease among individuals in the study who had other forms of heat illness (heat syncope, heat cramps, heat exhaustion, heat fatigue, heat edema and other unspecified effects) compared to the control group that had no prior heat illness. In a long-term follow-up study of military personnel who had experienced exertional heat illness, Phinney et al. reported a transient and small but observable increase in the rate of subsequent hospitalizations and decreased retention in the military (Phinney et al., 2001). While these studies suggest a relationship between episodes of serious heat illness and subsequent health effects, this body of research is small and subject to some limitations. The cross-sectional nature of some of these studies does not allow for determination of causality on their own. Additionally, given the retrospective nature of some of these studies it is possible that important confounding variables were not adjusted for in analyses, including occupation in some cases.

IV. Summary.

The description of evidence presented here demonstrates that there is some evidence to support a link between occupational heat exposures and adverse reproductive health outcomes. There is also limited evidence that prior episodes of heat illness may affect health outcomes later in life such as increased risk of cardiovascular disease and kidney diseases. This evidence of reproductive and developmental health effects and health effects associated with prior episodes of heat illness, while suggestive, is still nascent and requires further investigation.

O. Factors that Affect Risk for Heat-Related Health Effects.

I. Introduction.

This section discusses individual risk factors for heat-related injury and illness. The purpose of this discussion is to summarize the factors that may exacerbate the risk of workplace heat-related hazards and to provide information to better inform workers and employers about those hazards. However, exposure to workplace heat contributes to heat stress for all workers and can be detrimental to workers' health and safety regardless of individual risk factors. OSHA is not suggesting that application of the proposed standard would depend on an employer's knowledge or analysis of these factors for their individual workers. Nor do these individual risk factors detract from the causal link between occupational exposure to heat and adverse safety and health outcomes or an employer's obligation to address that occupational risk (see *Reich v. Arcadian Corp.*, 110 F.3d 1192, 1198 (5^{th} Cir. 1997) (Congress intended the Act to protect all employees, "regardless of their individual susceptibilities"); *Pepperidge Farm, Inc.*, 17 O.S.H. Cas. (BNA) ¶ 1993 (O.S.H.R.C. Apr. 26, 1997) (that non-workplace factors may render some workers more susceptible to causal factors does not preclude finding the existence of an occupational hazard); see also *Bldg. & Const. Trades Dep't, AFL-CIO v. Brock*, 838 F.2d 1258, 1265 (D.C. Cir. 1988) (holding that OSHA did not err in including smokers in its analysis of the significant risk posed by occupational exposure to asbestos, despite the "synergistic effects" of smoking and asbestos)). Many factors can influence an individual's risk of developing heat-related health effects. These factors include variation in genetics and physiology, demographic factors, certain co-occurring health conditions or illnesses, acclimatization status, certain medications and substances, and structural factors (e.g., economic, environmental, political and institutional factors) that lead to disproportionate exposures and outcomes. Although there is a lack of evidence that explores the full extent to which these factors interact to affect heat-related health effects, or how various risk factors compare in their impacts, there is evidence that each of these factors can affect risk of heat-related health effects. This section focuses on factors that relate to an individual's health status. For an in-depth discussion on acclimatization as a risk factor, see Section V., Risk Assessment, and for an in-depth discussion on demographic factors and structural factors that affect risk of heat-related illness, see Section VIII.I., Distributional Analysis.

II. Risk Factors.

There are a number of factors that can impact an individual's response to heat stress and lead to variation in heat stress response between individuals. These include variation in genotype (Heled et al., 2004), gene expression (Murray et al., 2022), body mass and differences in thermoregulation between the biological sexes (Notley et al., 2017), differences in thermoregulation as people age (e.g., Pandolf 1997, Kenny et al., 2010; Kenny et al., 2017), and pregnancy (Wells, 2002; NIOSH, 2016). Normal variation across individuals in genetics, physiology, and body mass results in variation in how individuals respond to heat stress. There is some evidence that, at least in some specific populations, variation in genotype (i.e., genetic makeup) can affect heat storage and heat strain (Heled et al., 2004; Gardner et al., 2020). Normal variation in body mass can also correspond to variation in thermoregulation between individuals (e.g., Havenith et al., 1998). Results from Havenith et al.'s experimental study of heat stress under different climate and exercise types indicates that one reason for this effect may be due to the relationship between size and surface area of the skin which plays an important role in cooling capacity (Havenith et al., 1998). A more detailed discussion of the relationship between obesity and heat stress response can be found below.

There is some evidence that biological sex could be considered a risk factor for heat-related illness, although the evidence is mixed. Some studies find differences in heat stress response between males and females (e.g., Gagnon et al., 2008; Gagnon and Kenny, 2011; Gagnon and Kenny, 2012). These differences may be due to differences in body mass (Notley et al., 2017), lower sweat output in females or differences in metabolic heat production (Gagnon et al., 2008; Gagnon and Kenny, 2012). However, recent experimental data assessing differences in thermoeffector responses (autonomic responses that affect thermoregulation, such as skin blood flow and sweat rate) between males and females exposed to exercise show that differences between the sexes in heat stress response are mostly explained by differences in morphology (body shape and size and the resultant mass-surface ratios) (Notley et al., 2017). Although, Notley et al.'s (2017) experiment only involved heat environments where enough heat could be lost so that the body does not continue to gain heat (compensable heat stress), so it is unclear if an increased effect due to biological sex would occur in conditions where heat gain is expected, such as in occupational settings where environmental heat or environmental heat and exertion exceed the body's ability to cool.

Healthy aging processes can also make individuals more susceptible to heat-related illness. Aging may impact thermoregulation through reduced cardiovascular capacity (Minson et al., 1998; Lucas et al., 2015), reduced cutaneous vasodilation (the widening of blood vessels at the skin to aid heat loss), sweat rate, altered sensory function (Dufour and Candas, 2007; Wong and Hollowed, 2017), and changes in fluid balance and thirst sensation (Pandolf, 1997). Observational evidence tends to show that elderly individuals, particularly those with co-existing chronic or acute diseases, are at highest risk for morbidity or mortality related to heat exposures, and that risk increases with age (e.g., Semenza et al., 1999; Fouillet et al., 2006; Knowlton et al., 2008). However, experimental evidence shows that, under certain conditions, when individuals are matched for fitness level and body build and composition, middle-aged individuals can compensate for heat exposures similarly to younger adults (Lind et al., 1970; Pandolf, 1997, Kenny et al., 2017). Conversely, observational studies of occupational populations often find that younger workers experience greater rates of heat-related illness than do older workers (e.g., Harduar Morano et al., 2015; Hesketh et al., 2020; Heinzerling et al., 2020). While it is unclear why younger workers appear to have greater rates of heat-related illness in epidemiological data, Heinzerling et al. (2020) suggest that this could be a result of a greater number of younger workers being employed in high-risk occupations. Further, younger workers have less work experience, meaning that younger workers are less familiar with the heat risks associated with their jobs, how their body responds to heat, and/or how to respond if they experience symptoms of heat-related illness.

Health status is another factor that plays a role in how someone responds to heat stress (e.g., Semenza et al., 1999; Knowlton et al., 2008; NIOSH, 2016; Vaidyanathan et al., 2019, 2020). Conditions such as cardiovascular disease and diabetes can affect risk of heat-related illness (e.g., Kenny et al., 2016; Kenny et al., 2018). The cardiovascular system plays an integral role in thermoregulation and heat stress response (Costrini et al., 1979; Lucas et al., 2015; Wong and Hollowed, 2017; Kenny et al., 2018). Cardiovascular diseases can affect the heart and blood vessels, increasing cardiovascular strain and decreasing cardiovascular function and thermoregulatory capacity (Kenny et al., 2010) and, as a result, increase risk of heat-related illness during heat stress (Kenny et al., 2010; Semenza et al., 1999). For example, people with hypertension (i.e., high blood pressure) may be at increased risk of heat-related illness due to changes in skin blood flow that can impair heat dissipation during heat stress (Kenny et al., 2010). Further, many individuals with hypertension and cardiovascular diseases may take prescription medications that reduce thermoregulatory functions, through mechanisms like reduced blood flow to the skin, which can increase sensitivity to heat (Wee et al., 2023). Studies estimate that a substantial percentage of the population, and therefore the population of workers, have the type of health status (i.e., having a chronic condition such as cardiovascular diseases) (Boersma et al., 2020; Watson et al., 2022) that could affect their response to heat stress. For example, Watson et al. (2022) estimate that of the 46,781 surveyed adults between the ages of 18 and 34 who reported being employed, 26.1% have obesity, 11% have high blood pressure, and 9.7% have high cholesterol. Additionally, 19.4 % were estimated to have depression, which is sometimes treated with medications that can affect thermoregulation.

Diabetes and obesity are other factors that may affect risk of developing heat-related illness (Kenny et al., 2016). Both diabetes and obesity may affect thermoregulation by reducing a person's ability to dissipate heat through changes in skin blood flow and sweat response (Kenny et al., 2016). While some evidence shows that individuals with well-controlled diabetes may be able to maintain normal thermoregulatory capacity (Kenny et al., 2016), some evidence indicates that individuals with poorly controlled diabetes (Kenny et al., 2016) or older individuals with Type 2 diabetes (Notley et al., 2021) may experience decreased heat tolerance. Obesity has also been identified as a risk factor for exertional heat illness in the military (e.g., Bedno et al., 2014; Nelson et al., 2018b; Alele et al., 2020). Gardner et al. (1996) reported increasing risk of exertional heat illness among male Marine Corps recruits as BMI increased. Additionally, a smaller body mass to surface area ratio can reduce capacity for heat loss since surface area is relatively smaller in relationship to mass (Bar-Or et al., 1969; Kenny et al., 2016). Differences in tissue properties between adipose (fat) tissue and other body tissues may indicate that a higher body fat mass can lead to greater rises in core temperature for a given amount of heat storage in the body (Kenny et al., 2016).

Beyond chronic health conditions, prior episodes of significant heat-related illness and recent or concurrent acute illness or infection may also affect an individual's response to heat stress and increase the risk of heat-related illness (e.g., Carter et al., 2007; Nelson et al., 2018a; Nelson et al., 2018b; Alele et al., 2020). Reviews of research and case studies of heat-related illness indicate that acute illnesses that may affect risk of heat-related illness include upper respiratory infections and gastrointestinal infections (Casa et al., 2012; Alele et al., 2020). However, statistical evidence is limited (Alele et al., 2020). Leon and Kenefick (2012) discuss results from a study of four marine recruits who presented with exertional heat illness and who also had an acute illness separate from heat-related illness. The recruits' blood tests showed elevated levels of immune-related substances which Leon and Kenefick identify as being substances that are both mediators of viral infection symptoms and substances associated with exertional heat illness. Leon and Kenefick interpret this observation, along with evidence from a study on rats that showed that bacteria exposure exacerbated inflammation and organ dysfunction due to heat stress, to suggest that pre-existing inflammatory states, such as those that occur with acute viral illness, compromise the ability to thermoregulate appropriately (Carter et al., 2007; Leon and Kenefick, 2012) (see also Bouchama and Knochel, 2002). Several studies in military populations also show that a prior heat illness may increase risk of a future episode of heat illness (Nelson et al., 2018b; Alele et al., 2020). Assessments of heat and epigenetics (the study of how the environment and behavior affects genes) suggest that the complex physiological responses to heat impact genetic mechanisms that could play a role in increasing susceptibility to future heat illness following an episode of heat illness (Sonna et al., 2004; Murray et al., 2022).

Certain medications can also affect thermoregulation and risk of heat-related illness. Medications that may decrease thermoregulatory capability include medications that treat cardiovascular diseases, diabetes, neuropsychiatric diseases, neurological diseases, and cancer (Wee et al., 2023). Some of these medications affect thermoregulation by directly affecting the region of the brain that controls thermoregulation or through other central nervous system effects (e.g., antipsychotics, dopaminergics, opioids, amphetamines) (Cuddy, 2004; Stollberger et al., 2009; Musselman and Saely, 2013; Gessel and Lin, 2020; Wee et al., 2023). Other medications affect thermoregulation through effects on heat dissipation that occur due to changes in sweat response and/or blood flow to the skin (e.g., anticholinergics, antihypertensives, antiplatelets, some antidepressants and antihistamines, aspirin) (see, e.g., Freund et al., 1987; Cuddy, 2004; Stollberger et al., 2009; Wee et al., 2023; CDC, 2024b). There are also medications that may affect ability to perceive heat and exertion (e.g., dopaminergics) (Wee et al., 2023). Some medications can affect electrolyte balances (e.g., diuretics, beta-blockers, calcium channel blockers, and antacids) (CDC, 2024b). When accompanied by dehydration, some medications also pose a toxicity risk (e.g., apixaban, lithium, carbamazepine) (CDC, 2024b). Finally, some medications can affect fluid volume, kidney function, hydration status, thirst perception, or cardiac output (e.g., diuretics, ACE inhibitors, some anti-diabetics, beta-blockers, non-steroidal anti-inflammatories (NSAIDs), tricyclic antidepressants, laxatives, and antihistamines) (Stollberger et al., 2009; Wee et al., 2023; CDC, 2024b). The NIOSH *Criteria for a Recommended Standard for Occupational Exposure to Heat and Hot Environments* (Table 4-2), the Department of the Army's Technical Bulletin 507 (Table 4-2), and CDC's *Heat and Medications – Guidance for Clinicians* contain additional information about classes of medications and the proposed mechanisms for how they affect thermoregulation (NIOSH, 2016; Department of the Army, 2022; CDC, 2024b).

Medications that can affect how individuals respond to heat are used by a significant portion of the U.S. population. Survey data from the National Health and Nutrition Examination Survey from 2015-2016 showed that 60% of adults aged 40-79 used a prescription medication within the last thirty days and approximately 22% of adults in that same age range took five or more prescription medications (Hales et al., 2019). Many of the medications reported by survey respondents are medications that can affect an individual's response to heat (e.g., commonly used blood pressure and diabetes medications).

Amphetamines (whether prescription or illicit), methamphetamines, and cocaine can also affect thermoregulation and increase risk of heat-related illness (NIOSH, 2016; Department of the Army, 2022). These substances can affect the central nervous system's thermoregulatory functions, stimulate heat generation, and reduce heat dissipation through vasoconstriction (Cuddy, 2004). The synergy between the hyperthermia induced by these substances, physical activity, and heat exposure can increase risk of heat-related illness (Kiyatkin and Sharma, 2009). Analyses of occupational heat-related fatalities find amphetamines and methamphetamines to be an important risk factor (Tustin et al., 2018a, Karasick et al., 2020; Lin et al., 2023). In Lin et al.'s 2023 review of heat-related hospitalizations and fatalities documented through NIOSH *Fatalities in Oil and Gas Database* (2014-2019) and OSHA's Severe Injury Report Database (2015-2021), 50% of identified fatalities occurred in workers that had tested positive for amphetamines or methamphetamines after they died. However, small sample sizes, sampling strategies, and incomplete data have so far limited the ability of studies to fully characterize the association between these substances and risk of heat-related illness or fatality. Poor data quality or limited data has also limited current studies from concluding if and when amphetamine-like substances are from prescription or non-prescription use.

Alcohol and caffeine use may also affect risk of heat-related illness through effects on hydration status and heat tolerance (NIOSH, 2016; Tustin, 2018; Department of the Army, 2022). There have been cases of fatalities due to occupational heat exposure in individuals with a history of “alcohol abuse or high-risk drinking” (Tustin et al., 2018a, p. e385). Both alcohol and caffeine may affect how someone responds to heat stress due to their ability to cause loss of fluids and subsequently dehydration, and alcohol also affects central nervous system function (NIOSH, 2016). In the case of caffeine, it appears that moderate consumption associated with normally caffeinated beverages (e.g., one cup of coffee, tea, soda) may not interfere with thermoregulation in a way that negatively affects response to heat stress (NIOSH, 2016; Kazman et al., 2020; Department of the Army, 2022). However, heavily caffeinated beverages, such as energy drinks, have been linked to negative health outcomes (Costantino et al., 2023) and could potentially exacerbate heat stress through diuretic (salt and water loss) mechanisms and cardiovascular strain (NIOSH, 2016). Overall, there is a lack of robust data that quantify the specific amounts of alcohol or caffeine that are problematic for heat stress response. However, experts generally advise against drinking alcohol or caffeinated beverages before or during work or exercise in the heat (NIOSH, 2016; Department of the Army, 2022; CDC, 2022).

III. Summary.

The evidence presented in this section demonstrates that there are numerous factors that can affect risk of heat-related illness (e.g., genetics, age, body mass, some chronic conditions, prescription medications and drugs). Because prevalence data show that a majority of working-age adults live with or experience at least one risk factor, these factors should be considered an important component of understanding how individuals can be at increased risk for heat-related illness. OSHA acknowledges, however, that for most of the described risk factors, the evidence is not robust enough to determine the full picture of how the factor impacts risk of heat-related illness or to establish the degree to which the risk factor contributes to overall risk of developing heat-related illness. There is also a lack of evidence evaluating the way in which multiple risk factors combine to affect risk of heat-related health outcomes.

P. Heat-Related Injuries.

I. Introduction.

In addition to heat-related illnesses, heat exposure can lead to a range of occupational heat-related injuries. A heat-related injury means an injury, such as a fall or cut, that is linked to heat exposure. A heat-related injury may occur as a result of a heat-related illness, such as a fracture following heat syncope. The association between heat exposure and heat-related injury among workers has been well documented over the last decade (Tawatsupa et al., 2013; Xiang et al., 2014b; Adam-Poupart et al., 2015; Spector et al., 2016; McInnes et al., 2017; Calkins et al., 2019; Dillender, 2021; Dally et al., 2020; Park et al., 2021; Negrusa et al., 2024). In particular, analyses of workers' compensation claim data has demonstrated the increased risk of occupational traumatic injury with increasing heat exposure (Xiang et al., 2014b; Adam-Poupart et al., 2015; Spector et al., 2016; McInnes et al., 2017; Calkins et al., 2019; Dillender, 2021; Park et al., 2021; Negrusa et al., 2024). These types of heat-related injuries can cause hospitalizations, extended time out of work, and reduced productivity. In some instances, a heat-related injury may be fatal, like in the event of accidents such as a slip, trip, or fall. In 1972, NIOSH identified occupational heat exposure as contributing to workplace injuries, and discussed how accidents and injuries were outcomes that could be prevented by a heat stress standard (NIOSH, 1972). Specifically, NIOSH highlighted how reduced physical and psychological performance, fatigue, accuracy of response, psychomotor performance, sweaty palms, and impaired vision may result in a workplace heat-related injury.

Since multiple types of injuries can be heat-related (e.g., strain, fracture, crushing) and the mechanisms underlying those injuries vary (e.g., impaired speed and reaction time, impaired vision, impaired dexterity), the identification and classification of heat-related injuries varies on a case-by-case basis. Although there are no ICD or OIICS codes specific to diagnosing heat-related injuries, medical professionals and occupational health professionals can combine a heat-related illness code with other injury related codes to indicate an injury is heat-related. An injury specifically attributed to heat would be expected to be assigned both a heat-related OIICS or ICD code and an injury OIICS or ICD code. Numerous researchers have used ICD and OIICS code to conduct studies on heat-related injuries (Dillender, 2021; Garzon-Villalba et al., 2016; Morabito et al., 2006; Spector et al., 2016).

This section first presents the epidemiological evidence of increasing occupational injuries during periods of hotter temperatures, followed by a discussion of mechanisms that can lead to heat-related injuries.

II. Occupational Heat-Related Injuries.

A multitude of studies have identified an association between heat exposure and occupational injury in the U.S. (Knapik et al., 2002; Fogleman et al., 2005; Garzon-Villalba et al., 2016; Spector et al., 2016; Calkins et al., 2019; Dillender, 2021; Park et al., 2021; Negrusa et al., 2024). These analyses primarily rely on workers' compensation claim data and meteorological data and are often case-crossover or observational time-series in design.

In two studies of outdoor agricultural workers (Spector et al., 2016) and outdoor construction workers (Calkins et al., 2019) in Washington state, traumatic injury claims were significantly associated with heat exposure. Among outdoor agricultural workers (n=12,213 claims), Spector et al. (2016) found a statistically significant increased risk of traumatic injuries at a daily maximum humidex (the apparent, or "feels like," temperature calculated from air temperature and dew point, similar to heat index) above 25°C (77°F). Among outdoor construction workers (n=63,720 claims), Calkins et al. (2019) found an almost linear statistically significant association between traumatic injury risk and humidex. Both studies reported that injuries most commonly resulted from falls or bodily reaction and exertion, which may include sudden occurrences of strains, sprains, fractures, or loss of balance, among others (Spector et al., 2016; Calkins et al., 2019).

Using workers' compensation claim data from Texas, Dillender (2021) found that hotter temperatures resulted in larger percent increases in traumatic injuries among two similar sets of injury types, "open wounds, crushing injuries, and factures" and "sprains, strains, bruises, and muscle issues." Park et al. (2021) examined over 11 million workers' compensation records in California and estimated that approximately 20,000 additional injuries per year between 2001 and 2018 were related to hotter temperatures. In comparison to a day with temperatures in the 60s°F, the risk of occupational heat-related injury increased by 5-7% ($p<0.05$) and 10-15% ($p<0.05$) on days with high temperatures between 85-90°F and above 100°F, respectively (Park et al., 2021).

In these case-crossover studies, cases serve as their own controls, allowing for variables such as age, sex, race, and ethnicity, as well as other known and unknown time-invariant confounders to be controlled. However, there are still some limitations to these studies, such as the potential for time-varying confounders (e.g., air pollutants like ozone and sleep duration influenced by nighttime temperatures).

Studies conducted among workers outside the U.S. have also reported a relationship between working in the heat and increased risk of injuries (Morabito et al., 2006; Tawatsupa et al., 2013; Adam-Poupart et al., 2015; McInnes et al., 2017; Martinez-Solanas et al., 2018). Analyses from Dally et al. (2020), found an increase in injury risk with increasing average daily mean WBGT above 30°C (86°F) among sugarcane harvesters in Guatemala; although this result was not statistically significant, this may have been due to small sample and event size.

III. Mechanisms.

Heat exposure can impair workers' psychomotor and mental performance, which can interfere with routine occupational tasks. Consequently, the risk of work-related injuries, including slips, trips, and falls, as well as cuts and other traumatic injuries, is exacerbated when job tasks are performed in hot environments. As summarized in the prior health effects sections of this preamble, heat can impair a variety of physiological systems and produce a range of symptoms. Changes in the cardiorespiratory, locomotor, and nervous systems due to heat exposure can induce various bodily responses such as fatigue, which may lead to injury (Ross et al., 2016). Changes from elevated skin and core body temperatures, which may result in increased sweating and dehydration, can cause decrements in physical, visuomotor, psychomotor, and cognitive performance (Grandjean and Grandjean, 2007; Lieberman, 2007). Even experiencing a high level of heat sensation may contribute to discomfort and distress, causing distraction and other behavioral changes that can result in accidents and injuries (Simmons et al., 2008). An explanation of how heat exposure can impair psychomotor and mental performance, and consequently lead to occupational heat-related injuries is provided below.

A. Impaired Psychomotor Performance.

Heat exposure can impair psychomotor function (i.e., the connection between mental and muscle functions) which may cause heat-related injuries. Impaired psychomotor function from heat exposure can take multiple forms, including impaired movement, strength, or coordination (fatigue); impaired postural stability and balance; and impaired accuracy, speed, and reaction time. Each of these impairments to psychomotor performance are discussed in turn below.

I. Impaired Movement, Strength, or Coordination (Fatigue).

Heat exposure can hamper psychomotor performance by impairing workers' movement, strength, or coordination and causing fatigue. Fatigue has been described as having a lack of energy or a feeling of weariness or tiredness (NIOSH, 2023b). Effects from heat strain on the cardiorespiratory and locomotor systems can cause both central and peripheral fatigue due to increased heat storage at the brain and muscle levels, along with other physiological mechanisms (Ross et al., 2016). As an individual's metabolic rate increases in hot environments, blood pH level may become more acidic and cause muscle fatigue from increased muscle glycogen degradation, lactate accumulation, and elevated carbohydrate metabolism (Varghese et al., 2018). These changes have been shown to compromise performance.

Numerous studies demonstrate the relationship between heat exposure and fatigue. In a cross-sectional survey of 256 occupational health and safety professionals in Australia, fatigue was the most reported incident in workers during higher temperatures (Varghese et al., 2020). Among two groups of 55 steel plant workers who completed a questionnaire assessing fatigue, the group of workers exposed to hotter environments (30 – 33.2°C (80 – 91.76 °F) WBGT) were significantly more likely to report symptoms of fatigue in comparison to workers in cooler environments (25.4-28.7°C (77.7–83.6°F)

WBGT) (Chen et al., 2003). This study highlights how fatigue symptoms increase with rising heat exposure levels (Chen et al., 2003).

Moreover, in a review of 55 studies on workplace heat exposure, core temperature elevation and dehydration have been shown to have numerous negative behavioral effects including fatigue, lethargy, and impaired coordination, which may lead to injury (Xiang et al., 2014a). These 55 articles included ecological (22%), cross-sectional (64%), and cohort (5%) studies, as well as epidemiological experiments (9%). From one study included in the review, 42% of construction workers surveyed reported it was "easy to get fatigued" while working in the summer (Inaba and Mirbod, 2007). In another review of heat stress risks in the construction industry, Rowlinson et al. (2014) also discussed the association of high temperatures and level of fatigue, which has been considered one of the critical factors leading to construction accidents (Garrett and Teizer, 2009; Chan, 2011). In a case study of 15 workers who experienced fatigue-related accidents, fatigue was shown to trigger other safety risks, such as not following proper safety procedures or becoming distracted, which can induce injury (Chan, 2011).

II. Impaired Postural Stability and Balance.

Heat exposure has also been shown to impair postural stability and balance as increases in metabolic heat can impact workers' gross motor capacity (i.e., the ability to move the body with appropriate sequencing and timing to perform bodily movements with refined control), including postural balance. As individuals become dehydrated, they may experience negative neuromuscular effects. Distefano et al. (2013) demonstrated the detrimental impact of dehydration during task performance in hot conditions, where subjects experienced decreased neuromuscular control as characterized by poorer postural stability. The authors found that neuromuscular control was impaired while participants were hypohydrated (defined as uncompensated loss of body water) and hyperthermic. Additionally, when an individual is experiencing high-intensity exertion in hot environments and is already dehydrated, this can result in further dilution of blood sodium. When blood sodium is diluted, water may be forced from the extracellular compartment into the intracellular compartment, which could lead to pulmonary congestion, brain swelling, and heat stroke (Distefano et al., 2013). At this stage, neurons begin degenerating in the cerebellum and cerebral cortex, and this process coupled with the rise in body temperature, impairs central nervous system functionality (Sawka et al., 2011; Nybo, 2007; Distefano et al., 2013).

Research also indicates that performing exertional activities in a hot environment may impair balance. To better understand lower extremity biomechanics, Distefano et al. (2013) used an assessment tool to measure gross movement errors, such as medial knee displacement, hip or knee rotation, and limited sagittal plane (front to back) motion. The authors found that after performing the exercise protocol, participants demonstrated poorer movement technique when they were hypohydrated in a hot environment compared with when they were hypohydrated in a temperate environment or in a hot environment but euhydrated (state of optimal total body water content) (Distefano et al., 2013). These findings suggest that working in hot temperatures while dehydrated may increase risk for injury due to impaired balance (Distefano et al., 2013).

III. Impaired Performance in Accuracy, Speed, and Reaction Time.

The compromising effects of heat strain on psychomotor function have long been established, but the level of performance deterioration is dependent on the severity of heat strain and the complexity of the task (Taylor et al., 2016; Hancock, 1986; Ramsey, 1995; Pilcher et al., 2002; Hancock and Vasmatzidis, 2003). Some research has found that when high skin and core temperatures increase cardiovascular strain, heat exposure results in faster reaction times where individuals respond more quickly, but less accurately when in the heat (Simmons et al., 2008). Other research, such as Mazloumi et al. (2014), found that heat stress conditions impair selective attention (the ability to select and focus on a particular task while simultaneously ignoring other stimuli) and reaction time. In their study of 70 workers in Iran, where half of the workers experienced heat stress and half worked in air-conditioning, the authors found impaired psychomotor function among the exposed workers indicated through an increase in the duration of a task and response time as well as an increase in the number of errors (Mazloumi et al., 2014).

Additional studies examine the impacts of high skin and core temperatures on psychomotor function contributing to more mistakes (Allan and Gibson, 1979; Gibson and Allan, 1979; Gibson et al., 1980). In one study of foundry workers, response time, reaction time, and number of errors were reported to be adversely affected when workers were exposed to WBGTs of 31-35°C (87.8-95°F) compared to unexposed workers in a WBGT of 17°C (62.6°F) (Mazlomi et al., 2017). A meta-analysis review of 23 studies supports these conclusions, finding that under hot conditions, performance on mathematical-related tasks and reaction time tasks can be negatively impacted at 32.2°C (89.9°F) with a roughly 15% average decrement in performance (Pilcher et al., 2002).

Pyschomotor performance is an important factor when considering job tasks that require precision and concentration to prevent injuries. In a study observing steel plant workers, it was found that electrical arc melting workers who were exposed to hotter environments (30-33.2°C WBGT) experienced a significant decrease in their attention span and slower response time compared to the continuous cast workers, who worked in cooler environments (25.4-28.7°C WBGT) (Chen et al., 2003). A decline in psychomotor function could also negatively affect speed of response, reasoning ability, associative learning, mental alertness, and visual perception, which has been reported as a key cause of fatal accidents (Rowlinson et al., 2014).

B. Impaired Mental Performance.

The effects of heat exposure on mental performance can also play a significant role in increasing workplace accidents and injuries and compromise workplace safety. Heat exposure can result in impaired cognition or cognitive performance; impaired visual motor tracking; and impaired decision-making or judgment, which can lead to unsafe behaviors (like the removal of required PPE). Each of these are discussed in turn below.

I. Impaired Cognition or Cognitive Performance.

Declines in cognitive function from heat are correlated with an elevated risk of injury. Evidence indicates a statistically significant increase in unsafe behaviors above 23°C WBGT and an increased risk of accidents (Ramsey et al., 1983). When an individual experiences hyperthermia, even if it is mild and only occurring for a short period, the central nervous system is vulnerable to damage (Hancock and Vasmatzidis, 2003). This can acutely affect memory, attention, and ability to process information (Walter and Carraretto, 2016). When hyperthermia triggers cerebral damage, these cerebral injuries can be characterized into three broad areas. The first area includes cellular effects (where cells are damaged as temperatures continue to rise and normal cell function is disrupted and cell replication is no longer possible). The second area includes local effects (like inflammatory changes and vascular damage), and the third area includes systemic changes (like changes in cerebral blood flow (Walter and Carraretto, 2016). These negative effects are typically seen when core body temperatures reach 40°C (104°F), although some changes can begin at temperatures of 38°C (100.4°F) (Walter and Carraretto, 2016). These physiological changes also negatively impact cognitive performance.

Heat exposure has been shown to affect cognitive performance differentially, based on type of cognitive task (Yeoman et al., 2022). The more complex a task, especially if it requires motor accuracy, the more likely an individual's cognitive ability to perform the task will decline because of heat stress (Hancock and Vasmatzidis, 2003). Some research indicates a decrease in cognitive performance for tasks requiring more perceptual motor skills will be observed in the 30-33°C (80-91.4°F) range, well before the physiological system reaches its tolerance limit (Ramsey and Kwon, 1992; Hancock and Vasmatzidis, 2003; Piil et al., 2017). Ramsey and Kwon (1992) have summarized over 150 studies looking at task exposure time and task type and found statistically significant performance decrements at the 30-33°C (80-91.4°F) range. The decrements at this range occurred regardless of duration of exposure (from short exposures under 30 minutes and longer exposures up to 8 hours) (Ramsey and Kwon, 1992). Furthermore, in a case study of nine male volunteers, results indicate that highly motivated subjects were strongly affected by heat load within the first two hours of exposure, and that these subjects' performance was significantly impaired when assigned complex tasks requiring a significant amount of reasoning and judgment (Epstein et al., 1980). The authors found that performance began to decrease when workers were exposed to temperatures above 27°C (80.6°F).

Moreover, in a review of fifteen laboratory experiments assessing the effects of high ambient temperature on mental performance, one study found that mental performance declines were statistically significant at exposure durations of four consecutive hours in 87°F (30.55°C) temperatures (Wing, 1965). Similarly, in a study of the effects of hot-humid and hot-dry environments on mental functioning, 25 participants were exposed to a variety of temperatures in humid and dry conditions, while performing physical exercises with bouts of rest, to assess mental alertness, associative learning, reasoning ability and dual-performance efficiency (Sharma et al., 1983). The authors found that all the psychological functions tested were adversely affected under heat stress, and that a significant drop in various psychological functions was seen at temperatures of 32.2°C (89.9°F) and 33.3°C (91.9°F) in hot-humid and hot-dry conditions, respectively. Moreover, the authors suggest that, for heat-acclimatized subjects who continuously work for four hours, that the temperature should not exceed

31.1 °C (87.9°F) in hot and humid conditions, and 32.2°C (89.9°F) for workers in hot desert conditions (Sharma et al., 1983).

II. Impaired Visual-Motor Tracking.

Hyperthermia and dehydration, a common symptom of heat exposure, have been found to impair visual-motor tracking (i.e., the eyes' ability to focus on and follow an object), increasing the risk of workplace injury. In a review of studies on hydration and cognition, the authors indicate that a 2% or more loss of body weight due to dehydration from heat and exercise can result in significant reduction in visual-motor tracking (Lieberman, 2007). In an experimental study assessing performance in complex motor tasks in hyperthermic humans (Piil et al., 2017), the authors found that visual-motor tracking performance was reduced following exercise-induced hyperthermia. Participants were exposed to hot (40°C (104°F)) and control (20°C (68°F)) conditions. At baseline, and after exercise, participants completed simple and complex motor tasks, which included visual tracking assessment. The authors concluded that visual-motor tracking is impaired by hyperthermia, and especially so when multiple tasks are combined (Piil et al., 2017).

III. Impaired Decision-making or Judgment.

Heat exposure has been found to affect decision-making or judgment amongst workers, increasing the risk of injury. In a review of ecological, cross-sectional, and cohort studies, as well as epidemiological experiments, Xiang, et al. indicate that core temperature elevation and dehydration impair judgment and concentration (Xiang, et al., 2014a). In a study analyzing over 17,000 observations of unsafe behavioral acts (e.g.

mishandling tools, equipment, or materials) in two industrial facilities with varying temperature conditions, authors found that unsafe behavioral acts decreased within the zone of preferred temperature (approximately 17°C (62.6°F) to 23°C (73.4°F), WBGT) and increased outside of this zone (when the temperature was equal to or less than 17°C WBGT or equal to or greater than 23°C WBGT) (Ramsey et al., 1983). This study indicates that the risk of unsafe behavioral acts may increase when the temperature increases.

C. Other Factors Contributing to Heat-Related Injury.

In addition to psychomotor and mental impairments that can result from heat exposure, other mechanisms may also contribute to heat-related injuries. The purpose of this section is to summarize some additional factors that may exacerbate the risk of workplace heat-related injuries and to provide information to better inform workers and employers about those hazards.

PPE is another factor that plays a role in increasing susceptibility to a heat-related injury given that some PPE insolates the body and reduces evaporative cooling capacity. For instance, research among firefighters finds that a self-contained breathing apparatus can lead to heat buildup and can impact postural stability and balance (Hur et al., 2015; Hur et al., 2013; Games et al., 2020; Mani et al., 2013; Ross, 2016). Other examples of PPE that may result in heat stress, and therefore increase the risk of heat-related injuries, include reflective vests that are made of water impermeable material that block effective heat dissipation and safety helmets with no ventilation that can raise the temperature inside the helmet. In one case, the air temperature inside a worker’s helmet (57°C

(134.6°F)) was measured to be over 20°C hotter than the environmental temperature (33°C (91.4°F)) they were working in (Rowlinson et al., 2014). The authors found that workers will often remove helmets in these situations to alleviate heat stress, exposing them to other workplace hazards (e.g., falling objects) (Rowlinson et al., 2014). Other research by Karthick et al. (2023) found that in hot weather conditions, physical health challenges, specifically major accidents at the job site, minor injuries, physical fatigue, excessive sweating, and dermatological problems were found to be significant based on a workers' clothing comfort. The authors highlighted how PPE can make workers feel uncomfortable, and when combined with extremely hot weather, it creates fatigue which may increase the number of workplace injuries and accidents (Karthick et al., 2023).

There is also evidence indicating heat exposure can contribute to impaired vision, which may lead to workplace injuries. For example, fogged safety glasses or sweat in eyes due to heat exposure can reduce workers' visibility, creating additional hazards and increasing risk of injury (NIOSH, 2016). Individual case studies also report issues with protective eyewear in hot temperatures, noting the uncomfortable feeling of the eyewear under heat and in sunlight as well as difficulty seeing through the glasses (Choudhry and Fang, 2008). In a survey conducted among occupational health and safety professionals in Australia, one of the most frequently cited causes of heat-related injuries was from "impaired vision due to fogged safety glasses (39%)" (Varghese et al., 2020). Injuries resulting from impaired vision may include manual handling (musculoskeletal injuries), joint/ligament injuries, hand injuries, wounds or lacerations, burns, head or neck injuries, motor vehicle accidents, eye injuries, or fractures (Varghese et al., 2020).

When exposed to heat, workers may also experience impaired dexterity (or fine motor skills) leading to workplace injuries. For example, sweaty palms and hands due to heat exposure can reduce workers' ability to handle tools or other work-related materials, increasing the risk of injury. Occupational health and safety professionals have reported losing control of tools as one of the most common causes for heat-related injuries (Varghese et al., 2020). Researchers have also found sweaty palms to increase the risk of workplace injuries (Shulte et al., 2016).

IV. Summary.

The scientific and mechanistic data and association studies on heat-related injuries summarized in this section demonstrate that heat-related injuries are a recognized health effect of occupational heat exposure. While the types of heat-related injuries can be broad, the scientific community recognizes that heat exposure can diminish the body's senses through various mechanisms like impaired psychomotor performance (e.g., fatigue, impaired balance, or impaired dexterity), and impaired mental performance (e.g., impaired cognition or vision) which can result in various types of injuries. The best available evidence demonstrates that heat-related injuries can have serious adverse effects on worker safety and health.

Q. Requests for Comments.

OSHA requests information and comments on the following question and requests that stakeholders provide any relevant data, information, or additional studies (or citations) supporting their view, and explain the reasoning for including such studies:

- Has OSHA adequately identified and documented the studies and other information relevant to its conclusions regarding heat-related health effects, and are there additional studies OSHA should consider?

V. Risk Assessment

A. Risk Assessment.

I. Introduction.

In this risk assessment, OSHA relied on surveillance data of occupational heat-related fatalities and non-fatal injuries and illnesses reported by the Bureau of Labor Statistics (BLS). Additionally, OSHA relied on annual incidence estimates derived from state workers' compensation systems and hospital discharge datasets. These estimates were calculated and reported in a variety of sources, such as reports from state health departments, as well as the peer-reviewed scientific literature. OSHA has preliminarily concluded that inclusion criteria for HRIs in these data sources (days away from work, workers' compensation claim, emergency department visit, or inpatient hospitalization) demonstrate that the HRIs are a material impairment of health, thus making these data sources relevant to OSHA's determination of significant risk.

OSHA has previously relied on such injury, illness, and death data to demonstrate the extent of risk (see, e.g., Fall Protection, 81 FR 82494 (2016); Working Conditions in Shipyards, 76 FR 24576 (2011); Permit-Required Confined Spaces, 58 FR 4462, 4465 (1993) (finding significant risk based on available accident data showing that confined space hazards had caused deaths and injuries); Hazard Communication, 48 FR 53280, 53284-85, 53321 (1983) (finding significant risk of harm from inadequate chemical hazard communication based on BLS chemical source injury and illness data)).

Estimating annual incidence among heat-exposed workers (i.e., the number of annual work-related HRIs divided by the number of heat-exposed workers) requires being able to accurately estimate the number of exposed workers and using that number in the denominator. Unfortunately, there is no published estimate for the number of U.S. workers exposed to hazardous heat on the job and the majority of the incidence estimates that OSHA identified used a denominator that would include both exposed and unexposed workers. This use of a larger denominator has the effect of diluting the resulting annual incidence estimates. For instance, BLS estimates and reports annual incidence of injuries and illnesses involving days away from work that were the result of "exposure to environmental heat," but in their calculation, BLS captures the broader U.S. workforce in the denominator, which includes a large number of unexposed workers (e.g., office workers in climate-controlled buildings).

Some of the annual incidence estimates that OSHA identified, such as those based on workers' compensation claims in California and Washington state, were stratified by sector, industry, or occupation. OSHA considers these incidence estimates to be helpful in getting to a more accurate estimate of risk among heat-exposed workers, specifically the sectors, industries, and occupations where exposure to hazardous heat on the job is more common. Furthermore, OSHA identified incidence estimates from cohort data in which the entire cohort was presumed to be exposed to hazardous heat on the job. These estimates are much higher than the estimates based on surveillance data. One potential reason for this difference is that the denominator used in the cohort studies contains much less unexposed worker-time.

In the following sections (V.A.II., and V.A.III.), OSHA has summarized the best available incidence data that the agency identified. Given the limitations with these data, OSHA relied on this incidence data as a range of possible incidence estimates with the assumption that many of these estimates represent a lower bound and that the true incidence is likely higher.

II. Reported Annual Incidence of Nonfatal Occupational Heat-Related Injuries and Illnesses.

A. BLS Survey of Occupational Injuries and Illnesses.

The BLS Survey of Occupational Injuries and Illnesses (SOII) is the primary nationwide source of surveillance data for nonfatal occupational injuries and illnesses. The scope includes both private and public (state and local government) sector employees, but excludes the self-employed, workers on farms with 10 or fewer employees, private household workers, volunteers, and federal government employees. The data are derived from a two-stage sampling process, during which a sample of employers are surveyed and report to BLS the number of injuries and illnesses occurring at their workplace. To reduce the reporting burden on employers, BLS only requires detailed case information on a sample of the injuries and illnesses that occurred at each establishment. BLS uses these survey responses to estimate the counts and incidence for nonfatal injuries and illnesses across all workplaces. In estimating annual incidence, BLS uses a denominator of full-time equivalent (FTE) workers, which is based on 2,000 hours worked per year (i.e., 40 hours per week over 50 weeks). Relevant Occupational Injury and Illness Classification System (OIICS) v2.01 event and nature codes for this proposed standard include “Exposure to environmental heat” (event code-531) and “Effects of heat and light” (nature codes beginning in 172-). Codes beginning with 172- include heat stroke and heat exhaustion (among other outcomes) but exclude sunburn and loss of consciousness without reference to heat. For more information about OIICS codes generally, see Section IV., Health Effects.

Between 2011 and 2020, there were an estimated 33,890 work-related injuries and illnesses that involved days away from work that were coded with event code 531, for an annual average of 3,389 such injuries and illnesses during this period (BLS 2023b). In 2023, BLS reported biennial rather than annual estimates for work-related injuries and illnesses that involved days away from work (as well as for the first time reporting an estimate of injuries and illnesses involving job restriction or job transfer). The biennial estimate for 2021-2022 for heat-related cases meeting either of these criteria was 6,550 (5,560 cases involved days away from work; 990 cases involved job transfer or restriction) (BLS 2023g). The estimated annual heat-related injury and illness incidence (for cases involving days away from work) calculated by BLS for all workers covered by SOII from 2011-2020 varied by year but ranged from 2.0/100,000 workers to 4.0/100,000 workers. The average estimated annual incidence for the entire time period was 3.0/100,000 workers. However, as stated above, OSHA considers these incidence estimates to be underestimated for heat-exposed workers because BLS calculates the incidence rate for the entire U.S. workforce covered by SOII. Therefore, they are including workers who are not exposed to hazardous heat. In subsectors and industries where OSHA expects a greater proportion of workers to be exposed to hazardous heat, the incidence rate estimates are much higher. For instance, according to unpublished data from BLS SOII for the period 2011-2020, the crop production subsector (NAICS code 111) had an annual average incidence of 14.2/100,000 workers, and the specialty trade contractors subsector (NAICS code 238) had an annual average of 9.3/100,000 workers. This was also true of subsectors with primarily indoor workers where OSHA expects a greater proportion of those workers to be exposed to hazardous heat, including the primary metal manufacturing subsector (NAICS code 331), which had an annual average incidence of 13.1/100,000 workers for the period 2011-2020.

B. Workers' Compensation Claims.

Workers' compensation claims are an alternative way to quantify occupational injuries and illnesses, particularly those that involve outpatient medical treatment, inpatient hospitalization, intensive care, and/or lost workdays. OSHA identified five papers and a report from Wisconsin that have evaluated state workers' compensation data and calculated statewide incidence for heat-related injuries and illnesses.

I. Washington State.

The earliest of these, a paper by Bonauto et al., in 2007, evaluated workers' compensation claims submitted to and accepted by the Washington State Fund between 1995 and 2005 (Bonauto et al., 2007). The State Fund is the sole provider of workers' compensation insurance to Washington employers unless they are self-insured or fall under an alternative system (e.g., federal employees) and it covers approximately two-thirds of the state's workers. Certain workers are exempt from mandatory coverage, such as self-employed and household workers. The authors identified heat-related cases using the American National Standards Institute (ANSI) Z16.2 codes[2] submitted in the claims by workers or their physicians, the ICD-9 codes submitted on bills from healthcare providers and hospitals, and a physician review of cases that included relevant Z16.2 or ICD-9 codes. The researchers used all ICD-9 codes beginning in 992 ("Effects of heat and light," specifically 992.0–992.9) and the ANSI Z16.2 type code 151 ("Contact with general heat—atmosphere or environment"). ICD-9 codes were not available for claims from the self-insured, so the authors restricted the analysis to State Fund claims only. They also excluded claims in which the employer's physical location was outside of Washington (n=12).

Over the 11-year study period, 480 accepted claims met the authors' inclusion criteria after physician review, in which they identified and removed cases where the recorded illness had been miscoded, contained incorrect data, or represented a burn. Most of the 480 claims (n=442; 92.1%) were medical-only claims, meaning the State Fund only paid for the medical bills and did not compensate the worker otherwise (e.g., wage replacement, disability benefits). The claims included the employer's NAICS code, which the authors used to stratify cases by industry sectors and industries. Employers covered under the Washington State Fund are required to report hours worked by their

[2] The American National Standards Institute, or ANSI, created a standard for occupational health and safety metrics in 1962 (revised in 1969) referred to as ANSI Z16. The first version of OIICS was based on the ANSI coding scheme. ANSI revised the Z16 standard in 1995 and adopted the OIICS scheme in that revision.

employees every quarter (i.e., three-month increments), which the authors used to estimate denominators for rates assuming 2,000 work hours is 1 FTE. This means the authors could calculate rates for certain portions of the year rather than the whole year without needing to divide by the total number of annual workers (i.e., they could adjust for hours worked only during the specified portion). The employment reporting by quarter also allowed for the authors to estimate claim rates for the third quarter only (July, August, and September), which corresponded to the time of year with the "greatest level of exposure to elevated environmental temperatures" (Bonauto et al., 2007, p. 5).

The authors reported an average annual claim rate (which can be thought of similarly to an injury or illness incidence rate) of 3.1 claims/100,000 FTE for the overall workforce covered by the State Fund during the study period, with annual rates ranging from 1.9 to 5.1/100,000 FTE. They reported a corresponding average third-quarter claim rate of 8.6 claims/100,000 FTE for the overall workforce covered by the State Fund during the study period. In their paper, Bonauto et al. report annual and third-quarter rates for all sectors and industries that had more than five claims during the study period. The sectors (2-digit NAICS) with the highest annual average claim rates were:

1. Construction (12.1/100,000 FTE),
2. Public administration (12.0/100,000 FTE),
3. Agriculture, forestry, fishing, and hunting (5.2/100,000 FTE),
4. Administrative and support and waste management and remediation services (3.9/100,000 FTE), and
5. Transportation and warehousing (3.5/100,000 FTE).

The corresponding average third-quarter claim rates for these sectors were more than double the annual averages: 33.8/100,000 FTE, 31.2/100,000 FTE, 12.6/100,000 FTE, 9.9/100,000 FTE, and 10.6/100,000 FTE, respectively. This pattern was also true for some sectors with a majority of indoor claims. For example, Manufacturing (3.0/100,000 FTE vs. 7.6/100,000 FTE) and Accommodation and food services (1.7/100,000 FTE vs. 5.1/100,000 FTE).

The industries (6-digit NAICS) with the highest annual average claim rates were:

1. Fire protection (80.8/100,000 FTE),
2. Roofing construction (59.0/100,000 FTE),
3. Highway, street and bridge construction (44.8/100,000 FTE),
4. Site preparation construction (35.9/100,000 FTE) (tie), and
5. Poured concrete foundation and structural construction (35.9/100,000 FTE) (tie).

Similar to the pattern observed among sectors, the corresponding third-quarter claim rates for the top 5 industries were more than double the annual averages, except for fire protection—158.8/100,000 FTE, 161.2/100,000, 105.6/100,000 FTE, 106.5/100,000 FTE, and 102.6/100,000 FTE, respectively. This was also true for restaurants: limited service restaurants (2.4/100,000 FTE vs. 6.0/100,000 FTE) and full service restaurants (1.6/100,000 FTE vs. 5.3/100,000 FTE). These industries have few to no outdoor claims, indicating that even some industries that involve primarily indoor work are at higher risk in the summer months.

A follow-up paper to Bonauto et al., 2007, published in 2014, examined heat-related illnesses among workers in Washington state in certain agriculture and forestry subsectors between 1995 and 2009 (Spector et al., 2014). The state changed their injury and illness codes from ANSI to OIICS in July 2005, so for this paper, the researchers used a combination of ANSI (prior to July 2005), OIICS (beginning in July 2005), and ICD-9 codes to identify potential heat-related claims and then reviewed each claim to ensure it was heat-related. These authors used additional ICD-9 codes that were not included in the 2007 paper, specifically: prickly heat (705.1), hyperosmolality and/or hypernatremia (276.0), volume depletion (276.5 and 276.50), dehydration (276.51), hypovolemia (276.52), and acute renal failure (584 and 584.9). The authors identified 84 accepted claims meeting their eligibility criteria, the majority of which (n=76; 90%) were medical only claims. Of the 84 claims, 61 (73%) met the diagnostic code criteria used in the 2007 paper (ICD-9 codes beginning in 992). The average annual claim rate for the agriculture and forestry subsectors the authors examined over the 15-year period was 7.0/100,000 FTE and the average third-quarter (July – September) claim rate was 15.7/100,000 FTE. The majority of claims (61%) were among crop production and support workers (NAICS 111 or 1151).

A second follow-up paper to Bonauto et al., 2007, was published in 2020 and included all Washington State Fund-covered workers over a more recent 12-year period, 2006 to 2017 (Hesketh et al., 2020). The authors used similar methods, except for different screening criteria for ascertaining cases prior to investigators reviewing each case. To identify potential heat-related claims, they used OIICS v1.01 event/exposure code 321, OIICS nature code 072*, OIICS source codes 9362 and 9392 (Sun), and the ICD-9 codes used in Spector et al., 2014. (Note that these OIICS codes are v1.01 OIICS, which was the coding scheme used from 1992-2010. BLS updated the coding scheme in 2010, which first applied to 2011 data.) The state adopted ICD-10 coding in October 2015, so the following ICD-10 codes were used for claims after that date: E86* (Volume depletion), T67* (Effects of heat and light), T73.2* (Exhaustion due to exposure), W92* (Exposure to excessive heat of man-made origin), X30* (Exposure to excessive natural heat), and Z57.6 (Occupational exposure to extreme temperature). The researchers excluded claims in which service date for treatment of dehydration or kidney failure was not within one day of the illness date or claims in which dehydration or kidney failure were the only identifiers flagged, as they noted that these cases often did not represent heat-related illnesses.

The authors reported a total of 918 confirmed heat-related claims, of which 654 (71%) were accepted claims. Of the accepted claims, 595 (91%) were medical-only claims. Using only accepted claims, they estimated an average annual claim rate of 3.2 claims/100,000 FTE for the overall workforce covered by the State Fund during the study period (Communication with David Bonauto and June Spector, June 2024). Similar to Bonauto et al., 2007, the authors reported claim rates for all sectors and industries with more than 11 claims. The sectors (2-digit NAICS) with the highest annual average accepted claim rates were:

1. Agriculture, forestry, fishing, and hunting (13.0/100,000 FTE),
2. Construction (10.8/100,000 FTE),
3. Public administration (10.3/100,000 FTE),

4. Administrative and support and waste management and remediation services (4.6/100,000 FTE), and
5. Transportation and Warehousing (3.8/100,000 FTE).

The average third-quarter (July – September) claim rates for some sectors were more than 10 times greater than the average annual rates. These third-quarter claim rates were also much higher than those calculated for 1995-2005 in Bonauto et al., 2007. The sectors with the highest average third-quarter accepted claim rates were:

1. Public administration (131.3/100,000 FTE),
2. Agriculture, forestry, fishing, and hunting (102.6/100,000 FTE),
3. Construction (70.0/100,000 FTE),
4. Administrative and support and waste management and remediation services (61.5/100,000 FTE), and
5. Wholesale trade (44.9/100,000 FTE).

The industries (6-digit NAICS) with the highest annual average accepted claims rates were:

1. Farm labor contractors and crew leaders (77.3/100,000 FTE),
2. Fire protection (60.0/100,000 FTE),
3. Structural steel and precast concrete contractors (54.2/100,000 FTE),
4. Poured concrete foundation and structure contractors (31.6/100,000 FTE), and
5. Roofing contractors (29.0/100,000 FTE).

The ratio between third-quarter rates and annual rates for all industries reported in Table 3 of the paper ranged from 2.5-13.7, with the highest average third-quarter accepted claim rates in the following industries:

1. Farm labor contractors and crew leaders (600.9/100,000 FTE),
2. Fire protection (394.6/100,000 FTE),
3. Administration of conservation programs (282.7/100,000 FTE),
4. Site preparation contractors (232.1/100,000 FTE), and
5. Poured concrete foundation and structure contractors (172.3/100,000 FTE).

II. California.

A group of researchers conducted a similar analysis for the state of California, using data from the California Workers' Compensation Information System (WCIS) between 2000 and 2017 (Heinzerling et al., 2020). Virtually all California employees are required to be covered by workers' compensation; voluntary, non-compensated workers, owners, and workers covered under separate programs are excluded. The WCIS contains all accepted and rejected workers' compensation claims in the state since 2000 that required medical treatment beyond first aid or more than one day of lost work time. The investigators identified heat-related claims in the system using WCIS-specific nature of injury and cause of injury codes (e.g., "temperature extremes"), heat-related illness keywords (e.g., "heat stroke"), and certain ICD-9 (992.0-992.9 and E900.0-E900.9) and ICD-10 (T67.0-T67.9, X30, and W92) codes. They also manually reviewed all claims that met only the ICD code identification criteria to ensure the claims were heat-related, as some of the codes they used to identify claims were not specific to heat-related illness or injury. In WCIS, the employer's industry is coded using NAICS codes classified by the claims adjusters. The authors converted the NAICS codes into the appropriate 2002 census industry codes using the NIOSH Industry and Occupation Computerized Coding System (NIOCCS). This was necessary to obtain the corresponding employment denominator estimates from the NIOSH Employed Labor Force Tool, which relies on data from the Current Population Survey (CPS), a Census Bureau survey conducted for BLS. The CPS data provide estimates of all employed and non-institutionalized civilian workers over the age of 15. To account for changes in coding schemes implemented in 2002, the investigators extrapolated 2002 – 2017 data to estimate denominators for 2000 and 2001.

The authors excluded claims for workers below 16 years of age (n=104 claims) and institutionalized workers (n=455 claims), as these workers are excluded from CPS data. They reported a final estimate of 15,996 claims meeting their inclusion criteria, corresponding to an overall annual claims rate of 6.0/100,000 workers. Industry and occupation codes were available for 86% and 74% of the included claims, respectively. The authors reported claim rates for all sectors, but the sectors with the highest annual claim rates were:

1. Agriculture, forestry, fishing, and hunting (38.6/100,000 workers; 95% CI: 26.9, 40.4),
2. Public administration (35.3/100,000 workers; 95% CI: 34.3, 36.3),
3. Mining (21.3/100,000 workers; 95% CI: 17.6, 25.7),
4. Utilities (11.4/100,000 workers; 95% CI: 10.1, 12.8), and

5. Administrative and support and waste management (8.8/100,000 workers; 95% CI: 8.3, 9.3).

The major occupational groups with the highest annual claim rates were:

1. Protective services (56.7/100,000 workers; 95% CI: 54.9, 58.7),
2. Farming, fishing, and forestry (35.9/100,000 workers; 95% CI: 34.1, 37.9),
3. Material moving (12.3/100,000 workers; 95% CI: 11.5, 13.1),
4. Construction and extraction (8.9/100,000 workers; 95% CI: 8.4, 9.4), and
5. Building and grounds cleaning and maintenance (6.0/100,000 workers; 95% CI: 5.6, 6.5).

III. Texas.

Another study examined workers' compensation claims in an unnamed, mid-sized Texas city before and after an intervention among a cohort of 604 municipal workers and calculated the incidence of HRI claims from 2009 to 2017 (McCarthy et al., 2019). The municipal departments included in the study were picked because the job descriptions for workers within each included work in hot environments with moderate and heavy physical activity. These departments were Streets and Traffic, Parks and Recreation, Utilities, and Solid Waste. After removing worker-time contributed by administrative personnel who were not exposed to heat on the job, the remaining worker-time represented 329 FTEs per year. Prior to the intervention in 2011, the heat-exposed workers experienced 17 total HRIs between 2009 and 2010. The authors reported an average annual rate of HRIs among the heat-exposed workers during this time of 25.5/1,000 FTEs (McCarthy et al., 2019, Figure 2). These estimates are much higher than other incidence estimates reported in this section, possibly because the denominator is solely comprised of heat-exposed workers. This explanation is supported by evidence of higher incidences reported in other cohort studies (e.g., approximately 3 HRIs/1,000 National Guard troops involved in flood relief activities between July 5 and August 18, 1993, calculated from data in Dellinger et al., 1996). The results of the voluntary intervention are discussed in Section V.C., Risk Reduction.

IV. Wisconsin.

Finally, a report issued by the Wisconsin Occupational Health and Safety Surveillance Program in 2024 summarized an analysis of heat-related workers' compensation claims in the state from 2010-2022 (Fall et al., 2024). The authors analyzed lost work time claims (under Wisconsin workers' compensation, there must be more than three days of lost work time to be compensable) reported by both insurance carriers and self-insured employers and reported rates by industry sector and industry subsector (rather than overall workforce rates). These do not include medical-only claims, which were the majority of HRI claims reported in the Washington State Fund database. The authors reported cumulative claim rates only. To convert cumulative rates to annual average rates, OSHA divided the reported rates by 13 (the number of years' worth of data reported). The sectors with the highest annual average claim rates were:

1. Administrative and Support and Waste Management and Remediation Services (2.9/100,000 FTE),
2. Public Administration (2.8/100,000 FTE),
3. Wholesale Trade (1.9/100,000 FTE),

4. Construction (1.4/100,000 FTE), and
5. Transportation and Warehousing (1.1/100,000 FTE).

The major occupational groups with the highest annual average claims rates were:

1. Protective Service (4.1/100,000 FTE),
2. Transportation and Material Moving (2.6/100,000 FTE),
3. Production (1.6/100,000 FTE),
4. Construction and Extraction (1.5/100,000 FTE), and
5. Building and Grounds Cleaning and Maintenance (1.5/100,000 FTE).

Similarly, the minor occupational groups with the highest annual average claims rates were:

1. Fire Fighting and Prevention (14.7/100,000 FTE),
2. Material Moving Workers (3.3/100,000 FTE),
3. Metal and Plastic Workers (2.8/100,000 FTE),
4. Motor Vehicle Operations (2.2/100,000 FTE), and
5. Assemblers and Fabricators (2.2/100,000 FTE).

C. Emergency Department (ED) Visits and Inpatient Hospitalizations.

Another way to quantify occupational injury and illnesses requiring medical treatment is to use data reported directly by hospitals to public health departments or national databases, such as the National Electronic Injury Surveillance System (NEISS). Data in NEISS are estimated from a nationally representative probability sample of hospitals across the country, which report data for every injury-related ED visit. A paper from 2010 analyzed NEISS data for heat-related emergency department visits from 2001-

2004 (Sanchez et al., 2010). The authors reported an annual average of 8,376 work-related ED visits for nonfatal heat injuries and illnesses. OSHA used annual average employment estimates from NIOSH's Employed Labor Force query system for 2001-2004 (both total workers and FTEs) to estimate a nationwide annual average rate of 6.1 visits/100,000 workers and 6.3 visits/100,000 FTEs from this study. More recent studies estimating the incidence of work-related ED visits and/or hospitalizations for HRIs within individual or multiple states are discussed below.

I. Southeast U.S.

A group of public health researchers from nine states in the Southeast (Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia) used hospital discharge data reported directly to state health departments to characterize rates of heat-related inpatient hospitalization and ED visits among workers from 2007 – 2011 (Harduar Morano et al., 2015). The researchers used ICD-9 codes to identify heat-related cases, specifically 992.0-992.9, E900.0, E900.1, and E900.9. To assess work-relatedness, they determined whether the expected payer was workers' compensation or if a work-related external cause of injury code (sometimes referred to as E-codes) was noted by the physician (e.g., E000.0 Civilian activity done for income). They restricted cases only to those where the patient was at least 16 years old but included both state residents and non-residents in reported case counts. To calculate rates, the investigators used CPS data for estimating denominators, which were age-adjusted using direct standardization and population weights for the entire U.S. Non-residents were not included in the rate calculations. The authors noted that hospital discharge data weren't available for every year in every state and that the missing data were primarily for discharges following ED visits.

Across the five-year study period, the authors identified 8,315 occupational heat-related ED visits (7,664 of these among residents, or 92%), which corresponded to an overall age-adjusted rate of 6.5 visits/100,000 workers (95% confidence interval, CI = 6.4, 6.7). While they reported rates for each state (e.g., 4.8 visits/100,000 workers in Florida and 17.3 visits/100,000 workers in Louisiana), they cautioned against directly comparing between states given differences in the data collection methods, data availability, and use of work-related variables. They identified 1,051 occupational heat-related inpatient hospitalizations (930 among residents, or 88%), which corresponded to an overall age-adjusted rate of 0.61 hospitalizations/100,000 workers (95% CI = 0.58, 0.66). The average length of stay for state residents was 2.7 days, which was comparable to non-residents (2.4 days).

II. Florida.

The Florida Department of Health published a similar analysis in 2011 using the same methods for the state of Florida for the years 2005 – 2009 (Florida DOH, 2011). They identified 2,198 occupational heat-related hospitalizations and ED visits, which corresponded to an average overall age-adjusted annual rate of 3.7 cases/100,000 workers (95% CI = 1.9, 5.5) and a crude rate (no age adjustment) of 5.1/100,000 workers (Communication with Laurel Harduar Morano, October 2023). The majority of these (89.4%) were ED visits. They identified 3 fatalities in this subset, which they noted corresponds to a case fatality rate of 1.4 fatalities/1,000 cases. They reported a third-quarter (July, August, and September) rate of 3.2 cases/100,000 workers using a denominator of total number of workers, whereas using a denominator of FTEs instead produced a third-quarter rate of 13.0 cases/100,000 FTE (Communication with Laurel Harduar Morano, October 2023). A 2016 study conducted a more in-depth analysis of the statewide Florida hospitalization data and included data for three additional years (2010, 2011, and 2012) (Harduar Morano et al., 2016). The authors restricted the data to cases occurring in May-October of each year and identified a total of 2,979 work-related ED visits and 415 work-related hospitalizations between 2005-2012. Using total number of workers in the denominator (calculated from monthly CPS data), these corresponded to average annual age-adjusted rates of 8.5 ED visits/100,000 workers and 1.1 hospitalizations/100,000 workers.

III. Louisiana.

In March 2023, the Louisiana Department of Health published a report on heat-related illnesses in the state using ED and hospitalization data from 2010-2020 (Louisiana DOH 2023). The authors used workers' compensation as payer and work-related ICD codes to determine which cases were among workers. They reported an annual average of 320 work-related ED visits and 20 work-related hospitalizations for heat-related illness during this period. Using state employment data from CPS, the authors calculated an overall age-adjusted rate of 15.1 work-related ED visits/100,000 workers and 0.9 work-related hospitalizations/100,000 workers. In 2024, the Department of Health released a syndromic surveillance report on ED visits for HRIs between April 1 and October 31, 2023 (Louisiana DOH 2024). They identified 1,412 ED visits for HRIs among workers during this time period.

IV. Multiple States.

Since 2013 over 20 states have reported rates of heat-related ED visits among workers to the Council of State and Territorial Epidemiologists (CSTE), comprising the organization's *Occupational Health Indicator #24* (see *www.cste.org/page/ohindicatorstable*). These data are compiled by the state health departments using workers' compensation as primary payer and external cause of injury codes to determine work-relatedness. Rates are calculated using CPS estimates of total employed persons by state. While multiple states report their annual rates to CSTE, the organization cautions against directly comparing these rates between states because "workers' compensation eligibility criteria and availability of data from workers' compensation programs varies among states, prohibiting state-level data from being directly compared to other states or with national estimates."

Additionally, given that these data are not available for every state, they cannot be combined to produce an accurate national rate. The state-reported rates are currently available for 2013-2019. During this period, the annual rates for heat-related ED visits ranged from 0.1 to 18.7 ED visits per 100,000 workers.

V. Maricopa County, Arizona.

Arizona is not one of the states to share their ED visit data to CSTE, but the most populated county in the state - Maricopa County - has published a *Heat Morbidity Report* in which they provide case counts for heat-related hospitalization discharges, including a breakdown of the “preceding activity type” (determined by ICD activity E-codes) (Maricopa County Public Health Department, n.d.). Using the case counts reported under “occupational” activity type and yearly estimates of the average annual employment for Maricopa County provided by the BLS Quarterly Census of Employment and Wages, there was an average annual hospitalization rate among workers of 4.1 cases/100,000 workers (range: 3.1-6.4/100,000) between 2010-2017. Primary payer of workers’ compensation was not used to determine work-relatedness, which means some occupational cases not involving E-codes may have been missed. Given that for the majority of cases (77%-83% per year), the preceding activity was marked as “unknown”, it's likely that some number of these were occupational in nature and just not listed as such. This is supported by the fact that an “Industrial Site” was the place of injury for, on average, 8% of cases, which may also be an underestimate. It should be noted that the authors only used the following ICD-9/ICD-10 activity E-codes to determine work-relatedness: E011/Y93.C Activities involving computer technology and electronic devices; E012/Y93.D Activities involving arts and handcrafts; and E016/Y93.H Activities involving exterior property and land maintenance, building and construction. To OSHA’s knowledge, the authors did not use any other external cause of injury codes, such as E000.0 Civilian activity done for income, but it is not clear from the report if these E-codes were not available or were just not used.

D. Indirect Injuries.

As discussed in Section IV.P., Heat Related Injuries, one area of research has used the natural fluctuations in temperatures to conduct quasi-experimental studies examining the relationship between heat and workers' compensation claims for traumatic injuries (e.g., Spector et al., 2016; Calkins et al., 2019; Dillender 2021; Park et al., 2021). The findings of these papers suggest that there may be many workers' compensation claims that are heat-related but not coded as such. For instance, Park, Pankratz, and Behrer (2021) estimated that approximately 20,000 injuries per year in California between 2001-2018 resulted from hotter temperatures (relative to "optimal" temperature). For comparison, for a similar time period (2000-2017), Heinzerling et al. (2020) only identified an average of 889 HRI workers' compensation claims per year in California (a 22-fold difference), suggesting that relying on workers' compensation claims coded as HRIs alone does not capture the higher incidence of injuries of other kinds where heat may have played a role. A research report from the Workers Compensation Research Institute expanded this type of analysis to 24 states, using a convenience sample of workers' compensation claims from May-October 2016-2021 (Negrusa et al., 2024). They found that the number of injuries increased 3.2-6.1% when the daily maximum temperature was 75°F or higher relative to a day with a daily maximum temperature of 65-70°F. This relationship was even more pronounced for the construction industry.

E. Worker Self-Reports.

Another source of incidence data is surveys of workers exposed to heat. Multiple papers describe the results of surveys of outdoor workers, typically agricultural workers, who are asked about heat-related symptoms experienced over a week-long period while working in the summer months (Fleischer et al., 2013; Kearney et al., 2016; Mutic et al., 2018). Commonly reported symptoms in these studies include heavy sweating (38-66%

of surveyed workers), headache (44-58%), muscle cramps (30-36%), dizziness (14-32%), weakness or fatigue (18%), and nausea or vomiting (9-17%). Notably, in two of these studies, multiple workers reported fainting on the job. A study in southern Georgia found that 4% of 405 farmworkers experienced fainting within the previous week, during which the heat index ranged from 100-108°F (Fleischer et al., 2013). Another study involved asking 281 farmworkers in North Carolina if they had ever worked in "extreme heat." Of those answering "yes", 3% reported having ever fainted on the job (Mirabelli et al., 2010). When asked about symptoms over a single workday, a separate study found that 25% of workers reported cramps, 22% headache, 10% dizziness, and 3% nausea (Smith et al., 2021).

F. Summary of Reported Annual Incidence of Nonfatal Occupational Heat-Related Injuries and Illnesses.

OSHA identified multiple sources that have reported annual incidence estimates for nonfatal HRIs among workers. These studies and reports generally reported heat-related incidence across an entire workforce (either national or state), using the total workforce as the denominator. This would understate the risk to workers who are actually exposed to heat on the job since the denominator includes a large percentage of workers who are not exposed to heat (e.g., office workers). Evidence in support of this claim comes from studies showing higher incidence of HRI when populations are stratified by sector, industry, or occupation, as well as those reporting incidence that occurred only during the third quarter (July, August, and September). For instance, in Heinzerling et al., 2020, the authors report an overall annual incidence of 6.0/100,000 workers whereas they report an annual incidence of 38.6/100,000 workers for workers in the agriculture, forestry, fishing, and hunting sector (a greater than 6-fold difference). OSHA considers these stratified estimates to be more accurate estimates of the “true” incidence of HRIs among heat-exposed workers.

A summary of the annual incidence estimates for nonfatal occupational HRIs discussed above can be found in Table V-1. In the same table, OSHA calculated the number of non-fatal HRIs that would be expected over a working lifetime (assuming a working lifetime is 45 years long) based on those annual incidence estimates (i.e., the annual incidence multiplied by 45). These estimates represent the total number of HRIs that may be expected to occur in a cohort of 100,000 workers all of whom enter the workforce at the same time and all of whom work for 45 years. Estimates of HRI risk over a working lifetime based on annual incidence among entire working populations (national or state) range from 90-180/100,000 for HRIs requiring days away from work, 140-270/100,000 for HRIs leading to a workers’ compensation claim, and 4.5-842/100,000 for HRIs leading to emergency department visits or inpatient hospitalizations. Like incidence estimates, these values understate the risk to workers who are actually exposed to heat on the job since the denominator includes a large percentage of workers who are not exposed to heat (e.g., office workers). However, when using incidence estimates specific to individual sectors, industries, or occupations, the HRI estimates over a working lifetime are much higher, ranging from 49.5-114,750/100,000 for HRIs leading to a workers’ compensation claim.

III. Reported Occupational Heat-Related Fatalities.

The BLS Census of Fatal Occupational Injuries (CFOI), established in 1992, is the primary source of surveillance data on work-related fatalities, including fatalities due to environmental heat exposure, for the United States. The fatality data in CFOI come from diverse data sources to identify, verify, and describe work-related fatalities. In each case, at least two sources (e.g., death certificates, workers' compensation reports, media reports, and government agency administrative reports) and an average of four are used to validate that the fatality was work-related and to verify the event or exposure leading to death and the nature of injury or illness in each case, which are then classified with OIICS codes. Heat-related fatalities can be identified with an event code ("Exposure to environmental heat") and/or a nature code ("Effects of heat and light").

According to BLS's CFOI, occupational heat exposure killed 1,042 U.S. workers between 1992 and 2022 (BLS, 2024c). Between 2011 and 2022, BLS reports 479 worker deaths, an average of 40 fatalities per year during that time. During the latest three years for which BLS reports data (2020-2022), there was an average of 45 work-related deaths due to exposure to environmental heat per year. Multiple sources have relied on BLS surveillance data to estimate annual incidence rates of occupational heat-related fatalities.

Gubernot et al. (2015) calculated overall fatality rates and fatality rates by industry sector using BLS CFOI data from 2000 – 2010 (Gubernot et al., 2015). The authors focused on the three industry sectors with the highest rates in preliminary analyses: Agriculture, Forestry, Fishing and Hunting (NAICS code 11); Construction (NAICS code 23); and Administrative and Support and Waste Management and Remediation Services (NAICS code 56). All other industry sectors were combined for comparison as a referent group. The authors used nationwide worker population data from the CPS to estimate fatality rates. The CPS data provide estimates of all employed and non-institutionalized civilian workers over the age of 15.

The authors identified 339 occupational heat-related deaths from 2000 – 2010, after excluding volunteers and military personnel. They reported an average annual heat-related fatality rate of 0.022 fatalities per 100,000 workers for the overall workforce.

For the three industry sectors preliminarily identified as having the highest rates, the authors reported the following average annual fatality rates:

1. Agriculture, forestry, fishing and hunting (0.306 fatalities per 100,000 workers),
2. Construction (0.113 fatalities per 100,000 workers), and
3. Administrative and Support and Waste Management and Remediation Services (0.056 fatalities per 100,000 workers).

For all other industry sectors combined, the average annual fatality rate was substantially smaller (0.009 fatalities per 100,000 workers). The agriculture and construction sectors combined accounted for 58% of the fatalities during the study period (n=207).

A CDC Morbidity and Mortality Weekly Report (MMWR) from 2008 reported by Luginbuhl et al. investigated heat-related fatalities among all workers - and agriculture workers in particular - using BLS CFOI data from 1992 – 2006 (Luginbuhl et al., 2008). During the study period, the authors identified 423 deaths related to environmental heat in CFOI using the OIICS v1.01 event/exposure code 321 (Exposure to environmental heat) and nature code 072* (Effects of heat and light). Similar to the approach taken by

Gubernot et al., the authors calculated rates using CPS estimates of the average annual worker population for denominators.

For the overall workforce, the authors calculated an average annual incidence of 0.02 fatalities/100,000 workers, which is similar to the estimate reported by Gubernot et al. for 2000 – 2010 (0.022/100,000). Of the 423 fatalities identified, 102 (24%) occurred in the agriculture, forestry, fishing, and hunting sector (average annual fatality rate of 0.16/100,000 workers) and 68 occurred among workers in crop production or support activities for crop production (annual fatality rate of 0.39/100,000 workers). The rates for crop workers in North Carolina, Florida, and California were 2.36/100,000 workers, 0.74/100,000 workers, and 0.49/100,000 workers, respectively. These findings were later included in a peer-reviewed article (Jackson and Rosenberg 2010).

The editorial note accompanying this MMWR report mentioned, among other limitations, that CPS estimates used for denominators likely underestimate the number of crop workers - because of the potential lack of stable residences among these workers and the seasonal trends in employment - which would lead to an overestimate of risk for these workers. This limitation would presumably apply to any rate estimates calculated with CPS data for this specific population. To OSHA’s knowledge, this is the only reported limitation in the included articles that would suggest a potential overestimation of incidence.

A third paper analyzed BLS CFOI heat-related fatality data for the construction sector, estimating fatality rates for various occupations within the sector using Standard Occupational Classification codes (Dong et al., 2019). Using the OIICS v2.01 nature code 172* (Effects of heat and light) to determine heat-relatedness and CPS estimates for sector-wide and occupation-specific denominators, the authors identified 82 heat-related construction deaths between 2011 – 2016 and estimated an average annual fatality rate for the entire sector (0.15 fatalities/100,000 workers) as well as for specific occupations. The occupations with the highest fatality rates included cement masons (1.62/100,000); roofers (1.04/100,000); helpers (1.03/100,000); brick masons (0.50/100,000); and laborers (0.29/100,000).

Finally, a paper from 2005 by Mirabelli and Richardson identified heat-related fatalities using medical examiner records from North Carolina for the period from 1977 to 2001, including 15 years of data before the creation of CFOI (Mirabelli and Richardson 2005). They determined that heat was a primary or underlying cause of death based on ICD-9 codes. The researchers used the decedents' location and activities reported in the records to determine work-relatedness, and they excluded cases in which the decedent was < 10 years old or those which involved manufactured sources of heat.

The authors identified 40 occupational heat-related deaths. They classified 18 of these as farm workers and reported an annual fatality rate among these farm workers of 1.52 fatalities/100,000 workers. They reported 10 cases having occurred at a construction site but did not report a fatality rate for this group of workers. The average annual fatality rate for the entire state working population was 0.05 fatalities/100,000 workers.

As none of the identified papers reported fatality rates for the overall workforce for years beyond 2010, OSHA used the heat-related fatality counts reported by BLS for 2011 – 2022 (479 worker deaths) and employment estimates for the same years from CPS to calculate fatality rates for these years. For the denominator, OSHA used the total number of workers and average hours worked to estimate total FTEs per year. The average annual fatality rate during this period was 0.029 deaths/100,000 FTEs.

A. Summary of Reported Occupational Heat-Related Fatalities.

OSHA identified multiple studies that calculated and reported annual incidence estimates for heat-related fatalities among workers using data from BLS CFOI or medical examiner records. These studies reported heat-related fatality rates across an entire workforce (either national or state), using the total workforce as the denominator. As mentioned above, this would understate the risk to workers who are actually exposed to heat on the job since the denominator includes a large percentage of workers who are not exposed to heat (e.g., office workers). Evidence in support of this claim comes from studies showing higher fatality rates when populations are stratified by sector, industry, or occupation. For instance, in Gubernot et al., 2015, the authors report an overall annual fatality rate of 0.022/100,000 workers whereas they report an annual fatality rate of 0.306/100,000 workers for workers in the agriculture, forestry, fishing, and hunting sector (a 14-fold difference). OSHA considers these stratified estimates to be more accurate estimates of the "true" incidence of heat-related fatalities among heat-exposed workers.

Table V-1 Estimated Risk of Experiencing a Heat-Related Injury or Illness Annually and Over a 45-Year Working Lifetime

Population	**Source of Data**	**Average Annual Rate (per 100,000 Workers)**	**Expected Number of Non-Fatal HRIs per 100,000 workers over Working Lifetime**
Rates Based on Entire Working Populations			
U.S., All Workers	BLS SOII Injuries and Illnesses Involving Days Away from Work	2.0 – 4.0[3]	90-180
State Working Populations	Workers' Compensation Records	3.1 – 6.0[4]	140-270
State Working Populations	Emergency Department Visits and/or Inpatient Hospitalization	0.1 – 18.7[5]	4.5-842
Rates Based on Sector-Specific Groups (2-digit NAICS)			
Agriculture, forestry, fishing, and hunting	Washington State, 1995-2005 Washington State, 2006 – 2017 California, 2000 – 2017	5.2 13.0 38.6	234 585 1,737
Construction	Washington State, 1995-2005 Washington State, 2006 – 2017 Wisconsin, 2010-2022	12.1 10.8 1.4	545 486 63.0
Public Administration	Washington State, 1995-2005 Washington State, 2006 – 2017 California, 2000-2017 Wisconsin, 2010-2022	12 10.3 35.3 2.8	540 464 1,589 126
Administrative and support and waste management and remediation services	Washington State, 1995-2005	3.9 4.6	176 207

[3] Ranges reflect varying annual average estimates between 2011-2020

[4] Ranges reflect values reported in Heinzerling et al., 2020, Bonauto et al., 2007, and Hesketh et al., 2020

[5] Ranges reflect values reported in or derived from Harduar Morano et al., 2015, Florida DOH 2011, Louisiana DOH 2023, Harduar Morano et al., 2016, CSTE, and Maricopa County Public Health Department

Population	**Source of Data**	**Average Annual Rate (per 100,000 Workers)**	**Expected Number of Non-Fatal HRIs per 100,000 workers over Working Lifetime**
	Washington State, 2006 – 2017 California, 2000-2017 Wisconsin, 2010-2022	8.8 2.9	396 131
Transportation and warehousing	Washington State, 1995-2005 Washington State, 2006 – 2017 Wisconsin, 2010-2022	3.5 3.8 1.1	158 171 49.5
Utilities	California, 2000-2017	11.4	513
Mining	California, 2000-2017	21.3	959
Wholesale Trade	Wisconsin, 2010-2022	1.9	85.5
Rates Based on Industry-Specific Groups (6-digit NAICS)			
Farm labor contractors and crew leaders	Washington State, 2006-2017	77.3	3,479
Fire protection	Washington State, 1995-2005 Washington State, 2006-2017	80.8 60.0	3,636 2,700
Structural steel and precast concrete	Washington State, 2006-2017	54.2	2,439
Poured concrete foundation and structural contractors	Washington State, 1995-2005 Washington State, 2006-2017	35.9 31.6	1,616 1,422
Roofing contractors	Washington State, 1995-2005 Washington State, 2006-2017	59.0 29.0	2,655 1,305
Highway, street, and bridge construction	Washington State, 1995-2005	44.8	2,016
Site preparation construction	Washington State, 1995-2005	35.9	1,616
Rates Based on Major Occupational Groups			
Protective services	California, 2000-2017	56.7	2,552

Population	Source of Data	Average Annual Rate (per 100,000 Workers)	Expected Number of Non-Fatal HRIs per 100,000 workers over Working Lifetime
	Wisconsin, 2010-2022	4.1	185
Farming, fishing, and forestry	California, 2000-2017	35.9	1,616
Transportation and Material moving	California, 2000-2017 Wisconsin, 2010-2022	12.3 2.6	554 117
Construction and extraction	California, 2000-2017 Wisconsin, 2010-2022	8.9 1.5	401 67.5
Building and grounds cleaning and maintenance	California, 2000-2017 Wisconsin, 2010-2022	6.0 1.5	270 67.5
Production	Wisconsin, 2010-2022	1.6	72.0
Municipal workers in departments governing streets and traffic, parks and recreation, utilities, and solid waste	Texas, 2009-2017	2,550	114,750
Rates Based on Minor Occupational Groups			
Fire Fighting and Prevention	Wisconsin, 2010-2022	14.7	662
Material Moving Workers	Wisconsin, 2010-2022	3.3	149
Metal and Plastic Workers	Wisconsin, 2010-2022	2.8	126
Motor Vehicle Operations	Wisconsin, 2010-2022	2.2	99.0
Assemblers and Fabricators	Wisconsin, 2010-2022	2.2	99.0

IV. Limitations and Underreporting.

Evidence suggests that existing surveillance data undercount the total number of heat-related injuries, illnesses, and fatalities, among workers. The incident rates presented in the previous section are likely vast underestimates both because they use this surveillance data as the numerator when calculating incidence rates and because they overestimate the number of workers exposed to hot work environments (i.e., the denominator for incidence rates). These sources of uncertainty are described below.

A. Incidence Estimation.

Incidence estimates based on BLS data are likely to underestimate the true risk to workers who are exposed to specific hazards, like heat, in part because of difficulties in estimating the population of exposed workers. The current approach for BLS SOII rate estimates is to use the population of all workers in the U.S. for the denominator, not just those exposed to the hazard of interest. For instance, the denominators used for the risk estimates presented above would include most office workers who work in climate-controlled buildings and would therefore not have occupational exposure to the levels of heat stress that have been associated with adverse outcomes. For 2022, BLS reported 116,435,925 full-time workers in the U.S. However, OSHA estimates the proposed standard would cover approximately 36 million workers, approximately one-third of the total full-time workers in the U.S. Therefore, BLS's use of a larger denominator likely underestimates risk because it includes workers not exposed to hazardous heat and therefore less likely to experience an HRI.

The denominators for the annual incidence estimates presented above also include worker-time for the entire year, even though for many workers, exposure to potentially harmful levels of heat only occurs during the hottest months of the year. Including unexposed worker-time in the denominator has the effect of diluting the incidence estimates, meaning annual incidence estimates do not accurately represent the risk to workers when they are actually exposed to hazardous heat. The risk to workers whose jobs do expose them to harmful levels of heat, on the days on which those exposures occur, would therefore be expected to be higher than the estimates published by BLS. In addition, using total worker populations as a basis for estimating incidence likely will underestimate the risk to particularly susceptible workers, such as older workers, workers with pre-existing conditions, and workers not acclimatized to the heat.

OSHA believes that studies that reported illness rates by sector or occupation provide evidence showing that the annual average illness rates reported across the entire workforce underestimate risk for exposed workers. For example, the Washington State and California workers' compensation studies found that heat-related illness rates for sector- or occupation-specific populations were substantially higher than the rates for the general working population in the state (Heinzerling et al., 2020; Bonauto et al., 2007; Hesketh et al., 2020). The sectors and occupations examined included those where exposure to hot environments was more likely than for the population as a whole (e.g., Construction and Agriculture, Forestry, Fishing, and Hunting). Additionally, many of the surveillance papers described above also reported the month in which the injury, illness, or fatality occurred and found that most cases were clustered in the hotter, summer months (e.g., June, July, and August). When researchers in Washington and Florida restricted their rate estimates to include data only for the third quarter (July, August, and September), they found rates that were several-fold higher than annual average illness rates over the whole population, which include many unexposed worker-days.

B. Undercounting of Cases.

The general underreporting and undercounting of occupational injuries and illnesses has been a topic of multiple government reports (e.g., Ruser, 2008; Miller, 2008; GAO, 2009; Wiatrowski, 2014). The authors of the peer-reviewed papers described in Sections V.A.II., and V.A.III., above list underreporting or misclassification of cases as a limitation in their analyses that would have the effect of underestimating risk.

I. BLS SOII.

Two papers from the early 2000s that linked workers' compensation records to BLS SOII data found evidence that SOII missed a substantial amount of workers' compensation claims, depending on the state analyzed and the assumptions and methodology used (Rosenman et al., 2006; Boden and Ozonoff, 2008). In response to increased attention around this topic at the time, BLS funded additional research to examine the extent of underestimation in SOII and potential reasons (Wiatrowski, 2014). One of these studies involved linking multiple data sources (i.e., not just SOII and workers' compensation) for cases of amputation and carpal tunnel syndrome (Joe et al., 2014). The authors found that the state-based surveillance systems included 5 times and 10 times more cases than BLS SOII, respectively.

Another study conducted as part of this broader effort estimated that approximately 30% of all workers' compensation claims in Washington between 2003 – 2011 were not captured in BLS SOII (Wuellner et al., 2016). This included sectors with higher rates of heat-related injuries and illnesses, such as Agriculture, Forestry, Fishing, and Hunting (28% of cases uncaptured) and Construction (28% uncaptured) (Wuellner et al., 2016, Table III). The rate of underreporting was particularly high for large construction firms (Wuellner et al., 2016, Table IV).

In response to the studies on SOII undercount, BLS authors have argued that differences in the inclusion criteria, scope, and purpose between BLS SOII and workers' compensation explain some of differences in the estimates and complicate the interpretations of the linkage-based studies (Ruser, 2008; Wiatrowski, 2014). SOII estimates OSHA-recordable injuries and illnesses each year and provides detailed case and demographic information (e.g., nature of injury) for a specific subset of the more severe cases (e.g., those involving days away from work). This scope (OSHA-recordable injuries and illnesses) inherently limits the ability for SOII to be used to estimate all occupational injuries and illnesses. Additionally, injuries and illnesses involving days away from work represent a limited percentage of the total injuries and illnesses reported to BLS. In 2022, these cases were 42% of total recordable cases, suggesting the case counts for HRIs in SOII could be missing up to 58% of all OSHA-recordable HRIs (i.e., those not involving days away from work) (*https://www.bls.gov/iif/latest-numbers.htm*).

The injury and illness data that employers report to BLS come from the employer's OSHA Form 300 Log of Work-Related Injuries and Illnesses and OSHA

Form 301 Injury and Illness Incident Report, so information on the quality of the data in these forms is relevant for understanding limitations of SOII. Through the Recordkeeping National Emphasis Program (NEP) from 2009-2012, OSHA found that almost half (47%) of establishments inspected by the agency had unrecorded and/or under-recorded cases, which were more common at establishments that originally reported low rates (Fagan and Hodgson, 2017). Several factors contributed to the under-recording and unrecording cases. First, in conducting thousands of interviews, the authors found that workers do not always report injuries to their employers because of fear of retaliation or disciplinary action. Second, some employers used on-site medical units, which the authors explained could contribute to underreporting (e.g., if these units were used to provide first aid when additional medical care, which would have warranted reporting on OSHA forms, should have been provided).

Employers rely on workers to report injuries and illnesses that may otherwise be unobserved, but workers have multiple reasons to not do so. In addition to Fagan and Hodgson 2017, multiple studies have interviewed or surveyed workers on this topic. A recent systematic review of 20 studies found that 20-74% of workers - which included cleaning staff, carpenters, construction workers, and healthcare workers - did not report injuries or illnesses to management (Kyung et al., 2023). Some of the researchers asked workers about the barriers to reporting, which included fear, a lack of knowledge on the reporting process, and considering the injury to be a part of the job or not serious.

Finally, employers are disincentivized from reporting injuries and illnesses on their OSHA logs. Disincentives for reporting include workers' compensation premiums being tied to injury and illness rates, competition for contracts involving safety records, and a perception that reporting will increase the probability of being inspected by OSHA (GAO, 2009).

In interviews with employers selected to respond to SOII, researchers found that 42% of them were not maintaining a log (Wuellner and Phipps, 2018). In the same study, researchers found evidence to suggest that misunderstandings about the reporting requirements would likely lead to employers underreporting cases involving days away from work. A similar study conducted among SOII respondents in Washington State found that 12% weren't maintaining a log and 90% weren't complying with some aspect of OSHA's recordkeeping requirements (Wuellner and Bonauto, 2014).

While the general underreporting articles described here are not specific to heat, Heinzerling et al. 2020 examined rates of heat-related injuries and illnesses among workers in California and found that California's workers' compensation database, WCIS, had 3-6 times the number of heat-related cases between 2009 – 2017 than the official BLS SOII estimates for California for each year in that period (Heinzerling et al., 2020). Part of the reason for this discrepancy could be the difference in inclusion criteria between the two datasets, however, it is still a useful estimate for contextualizing the potential magnitude of underreporting of heat-related cases when using only SOII. While outside the U.S., a recent survey of 51 Canadian health and safety professionals in the mining industry found that 71% of respondents believed HRIs were underreported (Tetzlaff et al., 2024).

II. Workers' Compensation.

While workers' compensation data may capture injury and illness cases not included in BLS SOII, the data are not available for the entire U.S., as insurance coverage and reporting requirements vary across states, and most states do not have single-payer systems. Therefore, the majority of claims data are compiled by various insurers and not within a single database. Even when the data are available for an entire state, it is generally presumed that not all worker injuries and illnesses are captured in these data, in part because of eligibility criteria and in part because of underutilization of workers' compensation for reimbursement of work-related medical expenses.

Multiple papers have examined the extent to which and reasons why workers don't always use workers' compensation insurance to pay for work-related medical expenses and other reimbursable expenses. Some reasons workers have reported for not filing workers' compensation claims include fear, a lack of knowledge, "too much trouble" or effort, and considering the injury to be a part of the job or not serious (Kyung et al., 2023; Scherzer et al., 2005). Using the Washington State Behavioral Risk Factor Surveillance System (BRFSS), a telephone survey, Fan et al. (2006) found that 52% of the respondents in 2002 reporting a work-related injury or illness filed a workers' compensation claim. Using similar methodology across 10 states, Bonauto et al. (2010) found that among respondents who reported a work-related injury, there was a wide range in the proportion who reported having their treatment paid for by workers' compensation by state - 47% in Texas to 77% in Kentucky (with a median of 61%). A study from 2013 estimated that 40% of work-related ED visits were paid for by a source other than workers' compensation (Groenewold and Baron, 2013). Worker race, geography, and having an illness rather than an injury were all predictors of whether workers' compensation was the expected payer.

There are a few papers that suggest this phenomenon is occurring for heat-related outcomes. Harduar Morano et al. 2015 (described above in Section V.A.II.) found that across several southeastern states, workers' compensation as expected primary payer alone captured 60% of all emergency department visits and inpatient hospitalizations, which varied by state (50-80% for emergency department visits and 38-84% for inpatient hospitalizations) (Harduar Morano et al., 2015). Similarly, in the 2011 report by the Florida Department of Health (described above in Section V.A.II.), 83% of claims identified were captured by workers' compensation as primary payer (Florida DOH, 2011). It should be noted that these percentages are influenced by the total number of captured cases and in both sources the authors presume that they did not capture all relevant cases.

III. Hospital Discharge Data.

Hospital discharge data are the only surveillance data presented in this risk assessment for which work-relatedness is not an inclusion criterion; therefore, researchers relying on this data need to take an additional step to assess work-relatedness for each case that introduces the possibility that work-related cases are not recognized as such and are thus excluded. Researchers identifying work-related cases typically use a combination of workers' compensation as the primary payer or ICD codes for external cause of injury. As discussed in the previous section, workers' compensation is not always used by workers, so relying on this variable will lead to undercounting. For external cause of injury codes (e.g., E900.9 Excessive heat of unspecified origin), researchers have found that these are not always present or accurate for work-related injury cases (Hunt et al., 2007), which isn't unexpected given that they aren't required for reimbursement. For instance, codes indicating the location of occurrence were present in 43% of probable work-related injury cases the authors reviewed (Hunt et al., 2007). Harduar Morano and Watkins (2017) used external cause of injury codes to identify work-related emergency department visits and hospitalizations for heat-related illnesses in Florida. They found that 2.8% of emergency department visits, 1.2% of hospitalizations, and 0% of deaths were identified solely by an external cause of injury code for work.

Both workers' compensation claims and hospitalization data are also affected by the accuracy of diagnostic codes for identifying heat-related cases. While the use of ICD codes for surveillance of heat-related deaths, illnesses, and injuries is widely accepted, it is not infallible, as these codes are designed for billing rather than surveillance. The use of specific codes is up to the discretion of healthcare providers, so practices may vary by provider and facility. Healthcare providers may not always recognize that a patient's symptoms are heat-related and thus, they may not record a heat-specific ICD code. For example, a patient who presents to the emergency room after fainting would likely be diagnosed with "syncope" (the medical term for fainting). If the provider is aware that the patient fainted due to heat exposure, they should record a heat-specific ICD-10 code, T67.1 *Heat syncope*. However, if the provider is unaware that the patient fainted due to heat exposure (or otherwise fails to recognize the connection between the two), they may record a non-heat-specific ICD-10 code, R55 *Syncope and collapse.* Researchers suspect underreporting when ICD codes are used for surveillance of HRIs (Harduar Morano and Watkins, 2017) and recommend researchers use all possible fields available (e.g., primary diagnosis, secondary diagnosis, underlying cause of death, contributing cause of death).

Researchers examining trends in heat-related illnesses using electronic health records for the Veterans Health Administration identified a dramatic increase in cases when ICD-10 was adopted, suggesting that the coding scheme in ICD-9 may have led to systematic underreporting of heat-related cases, at least for this population (Osborne et al., 2023). The authors also note that 8.4% of the HRI cases they identified were captured using unstructured fields (e.g., chief complaint, reason for admission) and not ICD codes.

Not all sick and injured workers go to an emergency department or hospital and those that do are likely to be more severe cases. Unfortunately, estimating the proportion of injured and sick workers who do go to the hospital or emergency room is difficult, given a lack of data on this topic. In a 1998 CDC Morbidity and Mortality Weekly Report written by NIOSH safety researchers, the authors reported an analysis of unpublished data from the 1988 National Health Interview Survey (NHIS) Occupational Health Supplement which found that 34% of all occupational injuries were first treated in hospital emergency departments, 34% in doctors' offices/clinics, 14% in work site health clinics, and 9% in walk-in clinics (NIOSH DSR 1998). 1988 was the last year that NIOSH asked that question in the NHIS.

Care-seeking for workers experiencing heat-related symptoms specifically may be low. In a study evaluating post-deployment survey response data among a subset of the

Deepwater Horizon oil spill responders (U.S. Coast Guard), Erickson et al. found that less than 1% of respondents reported seeking medical treatment for heat-related illness, yet 12% reported experiencing any heat-related symptoms (Erickson et al., 2019).

IV. BLS CFOI.

CFOI is well-regarded as the most complete and authoritative source on fatal workplace injuries. However, the approach used to classify the event and nature codes by BLS is not immune to misclassification of heat-related deaths. BLS relies on death certificates, OSHA fatality reports, news articles, and coroner reports (among other sources) to determine the primary or contributing causes of death. The criteria for defining a heat-related death or illness can vary by state, and among physicians, medical examiners, and coroners. Additionally, individuals who fill out death certificates are not necessarily equipped to make these distinctions or confident in their accuracy (Wexelman, 2013). Depending on state policies, individuals performing this role may be a medical professional or an elected official with limited or no medically relevant experience (National Research Council, 2009; CDC, 2023).

Researchers estimating fatality rates attributable to heat in the overall U.S. population using historical temperature records have produced much higher counts than approaches solely using death certificates (Weinberger et al., 2020). While outside the U.S., a recent study examining causes of death among migrant Nepali workers in Qatar from 2009-2017 demonstrated that deaths coded as cardiovascular-related (e.g., “cardiac arrest”) among these mostly young workers were unexpectedly common and correlated with higher wet bulb globe temperatures, suggesting that these deaths may have been heat-related but not coded as such (Pradhan et al., 2019). Heat-related deaths are uniquely hard to identify if the medical professional didn't witness the events preceding the death, particularly because heat can exacerbate an existing medical condition, acting as a contributing factor (Luber et al., 2006).

C. Summary.

In conclusion, the available evidence indicates that the existing surveillance data vastly undercount cases of heat-related injuries and illnesses among workers. OSHA additionally believes that the inclusion of unexposed worker-time in the denominator for incidence estimates underestimates the true risk among heat-exposed workers.

V. Requests for Comments.

OSHA requests information and comments on the following questions and requests that stakeholders provide any relevant data, information, or additional studies (or citations) supporting their view, and explain the reasoning for including such studies:

- Are there additional data or studies OSHA should consider regarding the annual incidence of HRIs and heat-related fatalities among workers?
- OSHA has identified data from cohort-based and time series studies that would suggest higher incidence rates than data from surveillance datasets (e.g., BLS SOII, workers' compensation claims). Are there other data from cohort-based or time series studies that OSHA should rely on for determining risk of HRIs to heat-exposed workers?

- Are employers aware of occupational HRIs that are not reported through BLS SOII, workers' compensation claims, or hospital discharge data? How commonly do HRIs occur that are not recorded on OSHA 300 logs?
- Are there additional data or studies that OSHA should consider regarding the extent of underreporting and underestimating of HRIs or heat-related fatalities?

B. Basis for Initial and High Heat Triggers.

I. Introduction.

In this section, OSHA presents the evidence that forms the basis of the heat triggers contained in the proposed standard. These triggers are based on the heat index and wet bulb globe temperature (WBGT). The WBGT triggers are based on NIOSH exposure limits (i.e., the REL and RAL), which are supported by empirical evidence dating back to the 1960s and have been found to be highly sensitive in capturing unsustainable heat exposures.

Although there are no consensus-based heat index exposure limits for workers, the question of which heat index values represent a highly sensitive and appropriate screening threshold for heat stress controls in the workplace has been evaluated in the peer-reviewed scientific literature. The evidence described below provides information on the sensitivity of alternative heat index values, that is, the degree to which a particular heat index value can be used to screen for potential risk of heat-related injuries and illnesses (HRIs) and fatalities. OSHA looked at both experimental and observational evidence, including efforts to derive more accessible and easily understood heat index-based triggers from WBGT-based exposure limits, to preliminarily determine appropriate heat index values for triggering heat stress control measures. Each of these evidence streams has strengths and limitations in informing this question.

Relevant experimental evidence in the physiology literature is often conducted in controlled laboratory settings among healthy, young volunteers, but the conditions may not always mimic conditions experienced by workers (e.g., workers often experience multiple days in a row of working in high temperatures). Observational evidence does not have this limitation because the data are collected among actual workers in real-world settings. However, observational evidence is potentially affected by exposure misclassification since exposure metrics are often derived from local weather stations and rely on maximum daily values. Experimental data does not have this limitation, since the laboratory conditions are highly controlled, including the exposure levels.

OSHA used both streams of evidence to support proposing an initial heat trigger of 80°F (heat index) and a high heat trigger of 90°F (heat index). The observational evidence that OSHA identified suggests that the vast majority of known occupational heat-related fatalities occur above the initial heat index trigger, making it a sensitive trigger for heat-related fatalities. The vast majority of nonfatal occupational HRIs also occur above this trigger. The experimental evidence (specifically the WBGT-based exposure limits) also suggests that when there is high radiant heat, a heat index of 90°F would be an appropriate time to institute additional controls (e.g., mandatory rest breaks). This is supported by observational evidence that shows a rapidly declining sensitivity above a heat index of 90°F. OSHA has preliminarily concluded that the experimental evidence also supports the selection of these triggers as highly sensitive and therefore protective.

II. Observational Evidence.

To determine an appropriate initial heat trigger, OSHA sought to identify a highly sensitive screening level above which the majority of fatal and nonfatal HRIs occur. This could presumably be used to identify the environmental conditions for which engineering and administrative controls would be most important to prevent HRIs from occurring. One challenge for determining this trigger level is that many factors influence an individual's risk of developing an HRI. In addition to workload, PPE, and acclimatization status, the risk of developing an HRI is also influenced by workers' abilities to self-pace at their jobs as well as whether there had been exposure to hot conditions on the prior day(s). There are also medications and comorbidities that may increase workers' risk of HRIs (see discussion in Section IV.O., Factors that Affect Risk for Heat-Related Health Effects).

The observational studies reviewed by OSHA used retrospective temperature and humidity data matched to the locations where HRIs and fatalities occurred over a period of time. Although these studies did not account specifically for workload, PPE use, acclimatization status, or other relevant factors, the HRI cases studied included worker populations where these factors were likely present to varying degrees. Therefore, OSHA has preliminarily determined that retrospective observational data collected among workers who have experienced fatal or nonfatal HRIs on the job is valuable to informing a screening level that reflects the presence of these multiple risk factors among worker populations. These studies are summarized in the following sections.

A. Fatalities.

In a doctoral dissertation from 2015, Gubernot matched historic weather data to the heat-related fatalities reported in BLS CFOI (fatality data described in Section V.A., Risk Assessment) between 2000-2010 (Gubernot, 2015). Gubernot used historic, weather monitor-based temperature and dew point measurements from the National Climatic Data Center to recreate the heat index (using daily maximum temperature and daily average dew point) on the day of each fatality. If there was not already a monitor in the county where a fatality occurred, then the next closest weather monitor to that county was used. Of the 327 fatalities identified as being related to ambient heat exposure (i.e., cases with secondary heat sources, like ovens, were excluded), 96.3% occurred on a day with a calculated heat index above 80°F and 86.9% occurred on a day above 90°F. Using a higher threshold such as a heat index of 95°F would have only captured approximately 71% of fatalities (estimated from Figure 4-2 of the study). The author also evaluated how many cases occurred on a day when a National Weather Service (NWS)-defined excessive heat event (EHE) was declared. In a directive to field offices, the NWS outlines when offices should issue excessive heat warnings—when there will be 2 or more days that meet or exceed a heat index of 105°F for the Northern U.S. and 110°F for the Southern U.S., with temperatures not falling below 75°F (although local offices are allowed to use their own criteria) (NWS, 2024a). Gubernot appears to have used a simpler criterion to evaluate the sensitivity of these EHEs - whether the heat index on the day of the fatality was at or above 105°F for northern states and at or above 110°F for southern states. Only 42 fatalities (12.8%) occurred on days meeting the EHE definitions, suggesting EHEs are not a sensitive trigger for occupational heat-related fatalities. During the SBREFA process, small entity representatives suggested that OSHA consider the NWS EHE definitions as options for the initial and/or high heat triggers, but based on these findings (and those reported in other studies summarized in this section), OSHA has preliminarily determined that these criteria are not sensitive enough and would not adequately protect workers.

Some limitations of this analysis include the use of nearest-monitor exposure assignment, as well as the use of maximum temperature with average dew point to calculate heat index, both of which may introduce exposure misclassification. Although the author did not refer to the latter as a daily maximum heat index, this estimate would most closely approximate that value, which would suggest that workers were likely exposed to heat index values below that level during the work shift leading up to the fatality.

In a meta-analysis published in 2020, Maung and Tustin (both affiliated with OSHA at the time) conducted a systematic review of studies, such as the one described above by Gubernot, where researchers retrospectively assigned heat exposure estimates to occupational heat-related fatalities (Maung and Tustin, 2020). The purpose of their meta-analysis was to identify a heat index threshold below which occupational heat-related fatalities do not occur (i.e., a highly sensitive threshold). Maung and Tustin identified 418 heat-related fatalities among civilian workers across 8 studies.

Approximately three quarters of these civilian fatalities (n=327; 78%) came from Gubernot 2015. The authors found a heat index threshold of 80°F to be highly sensitive for civilian workers - 96% of fatalities (402 of 418) occurred on days with a heat index estimate at or above this level. A heat index threshold of 90°F had slightly lower sensitivity—approximately 86% (estimated from Table 1 and Figure 3 of their study). Similar to the findings reported in Gubernot 2015, one of the NWS thresholds for issuing heat advisories (heat index of 105°F) did not appear to be a sensitive trigger, missing 68% of civilian worker fatalities.

The limitations for Gubernot 2015 apply to this analysis as well. These analyses (including the data from Gubernot, 2015) were limited to outdoor workers, potentially limiting the generalizability of the findings. This analysis also relied on single values (e.g., daily maximum heat index) to capture exposure across a work shift. As pointed out by Maung and Tustin, it is important to consider that exposure characterizations using daily maximum heat index likely over-estimates the exposures that workers experience throughout the shift leading to the fatality. For example, a fatality occurring on a day with a daily maximum heat index of 90°F likely involved prolonged exposure to heat index values in the 80s°F.

In 2019, a group of OSHA researchers published a similar analysis for both fatal and nonfatal HRIs reported to OSHA in 2016 among outdoor workers (Morris CE et al., 2019). They identified 17 fatalities in this subset and used nearest weather station data to estimate daily maximum heat index on the day of the fatality. All 17 fatalities occurred on a day with a daily maximum heat index of at least 80°F (the lowest was at 88°F). A daily maximum heat index of 90°F had a sensitivity of approximately 94%, while 100°F had a sensitivity of approximately 35%. A major limitation with this analysis is its small sample size (n=17 fatalities).

B. Non-Fatalities.

Morris et al., identified 217 nonfatal HRIs among outdoor workers reported to OSHA in 2016 (Morris CE et al., 2019). They found that 99% of these cases happened on a day with a daily maximum heat index of at least 80°F. There is a steep decline in sensitivity for daily maximum heat index values in the 90s°F - 89% for 90°F but approximately 58% for 100°F (estimated from Figure 5 of the study which combines fatal and nonfatal cases) - suggesting that many nonfatal HRIs occur on days when the heat index does not reach 100°F. One limitation of this dataset is potential selection bias, because the dataset only included cases that were reported to OSHA. This study therefore did not include cases in State Plan states.

A much larger analysis conducted among emergency department (ED) visits in the Southeastern U.S. was published by Shire et al. (Shire et al., 2020). The authors identified 5,017 hyperthermia-related ED visits among workers in 5 southeastern states (Florida, Georgia, Kentucky, Louisiana, and Tennessee) between May and September in 2010-2012. While the previously described studies used nearest monitor data, Shire et al. used data from the North American Land Data Assimilation System (NLDAS), which incorporates both observation and modeled data to fill in gaps between locations of monitors, providing data at a higher geographic resolution (0.125° grid). Since the authors only had ED visit data at the county level, they used the NLDAS data to compute population-weighted, county-level estimates of daily maximum heat index using all the grids within each county. They found that approximately 99% of ED visits occurred on days with a daily maximum heat index of at least 80°F and about 95% of cases on days with a maximum heat index of at least 90°F. Approximately 54% of cases occurred on days with a daily maximum heat index of 103°F or higher. This further supports the finding from Morris et al. (2019) that sensitivity declines steeply above a heat index of 90°F. One limitation of this analysis is the use of the emergency department location as the basis for the exposure assignment, which has the potential to introduce exposure misclassification if workers were working far away from the ED facility.

In a 2016 doctoral dissertation, Harduar Morano conducted a retrospective analysis of 3,394 heat-related hospitalizations and ED visits among Florida workers in May-October between 2005-2012, using data from the weather monitor nearest to the zip codes where the hospitalizations and ED visits occurred to characterize heat exposure (Harduar Morano, 2016). The vast majority of cases occurred on a day with a daily maximum heat index of at least 80°F, with approximately 91% of cases occurring on a day with a maximum heat index of at least 90°F (estimated from Figure 6-4). There was also a 13% increase in the HRI hospitalization and ED visit rate for every 1°F increase in heat index at values below 99°F (Figure 6-4, Lag 0 plot of the study), suggesting that potential triggers in the mid-to-high 90's would increasingly miss many cases. One limitation of this analysis and that conducted by Shire et al. is that hospitalization and ED visit data did not include enough information to distinguish between indoor vs outdoor workers; it is possible that indoor workers could have been exposed to conditions not captured by the weather data (such as working near hot industrial processes).

In addition, four studies of workers' compensation data in Washington State - three of which were reported in Section V.A., Risk Assessment - have examined maximum temperature or heat index on the days of reported HRIs (Bonauto et al., 2007; Spector et al., 2014; Hesketh et al., 2020; Spector et al., 2023). Hesketh et al., 2020 (an update on Bonauto et al., 2007) matched weather data to addresses for the HRI claims in the state's workers' compensation database between 2006 and 2017 (Hesketh et al., 2020). They found that, of the 905 claims for which they had temperature data, over 75% of HRIs occurred on days with a maximum temperature of at least 80°F and approximately 50% of claims occurred on days with a maximum temperature of at least 90°F (estimated from Figure 2). They also reported that approximately 75% of claim cases occurred when the hourly maximum temperature was at least approximately 79°F. This paper is part of the rationale for Washington state lowering the trigger level in its heat-specific standard from 89°F to 80°F - the old trigger of 89°F had missed 45% of cases in this dataset (Washington Dept. of Labor & Industries, 2023). A similar study published in 2023 expanded the dataset used by Hesketh et al. to include HRI claims from 2006 to 2021 (n=1,241) (Spector et al., 2023). The authors used gridded meteorological data from the PRISM Climate Group at Oregon State University and geocoded accident location (or business location or provider location if accident location was unable to be used) to determine the maximum temperature on the day of the event. They found that 76% of HRI claims occurred on a day with a maximum temperature of at least 80°F (this increased to 79% when restricted to cases that were "definitely" or "probably" outdoors). A major limitation of these studies is the use of ambient temperature, limiting the ability to compare findings to other papers that relied on the heat index. In Spector et al. 2014, the authors calculated the daily maximum heat index for each county with an HRI in their dataset on the date of injury (Spector et al., 2014). They obtained the county of injury and, when not available, imputed the location of the injury rather than using the employer address, which is assumed to be more accurate for characterizing exposure. In their analysis of 45 agriculture and forestry worker HRI claims between 1995-2009 that had corresponding weather data, Spector et al. found that 75% of HRI claims occurred on days when the maximum heat index was at least 90°F, whereas only 50% occurred on days when it was at least 99°F and 25% for 106°F.

C. Summary.

In summary, researchers have identified a heat index of 80°F as a highly sensitive trigger for heat-related fatalities (capturing 96-100% of fatalities) and nonfatalities (99-100%) among workers (excluding results from Washington state). When looking at ambient temperature, researchers in Washington found that 75-76% of HRI claims occurred on a day with a maximum ambient temperature of 80°F or greater. Multiple studies additionally identified a rapidly declining sensitivity above a heat index of 90°F, suggesting that additional protective measures (e.g., observation for signs and symptoms of HRIs) are needed once the heat index reaches approximately 90°F.

One of the common limitations of the analyses presented in this section is the use of a single reading (e.g., daily maximum heat index) to capture each affected worker's exposure on the day of the event. In reality, conditions fluctuate throughout the day, so relying on maximum measures would likely overestimate heat exposure across the workday. The use of nearest monitor weather data is also likely to lead to exposure misclassification. The inclusion of indoor workers in some of the studies is also a limitation, since the exposure for those workers could be very different (e.g., if there is process heat). In Spector et al. 2023, the authors noted an increase in the percent of cases occurring on days with a maximum temperature of 80°F when restricting to cases that definitely or probably occurred outdoors. In all these studies, researchers can only examine conditions for the cases that were captured in the surveillance systems. There could be a bias such that cases occurring on hotter days were more likely to have been coded as heat-related and included in these databases. Failure to ascertain HRI cases occurring at lower heat indices could have skewed the findings upwards, making it appear that hotter thresholds were more sensitive than they actually were. Finally, the use of heat index (or ambient temperature) ignores the impacts of air movement as well as radiant heat, which can substantially increase the heat stress a worker is exposed to and increase the risk of an HRI.

III. Experimental Evidence.

NIOSH has published exposure limits based on WBGT in its *Criteria for a Recommended Standard* going back multiple decades.[6] These exposure limits - the REL and RAL - account for the contributions of wind velocity and solar irradiance, in addition

[6] NIOSH plays an important role in carrying out the purpose of the OSH Act, including developing and establishing recommended occupational safety and health standards (29 U.S.C. 671).

to ambient temperature and humidity. (ACGIH has published similar exposure limits - the TLV and AL.) In addition to WBGT, NIOSH and ACGIH heat stress guidelines require the user to account for metabolic heat production (through the estimation of workload) and the contributions of PPE and clothing. The user adds an adjustment factor to the measured WBGT to account for the specific clothing or PPE worn (specifically those ensembles that impair heat loss) and uses a formula based on workload to estimate the exposure limit. They then compare the measured (or adjusted, if using a clothing adjustment factor) WBGT to the calculated exposure limit to determine if the limit is exceeded. Work-rest schedules with increasing time spent on break can further increase the exposure limit.

These exposure limits and guidelines are based in empirical evidence, such as laboratory-based trials conducted in the 1960s and 1970s. This basis for WBGT exposure limits is described in detail by both NIOSH and ACGIH (NIOSH, 2016; ACGIH, 2017). These exposure limits have been tested and found to be highly sensitive (100%) in modern laboratory conditions in capturing unsustainable heat exposures (i.e., when a steady increase in core temperature is observed) (Garzon-Villalba et al., 2017). Among workers in real-world settings, these WBGT-based exposure limits have been found to be highly sensitive for fatal outcomes (100% in one study; 92-100% in another) and, although slightly less so, still sensitive for nonfatal outcomes (73% in one study; 88-97% in another); however, these studies are limited by their small sample size and retrospective characterization of workload, acclimatization status, and clothing/PPE use (which are required for accurately estimating WBGT-based exposure limits) (Tustin et al., 2018b; Morris CE et al., 2019).

Two papers have attempted to apply the concepts of the WBGT-based exposure limits to the more easily accessible and understood heat index metric. Based on the relationship between WBGT and heat index, Bernard and Iheanacho developed a screening tool that reflects heat stress risk based on heat index and workload category—light (180 W), moderate (300 W), and heavy (415 W) - using assumptions about radiant heat but ignoring the contributions of wind and clothing (Bernard and Iheanacho, 2015). To do this, they created a model predicting WBGT from the heat index. From this model, WBGT estimates were produced within a 1°C range for heat index values of 100°F or more but the model was less accurate at heat index values below 100°F. Using their reported screening table, which allows the user to adjust for low vs high radiant heat, an acclimatized worker performing a heavy (415 W) workload in high radiant heat outdoors would be above the WBGT-based exposure limit and in need of a break at a heat index of 90°F. The same worker, if unacclimatized, would be above the exposure limit at a heat index of 80°F. These findings support the provision of 15-minute breaks at a heat index of 90°F in OSHA’s proposed standard, as well as the provision requiring these breaks for unacclimatized workers at a heat index of 80°F (unless the employer is following the gradual acclimatization schedule and providing breaks if needed). The authors noted that high radiant heat indoors could require even greater adjustments to the heat index. As further evidence for the need to adjust these values for radiant heat exposure, Morris et al. (2019) reported that for the days on which HRIs occurred in their dataset, cloud cover was often minimal suggesting there was exposure to high radiant heat when the HRIs occurred.

More recently, Garzón-Villalba et al. used an experimental approach to derive workload-based HI heat stress thresholds (Garzón-Villalba et al., 2019). The researchers used data from two progressive heat stress studies of 29 acclimatized individuals. Participants were assigned different work rates and wore different clothing throughout the trials, serving as their own controls. Once thermal equilibrium was established, the ambient temperature was increased in five-minute intervals while holding relative humidity constant. The critical condition defined for each subject was the condition at which there was a transition from a stable core body temperature to an increasing core body temperature (i.e., the point at which heat exposure became unsustainable). Using the results from these trials, the authors established an equation deriving a heat index exposure limit (equivalent to the TLV or REL) at different metabolic rates for a worker wearing woven clothing:

$$\text{HI benchmark (°C)} = 49 - 0.026\ M$$

Where M is workload in Watts.

Garzón-Villalba et al. assessed the effectiveness of the proposed heat index thresholds for predicting unsustainable heat stress by using receiver operating characteristic curves and area-under-the-curve (AUC) values to determine predictive power (this technique is commonly used to evaluate the predictive power of diagnostic tests). The AUC value for the proposed heat index thresholds with subjects wearing woven clothing was 0.86, which is similar to that of the WBGT-based thresholds, based on the authors' prior analysis (Garzón-Villalba et al., 2017). This result showed that the heat index thresholds derived by Garzón-Villalba et al. (2019) would reasonably identify unsustainable heat exposure conditions.

Compared to the heat index thresholds proposed by Bernard and Iheanacho (2015), the heat index thresholds proposed by Garzón-Villalba et al. are the same at low metabolic rates (111°F for 180 W) but higher at higher metabolic rates: 105.8°F versus 100°F at 300 W and 100.4°F versus 95°F at 415 W (Note: these values are unadjusted for radiant heat). This is likely because the ACGIH WBGT-based exposure limits, upon which Bernard and Iheanacho based their heat index thresholds, are intentionally more conservative at higher metabolic rates, whereas Garzón-Villalba used a less conservative linear model to derive their heat index thresholds (Garzón-Villalba et al., 2019). When adding an adjustment for full sunshine provided by the authors, the proposed heat index-based exposure limit derived from the Garzón-Villalba et al. (2019) equation for a worker performing a very heavy workload (450 W) is 92.8°F.

Thus, laboratory-derived heat index thresholds for unsustainable heat exposure are higher than heat index thresholds shown in observational studies to be sensitive for predicting the occurrence of HRIs. There are several reasons that may explain why values determined to be sensitive in laboratory settings are higher than those reported among workers in real-world settings. For one, volunteers in laboratory studies are often young, healthy, and euhydrated (i.e., beginning the trial adequately hydrated). They are also not exposed to consecutive days of heat exposure for eight-hour or longer work shifts. Working in hot conditions on the prior day has been demonstrated in the literature to be a risk factor for HRIs, even among acclimatized individuals (Garzón-Villalba et al., 2016; Wallace et al., 2005). Therefore, the use of volunteers and exposure conditions in laboratory-based trials may not always provide good proxies for workers and the environments in which they work. There is also significant inter-individual variability in heat stress tolerance, which may mean trial studies with few participants might not capture the full range of heat susceptibilities faced by workers.

In summary, long-established and empirically validated occupational exposure limits exist for WBGT. In observational studies, WBGT exposure limits have been found to be highly sensitive for detecting fatal HRIs among workers and, although slightly less so, still sensitive for nonfatal outcomes (although these studies are limited by small sample size and retrospective work characterization). Research efforts to crosswalk the WBGT-based exposure limits to the more accessible heat index metric have demonstrated that a heat index of 90-92.8°F would represent an appropriate trigger for controls such as mandatory rest breaks for acclimatized workers performing heavy or very heavy workloads in high radiant heat conditions (Bernard and Iheanacho, 2015; Garzón-Villalba et al., 2019). For unacclimatized workers performing heavy workloads in high radiant heat conditions, a heat index trigger of 80°F would be in line with the WBGT-based exposure limits (Bernard and Iheanacho, 2015). Although these two studies suggest that higher triggers could reasonably be applied to workers performing lighter workloads, the assumptions used may not always apply to workers (e.g., no exposure to working in the heat the prior day, healthy, euhydrated). This may explain, at least in part, the discrepancy in findings between the observational and experimental studies discussed in this section.

IV. State Standards and Non-Governmental Recommendations.

In their heat-specific standards, summarized in the table below, states use various initial and high heat triggers, some of which depend on the clothing or gear worn by workers. OSHA's proposed triggers are generally in line with those used by these states.

OSHA is proposing using the same initial heat trigger (heat index of 80°F) as Oregon’s existing standard and Maryland’s proposed standard (Or. Admin. R. 437-002-0156 (2022); Or. Admin. R. 437-004-1131 (2022); Code of Maryland Regulations 09.12.32: Heat Stress Standards (2024)). California and Colorado use an ambient temperature trigger of 80°F for outdoor work sites and agricultural sites, respectively, as does the Washington standard for workers wearing breathable clothing (Cal. Code of Regulations (CCR), tit. 8, § 3395 (2015); 7 Colo. Code Regs. § 1103-15 (2022); Wash. Admin. Code § 296-62-095 through 296-62-09560; § 296-307-097 through § 296-307-09760 (2023)). California’s proposed indoor standard uses an ambient temperature trigger of 82°F (CCR, tit. 8, § 3396 (2023)).

The high heat trigger that OSHA is proposing (heat index of 90°F) is the same as Oregon’s existing standard and Maryland’s proposed standard. California and Colorado use an ambient temperature high heat trigger of 95°F, while the Washington standard uses 90°F. The California indoor proposal uses an ambient temperature or heat index trigger of 87°F to impose additional requirements.

Table V-2 Summary of triggers used in various heat-specific standards at the state level

State	Setting	Initial Heat Trigger	High Heat Trigger
California	Outdoor	80°F (Ambient)	95°F (Ambient)
Washington	Outdoor	80°F (Ambient) (all other clothing) 52°F (non-breathable clothes)	90°F (Ambient)

California (proposal)	Indoor	82°F (Ambient)	87°F (Ambient or **Heat Index**), except for certain clothing or in high radiant heat (82°F)
Oregon	Indoor/Outdoor	80°F **(Heat Index)**	90°F **(Heat Index)**
Maryland (proposal)	Indoor/Outdoor	80°F **(Heat Index)**	90°F **(Heat Index)**
Colorado	Indoor/Outdoor Agriculture only	80°F (Ambient)	95°F (Ambient) or other conditions

Note: There are different provisions required at each trigger by each state.

In the Heat Stress and Strain chapter of their most recent TLV booklet, ACGIH recommends establishing a heat stress management plan when heat stress is suspected (ACGIH, 2023). One criterion they provide for determining when heat stress may be present is whether the heat index or air temperature is 80°F. In comments received from small entity representatives during the SBREFA process and a public commenter during the ACCSH meeting on April 24, 2024, OSHA heard feedback that the agency should consider different triggers that vary by geography. Neither the ACGIH TLV/REL nor NIOSH REL/RAL vary by geography; these formulas are used globally. Additionally, California regulators, in their existing outdoor heat standard and their proposed indoor heat standard, use single state-wide triggers, despite the state experiencing a wide range of microclimates (e.g., both desert and coastal areas exist in the state). Such microclimates would make it difficult to identify appropriate geographically specific triggers, as factors like elevation and humidity can vary widely even within a specific state or region. OSHA has also heard from stakeholders who suggested that the triggers in a proposed rule should be presented simply, which would be challenging if there were multiple triggers for different parts of the country.

V. Summary.

In conclusion, OSHA preliminarily finds that the experimental and observational evidence support that heat index triggers of 80°F and 90°F are highly sensitive and therefore highly protective of workers. These triggers are also generally in-line with current and proposed triggers in state heat-specific standards. Therefore, OSHA is proposing an initial heat trigger of heat index of 80°F and a high heat trigger of heat index of 90°F. OSHA is also proposing to permit employers to use the WBGT-based NIOSH RAL and REL, which are supported by empirical evidence and have been found to be highly sensitive in capturing unsustainable heat exposure.

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Whether OSHA has adequately identified, documented, and correctly interpreted all studies and other information relevant to its conclusion about sensitive heat triggers;
- Whether there are additional observational studies or data that use more robust exposure metrics (e.g., more than daily maximum heat index) to retrospectively assess occupational heat exposure on the day of heat-related fatalities and nonfatal HRIs;
- Whether OSHA should consider other values for the initial and/or high heat trigger and if so, what evidence exists to support those other values;
- The appropriateness of using heat index to define the initial and high heat triggers;

- Whether OSHA should explicitly incorporate radiant heat into the initial and/or high heat triggers, and if so, how;
- Whether OSHA should explicitly incorporate clothing adjustment factors into the initial and/or high heat triggers, and if so, how;
- Whether OSHA should use different triggers for different parts of the country, and if so, how;
- The appropriateness of applying the same triggers to employers who conduct on-site measurements as opposed to employers who use forecast data; and
- Whether OSHA should consider an additional trigger specific to heat waves or sudden increases in temperature and, if so, whether there are definitions of heat waves that are simple and easy-to-apply.

C. Risk Reduction.

I. Introduction.

OSHA identified and reviewed dozens of studies evaluating the effectiveness of various controls designed to reduce the risk of heat-related injuries and illnesses (HRIs). The studies captured include observational and experimental studies that examined the effect of either a single control or the combined effect of multiple controls. These studies were conducted among civilian workers, athletes, military personnel, and volunteers. Observational studies conducted outside the U.S. were included if OSHA determined the work tasks to be comparable to those of U.S.-based workers. OSHA also examined systematic review articles that summarized the literature on various individual controls.

OSHA acknowledges that observational studies evaluating the effectiveness of multi-pronged interventions or programs in reducing HRI incidence in "real-world" occupational settings are the most relevant for assessing the reduction in risk of the proposed rule. However, OSHA identified very few of these studies in the literature review and determined there to be some limitations in extrapolating their findings to the proposed rule. Therefore, OSHA also examined studies looking at the effectiveness of single interventions, many of which were experimental in design.

One limitation of the experimental studies - often conducted in laboratory settings - is that they were not conducted in "real-world" occupational settings. However, some of these studies were designed to simulate actual work tasks and work environments, which increases the generalizability for occupational settings (i.e., the extent that the study results can be applied to employees exposed in the workplace). Additionally, one advantage of experimental studies is that they can be conducted under controlled conditions and are thus able to better measure endpoints of interest and control for confounding variables. Experimental studies are also sometimes able to examine situations in which subjects experience high levels of heat strain because the close physiological monitoring of subjects allows the study to be stopped before the subject is at risk of heat stroke or death.

Although many of these studies evaluated measures of heat strain (e.g., core body temperature, heart rate) rather than instances of HRIs, OSHA believes that these metrics are important for understanding risk of HRIs. As discussed in Section IV., Health Effects, these metrics are intermediary endpoints on the path to HRIs (e.g., heat stroke, heat exhaustion). The controls required in the proposed standard are effective in that they reduce or slow the accumulation of heat in the body, which in turn reduces the risk of HRIs.

OSHA also examined and summarized systematic review articles that reviewed and discussed the experimental literature. These articles were written by prominent heat safety experts (in either an occupational or athletic context) and were typically conducted using a consensus-type approach. OSHA also looked outside the peer-reviewed literature for consensus statements, reports, recommendations, and requirements from governmental bodies and non-governmental organizations.

Despite the limitations noted above, the studies, review articles, and non-peer reviewed sources presented in this section represent the best available evidence OSHA has identified regarding the effectiveness of controls designed to reduce the risk of HRIs. The following summary of OSHA's findings demonstrates that the requirements of the proposed rule will be effective in reducing the risk of HRIs among workers.

II. Evidence on the Effectiveness of Individual Control Measures.

A. Systematic Reviews and Consensus Statements.

Several publications have summarized the literature on the efficacy of controls to reduce the risk of HRI in the form of review articles or consensus statements. For example, Morris et al. (2020) assessed systematic reviews, meta-analyses, and original studies on heat-related intervention strategies published in English prior to November 6, 2019, that included studies conducted at ambient temperatures over 28°C or among hypohydrated (i.e., fluid intake is less than water lost through sweat) participants, used healthy adult participants, and reported physiological outcomes (e.g., change in heart rate, core temperature, thermal comfort) and/or physical or cognitive performance outcomes. Most of the captured articles were from the exercise literature, but 9 of the 36 systematic reviews (i.e., a detailed and comprehensive reviews of relevant scientific studies and other evidence) mentioned occupational exposure in various professions, such as military personnel, firefighters, and emergency responders. A second search identified 7 original studies that were not covered in the systematic reviews. Based on their systematic review, the study authors identified the following effective interventions: environmental conditioning (e.g., fans, shade, air-conditioning); optimal clothing (e.g., hats; loose fitting, light/brightly colored/reflective, breathable, clothing; ventilation patches in PPE; cooling garments/PPE); physiological adaptation (e.g., acclimatization, improving physical fitness); pacing (e.g., reduced work intensity, breaks); hydration and nutrition (e.g., hydration, electrolytes); and personal cooling options (e.g., cold water ingestion, water immersion). They also noted that “a generally under investigated, yet likely effective. . . intervention is to utilize pre-planned breaks in combination with the cooling interventions mentioned above.” Morris et al. (2020) also noted that “maintaining hydration is important for maintaining cognitive and physical performance” (Morris et al., 2020).

Morrissey et al. (2021b) assembled 51 experts with experience in physiology, occupational health, and HRIs to review and summarize current data and gaps in knowledge for eight heat safety topics to develop consensus recommendations. The experts created a list of 40 heat safety recommendations within those eight topics that employers could implement at their work site to protect workers and to avoid productivity losses associated with occupational heat stress. These recommendations for each of the eight topics included:

(1) Hydration: e.g., access and availability to cool, potable water; training on hydration; addressing availability of fluids during rest breaks in the prevention plan;

(2) Environmental monitoring: e.g., measurements as close to the work site as possible; consideration of environmental conditions (e.g., temperature, humidity, wind speed, radiance), work demands, PPE, and worker acclimatization status in assessing heat stress; including environment-based work modifications (e.g., number of rest breaks) in a prevention plan;

(3) Emergency procedures and plans: e.g., availability of an emergency plan for each work site; identification of personnel to create, manage, and implement the plan; making available, rehearsing, and reviewing the plan annually;

(4) Body cooling: e.g., availability of rest/cooling/hydration areas made accessible to workers as needed; cooling during rest breaks (e.g., immersion, shade, hydration, PPE removal); use of fans (at temperatures below 40ºC (104ºF)) or air-conditioners; use of portable cooling strategies (e.g., ice, water, ice towels) in areas without electricity; use of cooling strategies before, during, and after work; cooling PPE used under other PPE when PPE can't be removed;

(5) Acclimatization: e.g., creation and implementation of a 5-7 day acclimatization plan; plans for both new and returning workers that are tailored to factors such as environmental conditions and PPE; training on benefits of acclimatization;

(6) Textiles/PPE: e.g., use of clothing/PPE that is thin, lightweight, promotes heat dissipation, that fits properly, and adequately protects against hazards; PPE with ventilated openings; removal of PPE/extra layers during rest periods;

(7) Physiological monitoring (e.g., checking heart rate/body temperature); and

(8) Heat hygiene: e.g., annual training on heat related illness, prevention, first aid, and emergency response in language and manner that is easily understood; designated personnel or "buddy approach to monitor for symptoms"; communication strategies to inform employees of heat mitigation strategies before the work shift, healthcare worker using examination results (if examinations are required or recommended) to educate employees.

Racinais et al. (2015) presented consensus recommendations to reduce physiological heat strain and optimize sports performance in hot conditions that were developed in roundtable discussions by a panel of experts. While recommendations were focused on athletes, the study authors noted that current knowledge on heat stress is mainly available from military and occupational research, with information from sport sciences available only more recently. The study authors recommended three main interventions. The first recommendation, considered to be most important by study authors, was acclimatization, involving repeated training in heat for at least 60 minutes a day over a 1-2 week period. The authors explained that acclimatization attenuates the physiological strain of heat by improving cardiovascular stability and electrolyte balance through an increase in sweat rate, skin blood flow, and plasma volume. The second recommendation was drinking sufficient fluids to maintain adequate hydration before and after exercise. Study authors explain that sweating during exercise can lead to dehydration which, if not mitigated by fluid intake, has the potential to exacerbate cardiovascular strain and reduce the capacity to exercise in the heat. The third recommendation was cooling methods to reduce heat storage and physiological strain (e.g., fanning, iced garments/towels, cold fluid intake, cooling vests, water immersion). Additional recommendations for event organizers included planning for shaded areas, cooling and rehydration facilities, and longer recovery periods (i.e., break periods) for hydration and cooling.

B. Summary for Systematic Reviews and Consensus Statements.

In conclusion, OSHA reviewed three sets of recommendations on effective controls to prevent HRI developed by scientific experts following extensive literature reviews. A number of the recommendations were consistent with requirements or options in OSHA's proposed standard. For example, all three groups of experts recommended hydration, rest breaks, shade, cooling measures such as fans, and acclimatization (Morris et al., 2020; Morrissey et al., 2021b; Racinais et al., 2015). Two of the expert groups also recommended cooling methods such as air conditioning (Morris et al., 2020; Morrissey et al., 2021b). One of the groups recommended environmental monitoring, development of emergency procedures and plans, training, a buddy system to monitor for health effects, and communication of heat mitigation strategies (Morrissey et al., 2021b).

III. Experimental and Observational Evidence.

A. Rest Breaks.

Administrative controls, such as varying employees' work schedules, are a well-accepted and long-standing approach to protect workers from occupational hazards. Administrative controls are regularly used to address limitations in human capacity for physical work and commonly include work-rest cycles. Rest breaks provide an opportunity for workers to reduce their metabolic rate and body temperature periodically throughout the day. Length and frequency of breaks can be adjusted based on heat exposure, workload, acclimatization, and clothing/PPE factors. Such an approach of work-rest cycles that consider these factors has been recommended by NIOSH and ACGIH (NIOSH, 2016; ACGIH 2023). Observational and experimental studies show the effectiveness of rest breaks in reducing heat strain that could lead to HRIs, and those studies are described below. In addition to reducing heat strain, rest breaks allow workers to take advantage of other cooling strategies, such as hydrating, removing PPE, and sitting in areas that are shaded, cooled, or fanned. The literature on the efficacy of rest breaks described below includes observational studies of workers, laboratory-based exercise trials, and predictive modeling.

I. Observational Studies.

Several observational studies examined participants in work settings or training exercises while at work and at rest and evaluated the associations between rest breaks or time at rest and markers of heat strain.

Horn et al. (2013) evaluated core body temperature and heart rate (HR) among nine firefighters (six male and three females, ages 20-45 years) over a 3-hour period in which four repeat bouts of firefighting drills were conducted (approximately 15-30 minutes each) while wearing full PPE and a self-contained breathing apparatus. The drills were separated by three rest periods (approximately 20-40 minutes each) in which the firefighters were encouraged to hydrate and cool down by removing their gear, while being evaluated/critiqued by instructors and refilling air cylinders. The study authors estimated the duration of work and rest cycle lengths based on sustained rates of heart rate increases and decreases. Ambient temperatures ranged from 15°C to 25°C (59-77°F) during the summer and fall months when this study was conducted. During work cycles, mean maximum core temperatures ranged from 38.4-38.7°C, mean peak heart rate ranged from 181.2-188.4 beats per minute (bpm), and the mean average heart rate (averaged over 60 second intervals per work cycle) ranged from 139.6-160.0 bpm. Mean maximum core temperature and mean average heart rate decreased during rest periods, and the study authors concluded that physiological recovery in this study appeared to be closely linked to the duration of rest periods. Rest break duration was significantly and negatively correlated with the following measurements taken during rest breaks: minimum heart rate (r: -0.687, $p<0.001$), average heart rate (r: -0.482, $p=0.011$), and minimum core temperature (r: -0.584, $p=0.001$), indicating that longer breaks result in reduced heat strain. The authors concluded that the association was independent of obesity, fitness, and intensity of firefighting activities. Limitations noted by study authors included enrollment of young firefighters who were screened for cardiovascular disease, and thus might not represent the whole firefighting population. In addition, “significant breaks” were provided and the duration of exposure to fires was shortened later in the day, both factors that might underestimate increases in core temperatures with longer firefighting activities and shorter breaks.

Petropoulos et al. (2023) characterized heat stress and heat strain in a cohort of 569 male outdoor workers in Nicaragua (sugarcane, plantain, and brickmaking industries) and El Salvador (sugarcane, corn, and construction industries) across three workdays in 2018. Median wet bulb globe temperatures (WBGT) ranged from 26.0-29.2 °C (78.8-84.6°F) and median heat index ranged from 28.5-36.1°C (83.3-97.0°F) at the work sites. Time spent on rest breaks-estimated based on physical activity data collected with an accelerometer (i.e., a device that can be used to measure physical activity and sedentary time)—was estimated at 4.1-21% of the shift. A 10% increase in the time spent on break was associated with a 1.5% absolute decrease in median percent maximum heart rate (95% CI: -2.1%, -0.85%; p<0.0001), when adjusting for industry/company, job task, shift duration, liquid consumption, median WBGT, and mean metabolic rate. Petropoulos et al. (2023) found no significant associations between rest breaks and maximum core body temperature, and concluded that the lack of findings could have been due to incomplete control of confounding factors.

Lucas et al. (2023) examined the effects of recommended rest breaks for sugarcane workers in Nicaragua, specifically in male burned cane cutters, by comparing the period from 2019-2020, identified as Harvest 3 (H3; n=40 burned cane cutters) with the period from 2018-2019, identified as Harvest 2 (H2; n=12 burned cane cutters).

OSHA notes that a major limitation of the study identified by authors was a shorter shift duration by 1 to 2 hours for seed cutters (SC) during H2, and that "the shorter shifts in H2 likely affected SC workload comparisons between H2 and H3 and could explain why increasing the rest component in H3 did not reduce the physiological workload in this group." Because of this limitation in seed cutters, this summary focuses on effects on burned cane cutters. In H3, an extra 10-minute rest break was recommended (increasing recommended rest breaks to a total of 80 min over a six-hour shift), and interventions from H2 were continued (e.g., improvements to hydration and movable tents, in addition to delaying cutting after burning to reduce radiant heat exposure). Daily average WBGT was higher in H2: 29.5°C (85.1°F) than in H3: 26.7°C (80.6°F). Rest periods were defined by a greater than 10 bpm drop in heart rate lasting 4 or more minutes, as determined by continuous measurements by heart rate sensors worn on the chest; based on those measurements, the rest/work ratio for burned cane cutters increased slightly from 21% rest in H2 to 26% rest in H3. Average percent maximum heart rate (adjusted for age) decreased slightly in H3 compared to H2 (mean [95% CI] 63% [60-65%] to 58% [56-60%]) across the work shift). No significant differences were noted for estimated core temperatures (based on modeling) from H2 to H3. The study authors acknowledged that observational study design, small number of workers in H2, and the lower temperatures in H3 may make conclusions uncertain; therefore experimental laboratory studies may better test the impact of the intervention. OSHA also observes that the increased number of burned cane cutters observed from H2 to H3 means that the population of workers observed was different in the two periods and results may have been affected by different characteristics of the workers.

Ioannou et al. (2021a) examined the effectiveness of rest breaks of different durations in agricultural, construction, and tourism employees. Findings in the intervention group were compared to a "business as usual" (BAU) group, where workers followed their normal routine. Of note, shaded areas, water stations, and air-conditioned areas to be used for rest breaks were part of BAU for construction workers in Spain; those same interventions were part of BAU for construction workers in Qatar, in addition to requiring workers to carry a water bottle, and education. BAU practices were not specified for the agriculture and tourism industries, but according to communications with study authors, the BAU agricultural employees in Qatar were not offered scheduled work/rest cycles, and agricultural employees who were monitored in Qatar performed low intensity work (Communication with Leonidas Ioannou, April 2024). Endpoints observed included core temperature, skin temperature, heart rate, and metabolic rate. No significant effects compared to the BAU group were observed for any of these endpoints for agricultural workers in Cyprus provided with a 90-second break every 30 minutes, tourism workers in Greece provided with a 90-second break every 30 minutes or a 2-minute break every 60 minutes combined with ice slurry ingestion, or construction workers in Spain provided with two 7-minute breaks over the workday. For employees in Qatar who were provided with 10-minute breaks every 50 minutes, significant differences in the intervention group compared to the BAU group included lower mean skin temperature, heart rate, and metabolic rate for construction employees, but increased heart rate for agricultural employees. The study authors postulated that the increased heart rate in agricultural workers resulted from inherent changes in body posture (i.e., moving from a crouching position while crop picking to standing and walking during breaks). A limitation in this study is that some BAU groups, which were used as comparison groups, appeared to have access to breaks in air-conditioned areas and it was not described how the frequency or duration of rest breaks varied between the intervention and BAU groups.

Two additional studies were conducted in utility workers. In a case study by Meade et al. (2017), conducted in an unspecified location, four highly experienced electrical utilities workers were observed via video analysis over two consecutive hot days. The study authors noted that employees often spent 80% or more of the monitoring period working in direct sunlight. Meade et al. (2017) reported similar average core body temperatures and average %HRmax on both days, despite an increase in the percentage of time spent at rest on Day 2 versus Day 1 (time at rest: 66±5%, range: 60-71%, on Day 2 versus 51±15%, range: 30-63% on Day 1). Three of the four workers had a higher peak core temperature on Day 2 than Day 1. The study authors attributed these core temperature and heart rate trends in part to residual heat storage or fatigue-related changes in work efficiency that possibly occurred over two consecutive work shifts. Meade et al. (2016a) observed work and rest periods in 32 electrical utilities workers (mean age of 36 years; 11 ground workers, 9 bucket workers, 12 manual pole workers; 17 in West Virginia, 15 in Texas) via video analysis and accelerometry over 1 day (Heat Index: West Virginia 48 ± 3°C (118.4°F), Texas 42 ± 3°C (107.6°F)). On average, the work-to-rest ratio was (3.1 ± 3.9):1 and workers rested for a total of 35.9 ± 15.9% of the work shift. Heat index, work-to-rest ratios, work shift duration, and time at rest were not significantly correlated with mean core temperature or %HRmax. However, time spent or percentage of time in heavy work was moderately, positively correlated with mean core temperature (r=0.51) and %HRreserve (r=0.40) (i.e., increased time spent in heavy work was associated with increased mean core temperature and %HRmax). OSHA notes limitation in these studies, including, for example, the very small sample size in Meade et al. (2017) and lack of adjustment for possible confounding factors in Meade et al. (2016a).

A limited number of cross-sectional studies surveyed or interviewed employees for self-reported symptoms of HRI to determine possible risks associated with inadequate breaks. These types of studies are the most limited because of uncertainties such as recall bias (i.e., inaccurate recollection of previous events or experiences) and the potential for dependent misclassification as a result of using self-reporting for characterizing both the exposure and outcome. Therefore, only brief summaries of these studies are provided. Two of these studies were conducted in agricultural workers in the U.S. (Spector et al., 2015; Fleischer et al., 2013), and one was conducted in pesticide applicators in Italy (Riccò et al., 2020). Spector et al. (2015) found a significantly increased odds of HRI in workers paid by piece as compared to workers paid hourly (OR: 6.20, 95% CI: 1.11, 34.54). Spector et al. (2015) noted that piece rate workers might work harder and faster because of economic incentives, thus leading to increased metabolic heat generation; however, adjustment for task and exertion in the small sample size of employees did not completely attenuate the observed association, thus suggesting other factors contributed to development of symptoms. Through population intervention modeling, Fleischer et al. (2013) estimated that the prevalence of three or more HRI symptoms could be reduced by 6.0% if workers had access to regular breaks, and by 9.2% if breaks were taken in shaded areas. Of note, participants in the study were asked about "regular breaks," but the term was not specified regarding frequency and duration. Lastly, Riccò et al. (2020) found taking rest breaks in shaded, non-air-conditioned areas was associated with experiencing HRI (adjusted OR: 5.5, 95% CI: 1.4, 22), while taking rest breaks in cooler, air-conditioned areas was not. Riccò et al. (2020) discussed possible reasons for the observed association between shaded rest breaks and incidences of HRI, including that (1) taking breaks in shade may be insufficient to prevent HRIs among pesticide applicators who undertake more strenuous tasks or have longer exposures to unsafe limits, and (2) rest breaks in shade may be taken to alleviate, rather than prevent, HRI symptoms (i.e. possible reverse causation).

II. Experimental Studies.

OSHA examined a number of laboratory studies that provide information on the efficacy of rest breaks for preventing heat strain or HRI in subjects exercising under conditions that include high heat and at least moderate activity. The studies typically measured rectal temperature, which allowed for an assessment of the efficacy of breaks in maintaining lower rectal temperatures and slowing the increase in rectal temperatures. ACGIH (2023) indicates that an increase in rectal temperature exceeding 1°C from a "pre-job" temperature of less than 37.5°C might indicate excessive heat strain. One study summarized below also examines the effect of rest breaks on the autonomic nervous system and cardiovascular function.

Smallcombe et al. (2022) conducted a study over a seven-hour period that was designed to mimic a typical workday in the U.S. In that study, 9 males (average age 23.7 years) of varying fitness levels walked on a treadmill at speeds to maintain a constant heart rate of 130 bpm, which the authors indicated to be the demarcation between moderate and heavy strain. The subjects completed six cycles of exercise for 50 minutes in the heat chamber separated by 10 minutes of rest at an ambient temperature of 21°C (69.8°F), 50% relative humidity (RH) while drinking water as desired. A one-hour lunch period was also provided at 21°C (69.8 F), 50% RH after the third exercise period, with all subjects given the same lunch and allowed to drink water as desired. Each subject was tested under 4 temperature conditions: 1) referent (cool condition) at 15°C (59°F) (WBGT = 12.6°C); 2) moderate condition at 35°C (95°F) (WBGT = 29.4°C); 3); hot condition at 40°C (104°F) (WBGT = 33.4°C); and 4) very hot condition at 40°C (104°F) (WBGT = 36.1°C). The RH for each temperature condition was approximately 50%, except for the very hot condition, which was 70% RH. In the very hot condition group, data were limited for the sixth exercise cycle because an unspecified number of participants reached the cut-off point for terminating the study (i.e., a heart rate exceeding 130 bpm while at rest).

Significant increases in mean rectal temperature were observed in the moderate, hot, and very hot condition groups in work period 1 versus work period 6, but the average rectal temperature remained at or below 38°C (100.4ºF) in all groups during each exercise period (Figure S1 and Table S2) (Smallcombe et al., 2022). No individual subject had a rectal temperature that exceeded 38°C in the referent and moderate condition groups, however, three subjects exceeded 38°C in the hot exposure group, and four subjects exceeded 38°C in the very hot exposure group. With the exception of two subjects whose rectal temperatures were measured at approximately 38.6°C (101.5°F) and 38.7°C (101.7°F) in the very hot exposure group, all rectal temperatures were below 38.5°C (as estimated from Figure S1). In addition, mean rectal temperatures dropped during each rest period, with all rectal temperatures measured near or below 38°C by the end of the rest period (as estimated from Figure 4). Skin temperatures did not increase during work periods. The authors concluded that under the conditions of this study, which limited metabolic heat production based on the fixed heart rate protocol, participants rarely reached levels of core temperature that would be concerning. Study limitations noted by study authors included possible limited relevance of breaks provided in cooler areas, and the possibility that thermo-physiological impacts may have been higher had breaks not been provided in cooler areas or metabolic heat production not been limited.

In Uchiyama et al. (2022) thirteen males (average age 39 years) each underwent two 225-minute trials that included 180 minutes of treadmill walking in a chamber at 37°C (98.6°F) and 40% RH interspersed with 45 minutes of rest breaks in an air-conditioned room at 22°C (71.6°F) and 35% RH, designed to mimic summer working and rest conditions at mines in Northwest Australia. Participants were allowed to drink room temperature water during exercise and refrigerated water while on rest breaks. Two different rest/work cycles were tested, including (1) current practice: 1 hour of work and 30 minutes of rest, followed by 1 hour of work and 15 minutes rest, and a final 1 hour work period; and (2) experimental: 1 hour of work and 15 minutes rest, followed by three half hour work periods separated by 10-minute rest periods and, and a final half hour work period. OSHA observes that in the current practice group, average core temperature only increased by more than 1°C (1.8°F) of baseline level at the final measurement reported at 180 minutes into the study (increased from 37.2°C at baseline to 38.29°C at 180 minutes). Average core temperatures remained within 1°C of baseline levels in the experimental group at all time points.

Three studies (Meade et al., 2016b; Lamarche et al., 2017; and Kaltsatou et al., 2020) conducted 2-hour studies in which small groups of 9-12 males cycled in a heat chamber at 360 watts (W) of metabolic heat production (considered moderate-to-heavy intensity and equivalent to conditions experienced by some workers in the mining and utility industries). Over the 2-hour period, the effects of various temperatures (approximate values provided) and work/rest protocols recommended by ACGIH were examined including: (1) continuous work at WBGT 28°C (82.4°F) (41°C (105.8°F) dry-bulb, 19.5% RH or 36°C (96.8°F) dry-bulb, 38% RH); (2) a 3:1 work/rest ratio (15 min work, 5 min rest) at WBGT 29°C (84.2°F) (43°C (109.4°F) dry-bulb, 17.5% RH or 38°C (100.4°F) dry-bulb, 34% RH); and (3) a 1:1 work/rest ratio (15 min work, 15 min rest) at WBGT 30°C (86°F) (46°C (114.8°F) dry-bulb, 13.5% RH or 40°C (104°F) dry-bulb, 30% RH). Meade et al. (2016b) examined a fourth condition: 4) a 1:3 work/rest ratio (15 min work, 45 min rest) at WBGT 31.5°C (88.7°F) (46.5°C (115.7°F) dry-bulb, 17.5%

RH). The mean age of participants in the Meade et al. (2016b) study was 21 years while the mean age in both the Lamarche et al. (2017) and Kaltsatou et al. (2020) studies was 58 years.

Meade et al. (2016b) found that among younger males, the percentages of participants with rectal temperatures exceeding 38°C over the 2-hour protocol was lower in the groups who took longer rest breaks, despite those groups also being subjected to a higher WBGT. Meade et al. (2016b) reported core temperatures exceeding 38°C in 12% of participants in the 1:3 work/rest at 31.5°C WBGT group, 0% in the 1:1 work/rest at 30°C WBGT group, 33% in the 3:1 work/rest at 29°C WBGT group, and 33% in the continuous work at 28°C WBGT group.

Lamarche et al. (2017) found that among older males, the percentage of participants with rectal temperatures exceeding 38°C over the 2-hour protocol was lowest in the group with the longest breaks (i.e., 67% in the 1:1 work/rest at 30°C WBGT group, 100% in the 3:1 work/rest at 29°C WBGT group, and 100% in the continuous work at 28°C WBGT group) although the findings did not achieve statistical significance. Lamarche et al. (2017) also reported that time to exceed a rectal temperature of 38°C was higher in both groups who received rest breaks as compared with the continuous work group and this did reach statistical significance. Specifically, the time to exceed a rectal temperature of 38°C was 100 minutes in the 1:1 work/rest at 30°C WBGT group, 79 minutes in the 3:1 work/rest at 29°C WBGT group, and 53 minutes in the continuous work at 28°C WBGT group. Further, because of heat exhaustion, five participants in the Lamarche et al. (2017) study did not complete the continuous work at 28°C WBGT protocol, one did not complete the 3:1 work/rest at 29°C WBGT protocol, but all completed the 1:1 work/rest 30°C WBGT protocol. No significant differences in heart rate were observed.

Kaltsatou et al. (2020) examined autonomic stress and cardiovascular function in the same subjects examined by Larmarche et al. (2017). The authors measured 12 markers of heart rate variability (HRV), a predictor of adverse heart events, most of which are associated with the autonomic nervous system (i.e., a part of the nervous system that controls involuntary responses including heart rate and blood pressure). After one hour of accumulated work and when rectal temperatures exceeded 38°C, three markers of HRV were significantly lower in the continuous work group than in the 3:1 work/rest at 29°C WBGT group. One marker of HRV was significantly lower in the continuous group, compared to the 1:1 work/rest at 30°C WBGT group at 1 hour of accumulated work. After 2 hours of accumulated work, 4 markers of HRV were significantly lower in the continuous work group compared to the 1:1 work/rest at 30°C WBGT group. Study authors interpreted these results to indicate that continuous work was the least safe for workers, while a 1:1 work/rest ratio offered the best protection. Kaltsatou al. (2020) concluded that breaks during moderate-to-heavy work in heat can reduce autonomic stress and increase the time to exceed a rectal temperature of 38°C.

In the studies by Meade et al. (2016b), Lamarche et al. (2017), and Kaltsatou et al. (2020), participants were well-hydrated before the study period but not provided drinking water during the study. Kaltsatou et al. (2020) acknowledged that not providing water during the study could have affected sweat secretion and, as a result heat balance, hydration status, baroreceptor function (involved in blood pressure regulation), and the autonomic control of heart rate. OSHA agrees and also notes that rest breaks were provided in the same ambient conditions as work periods, and studies were conducted at a fixed work rate that would have not considered possible effects of self-pacing. Because hydration and shade or cooling measures during rest breaks would be provided as part of an effectively implemented multi-pronged approach to preventing HRI, OSHA preliminarily concludes that some of the effects observed in these studies might have been less severe if interventions other than rest were provided.

In a study by Chan et al. (2012), recovery time, as measured by physiological strain index (based on heart rate and core temperatures), was determined in 19 healthy construction rebar employees (mean age 45 years) who had worked until exhaustion at building construction sites in Hong Kong in July and August of 2011. Average recovery during rest was reported at 94% in 40 minutes, 93% in 35 minutes, 92% in 30 minutes, 88% in 25 minutes, 84% in 20 minutes, 78% in 15 minutes, 68% in 10 minutes, and 58% in 5 minutes. Yi and Chan (2013) used the field-based meteorological and physiological data reported by Chan et al. (2012) to model ideal rest breaks to minimize HRI. Based on a Monte Carlo simulation, the authors determined that a 15-minute break after 120 minutes of continuous work in the morning at 28.9°C (84.0°F) WBGT and a 20-minute break after 115 minutes of continuous work in the afternoon at 32.1°C WBGT (90.0°F) maximized productivity time while protecting the health and safety of employees.

III. Conclusions for Rest Breaks.

OSHA reviewed several studies examining the effectiveness of rest breaks in preventing heat strain that could lead to HRI and were of sufficient quality for drawing conclusions (Horn et al., 2013; Smallcombe et al., 2022; Meade et al., 2016b; Lamarche et al., 2017; Kaltsatou et al., 2020; Petropoulos et al., 2023). The studies, involving individuals exposed to conditions of high heat stress, demonstrated the effectiveness of rest breaks in preventing measures of heat strain that can lead to HRI. Observational studies with detailed measurements of temperatures in firefighters doing training exercises and experimental studies in laboratory settings reported that rest breaks result in lower core or rectal temperatures during rest periods following work periods (Horn et al., 2013; Smallcombe et al., 2022), and lower rectal temperatures over the study period (Meade et al., 2016b; Lamarche et al., 2017), with all of the studies showing greater effectiveness of longer compared to shorter duration work breaks. Similarly, Chan et al. (2012) reported increased physiological recovery with longer rest periods. Uchiyama et al. (2022) reported little evidence of heat strain in participants exercising in hot conditions and provided rest breaks. The study by Lamarche et al. (2017) also found that rest breaks were effective in preventing heat exhaustion in a laboratory setting. OSHA also found evidence showing that rest breaks can reduce cardiovascular strain. For example, Horn et al. (2013) found that heart rates were lower in rest than in work cycles. One study done in participants in a laboratory setting showed that rest breaks can reduce autonomic stress that affects cardiovascular function (Kaltsatou et al., 2020). Those findings are consistent with an observational study of employees in occupational settings that found an association between time spent on rest breaks and decreases in heart rate when adjusted for industry/company, job task, shift duration, liquid consumption, WBGT, and metabolic rate (Petropoulos et al., 2023).

In conclusion, OSHA preliminarily finds rest breaks to be effective in reducing the risk of HRI by modulating increases in heat and cardiovascular strain.

B. Shade.

Working or resting in shade reduces the risk of HRI by decreasing exposure to solar radiation and in turn reducing overall heat load. Studies evaluating the impact of shade on heat strain metrics have predominantly been conducted in controlled settings where participants exercise in conditions approximating shade and sun exposure. Studies evaluating the physiological benefits of exercising in shade versus sun are likely to underestimate the benefits of rest breaks taken in shade because metabolic heat generation would be slowed while resting.

A number of studies examining the effects of exercising under natural or simulated conditions of sun or shade have demonstrated benefits of shade. One group of investigators conducted studies where participants cycled under simulated laboratory conditions of sun or shade (Otani et al., 2016; Otani et al., 2021); both studies were conducted under conditions of 30ºC (86ºF) and 50% RH, and participants cycled at a rate of 70% maximum oxygen uptake until reaching full exhaustion. The Otani et al. (2021) study also involved exposures to low and high wind speeds. The same investigators conducted 45-minute, self-pacing cycling trials outdoors under various natural sunlight conditions, including clear skies or thick and thin cloud covers (Otani et al., 2019). These studies reported that higher exposure to solar radiation resulted in higher skin temperatures (Otani et al., 2016, 2019, 2021) and reduced work output (measured as endurance capacity/time-to-exhaustion (Otani et al., 2016; 2021) or power output (Otani et al., 2019)). In increased sun conditions, Otani et al. (2021) reported higher rectal temperatures, heart rates, and thermal sensation. Otani et al. (2019) reported greater thermal sensations, and body heat gain from the sun, but no significant effects on rectal temperature or heart rate in increased sun conditions. Otani et al. (2016) reported no differences in rectal temperatures or heart rates in increased sun conditions. The authors speculated in their 2019 paper that the lack of rectal temperature increase in that study likely resulted from a reduction in self-regulated exercise under sunny conditions (Otani et al., 2019). They did not however speculate reasons for the lack of rectal temperature increases in their 2016 paper. OSHA notes that under equivalent (full sun) solar radiation levels the time it took participants to reach exhaustion in the Otani et al. (2021) study under low wind speeds (35.4 minutes) was longer than the time it took participants in the Otani et al. (2016) study to reach exhaustion (22.5 minutes), and OSHA expects that the disparate findings on rectal temperatures may have resulted from differences in total cycling time.

In a study by Nielsen et al. (1988) participants cycled at a fixed rate outdoors in the sun for 60 minutes, were shaded for 30 minutes while continuing to cycle, and then cycled again in the sun for another 30 minutes, for a total of 120 minutes. Study authors noted that cloud formation interrupted 3 of the 20 cycling trials. Average rectal temperatures rose sharply during the first period of cycling in sun, dropped slightly (non-significantly) during the period of cycling in shade, and then gradually increased again during the final cycling period in full sun. Skin temperatures remained fairly constant during the initial period of cycling in sun, dropped significantly by 1.5°C (2.7°F) while cycling in shade, and rose again sharply during the final cycling period in the sun. Heart rate, oxygen consumption, and sweat rate were significantly higher in the final cycling period in full sun, compared to the cycling period in shade. Study authors concluded that heat received from direct solar radiation "imposed a measurable physiological stress."

In a study examining work capacity in adults walking for one hour under various conditions of solar radiation (full sun or full shade), temperature (25°C through 45°C; 77°F through 113°F), humidity (20% or 80%), and clothing coverage, Foster et al. (2022b) reported that work capacity (calculated using treadmill speed and grade) was generally lower under full sun conditions than shaded conditions. Under humid conditions, work capacity was reduced by solar radiation for all scenarios. Under dry conditions, work capacity reduction varied by clothing coverage with those wearing full-body work coveralls showing reduced work capacity at temperatures ≥ 35°C (≥ 95°F) and those wearing minimal clothing showing reduced work capacity at temperatures ≥ 40°C (≥ 104°F). Skin temperature was generally higher under full sun conditions, and the authors speculated that a lack of effect on core body temperatures likely resulted from self-regulation during exercise.

Ioannou et al. (2021b) conducted a laboratory based randomized control trial in which seven participants completed cycling trials under full sun (800 W/m^2) and full shade (0 W/m^2) in hot (WBGT 30°C) and temperate (WBGT 20°C) conditions. The full sun condition was associated with increased skin temperature at both temperatures. Average core body temperature was similar between sunny and shaded conditions (37.7 and 37.6 °C for sun versus shade in hot conditions and 37.2 °C for both sun and shade in temperate conditions). Solar radiation had a small, positive relationship with heart rate (average heart rate of 114.0 and 109.1 bpm in sun versus shade in hot conditions and 102.6 and 95.4 bpm in sun versus shade in temperate conditions) (Ioannou et al., 2021b).

Although these experimental studies largely assessed the effects of shade during exercise and not rest periods, they do support the idea that shade reduces heat strain generally; therefore, OSHA preliminary concludes that it is reasonable to assume access to shade would also reduce heat strain during rest periods. This conclusion is also supported by evidence that shade reduces heat exposure (see discussion below) and that heat exposure is positively associated with heat strain (see discussion in Section IV., Health Effects). OSHA identified no major limitations in these studies that would preclude their use in drawing conclusions about effectiveness. One aspect of all these studies that limit applicability to the larger workforce is that participants were all young and healthy and all or mostly male (age was not specified in Ioannou et al., (2021b)), and the studies were done for relatively short durations of time (2 hours or less). The authors of the Otani et al. (2021) and Foster et al. (2022b) studies that used artificial solar radiation noted that their studies would not reflect changes in the sun's position during the day or changes in radiation intensity levels, and that limitation would be relevant to the other studies using artificial sources of solar radiation at one intensity level.

There are also two observational studies in the peer-reviewed literature that have evaluated the association between shade and risk of HRI. In a case-control study of 109 acclimatized construction and agriculture workers, Ioannou et al. (2021b) monitored workers for four or more consecutive 11-hour shifts, in which environmental factors were continuously measured and work hours characterized by the same thermal stress but different solar radiation levels were isolated. Solar exposure was categorized as either indoors, mixed indoors and outdoors, or outdoors, and analyses were done for data collected during conditions of 30°C WBGT. Results included a positive association between sun exposure and skin temperature and a significantly higher risk for heat strain symptoms (relative risk (RR)=2.40, 95% CI: 1.78, 3.24) and reported weakness (RR=3.17, 95% CI: 1.76, 5.71) among workers exposed to solar exposure characterized as outdoors as compared to workers exposed to solar exposure characterized as indoors. Core body temperature, heart rate, and metabolic rate were not found to be associated with sun exposure. The authors attributed the lack of change in core temperature and heart rate to the effect of self-pacing. OSHA notes that the study did not control for confounding variables.

Fleischer et al. (2013) used population intervention modeling of self-reported HRI symptoms in farmworkers in Georgia to estimate that the prevalence of three or more HRI symptoms could have been reduced by 9.2% (95% CI: -15.2%, -3.1%) if workers could always or usually take breaks in the shade. There were limitations to this analysis, including the cross-sectional study design, the self-reported exposure and outcome data, and low participation rate.

Additional studies have evaluated differences in microclimatic conditions between shady and sunny environments, independent of heat strain metrics measured in human subjects. These studies provide clear evidence that shade reduces radiant heat (Cheela et al., 2021; do Nascimento Mós et al., 2022; Fournel et al., 2017; Karvatte et al., 2016, 2021; Klok et al., 2019; Lee et al., 2020; Middel and Krayenhoff, 2019; Sanusi et al., 2016; Zhang et al., 2022). As discussed above, indicators of heat strain (e.g., rectal temperature) often increase with exposure to solar radiation. These authors examined the impact of shade through direct measures that assess radiant heat (e.g., globe temperature, mean radiant temperature) or through thermal stress metrics (e.g., Universal Thermal Climate Index) that incorporate radiant heat in their calculation.

The magnitude of the reduction in radiant heat from shade, however, varies by local conditions, with notable factors including the type of shade (e.g., trees, buildings, canopies, and other urban structures such as solar arrays), percent shade cover, time of day, season, and ground cover (due to its role in radiant heat emission). Fournel et al. (2017) estimated an average 4.4°C decrease in black globe temperature using data from five studies that assessed different shade interventions, while study-specific reductions ranged from 2°C to 9°C. These included a study by Roman-Ponce et al. (1977), who observed a 9°C difference in Florida under an insulated metal roof, and a study by Fisher et al. (2008), who observed a 2°C difference in New Zealand under a shade cloth structure. Examples of other studies that have evaluated the impact of shade on radiant heat include:

- Middel and Krayenhoff (2019) evaluated environmental conditions across 22 sites in Tempe, Arizona on the hottest day of the summer. They included diverse types of shade, including trees and urban structures. The authors concluded that trees decreased afternoon mean radiant temperature by up to 33.4°C and estimated that each 0.1 decrease in the sky view factor from trees (where a sky view factor of 1 is a completely open sky and 0 is fully blocked) resulted in an approximate decrease of 4°C in mean radiant temperature (Middel and Krayenhoff, 2019).
- Zhang et al. (2022) compared meteorological parameters among 12 locations in a coastal city in China. Mean globe temperature over the beach in full sun (40.9°C) was higher than mean globe temperatures in areas shaded by dense trees (28.9°C) or shaded by a pavilion canopy (30.8°C) (Zhang et al., 2022).
- Karvatte et al. (2016) evaluated the impacts of different types of natural shade (two densities of eucalyptus trees and isolated native trees) on environmental conditions in Brazil. Average black globe temperatures from 12:00pm to 1:00pm in the shade ranged from 33.2°C to 34.3°C, which were 2.4°C to 8.2°C lower than that measured in nearby sunny areas (Karvatte et al., 2016).
- do Nascimento Mós et al. (2022) evaluated the effectiveness of four different shade structures (native trees, black polypropylene netting, heat-reflective netting, and a combination of both types of netting) in the Brazilian savanna. Mean radiant temperature was consistently lower under shaded conditions. For example, at 11:00am and 12:00pm, the peak hours, the mean radiant temperatures were 16°C

to 20°C lower in shady conditions than sunny conditions (do Nascimento Mós et al., 2022).

I. Conclusions for Shade.

In conclusion, measurements of environmental conditions indicate that exposure to radiant heat is greater in full sun than in shaded conditions (e.g., Middel and Krayenhoff, 2019; do Nascimento Mós et al., 2022). It is well known that radiant heat contributes to heat stress (NIOSH, 2016). Studies confirm that indicators of heat strain (e.g., increased heart rate, increased rectal temperature) are often higher in participants exercising in conditions with actual or simulated solar radiation versus shade (e.g., Otani et al., 2021). One study showed that a 30-minute period of exercising in shade, interspersed between two periods of exercising in full sun, resulted in improved physiological responses (e.g., lower heat rate, oxygen consumption, and sweat loss) compared to the two periods of exercising in full sun (Nielsen et al., 1988). OSHA expects that improvements in physiological function might have been even greater if the participants had rested in shade because resting slows the metabolic generation of heat.

OSHA preliminarily finds that resting in shade will reduce the risk of HRI by decreasing exposure to radiant heat that contributes to heat stress and can lead to heat strain and then HRI.

C. Fans.

Fans are engineering controls that increase air movement across the skin and under the right environmental conditions can increase the evaporation of sweat, resulting in greater heat loss from the body. However, they may not be appropriate for all environments, such as at higher temperatures. Research on the role of fans in HRI prevention largely focuses on non-occupational and athletic populations, however some chamber trials have been designed to mimic working conditions. A summary of the experimental literature is provided here, beginning with studies that evaluate the use of fans during physical activity, before or after activity, and while people are at rest, and then concluding with studies that model efficacy thresholds for fan use.

Studies by Saunders et al. (2005) and Otani et al. (2018, 2021) examined the effects of different air speeds on individuals cycling in heated chambers with no rest period included in the study design (Saunders et al., 2005: 33.0°C ± 0.4°C and 59% ± 3% RH; air speeds ranging from 0.2 km/hr to 50.1 km/hr; Otani et al., 2018: 30°C and 50% RH; air speeds ranging from 0 km/hr to 30 km/hr; Otani et al., 2021: 30°C and 50% RH; air speeds of 10 and 25 km/hr). In measures of work output, at higher air velocities Saunders et al. (2005) reported increased cycling time before participants' core temperature reached 40°C (criteria for terminating the trial) and Otani et al. (2018, 2021) reported increased time to exhaustion. In lower/no compared to higher air velocities, (1) Saunders et al. (2005) reported higher mean body temperature (weighted mean of skin and rectal temperature), higher rectal and skin temperature, increased heat storage (a measure that considers changes in body temperature, in addition to body weight and surface area), and lower evaporative capacity; (2) Otani et al. (2018) reported higher rectal, skin, and mean body temperature, and lower evaporative heat loss; while (3) Otani et al. (2021) reported no significant effect on skin temperature but higher rectal temperatures. Higher heart rates were also observed at lower/no versus higher air velocities (Saunders et al., 2005; Otani et al., 2018, 2021).

Other studies have examined the effectiveness of fans during both exercise and rest periods. In Jay et al. (2019), participants conducted arm exercises designed to mimic textile work at 30°C (86°F) and 70% RH, with and without fanning. In a study by Wright Beatty et al. (2015), participants cycled in a chamber at 35°C (95°F) and 60% RH, with air velocities of 0.5 m/s and 3.0 m/s. Wright Beatty et al. designed the study to mimic occupational conditions, like those for miners (both workload and clothing). Under the fan/high air velocity conditions: (1) Jay et al. (2019) observed a smaller increase in rectal temperature, and lower skin temperature, but there was no change in heart rate because the study was designed to maintain a constant heart rate; and (2) Wright Beatty et al. (2015) observed lower rectal temperatures and heart rates. Jay et al. also compared effectiveness of fanning to the presence of air-conditioning (7°C lower temperature) and found higher work output and lower rectal temperature in both the fanning and air-conditioning groups (relative to the hot condition without fanning), while sweat loss was higher with fanning compared to air-conditioning (Jay et al., 2019). Wright Beatty et al. tested their conditions among both older (~59 years old) and younger (~24 years old) participants and observed similar benefits of higher air velocity among both age groups (Wright Beatty et al., 2015).

In a handful of other studies, researchers tested the efficacy of fan use during rest breaks, after subjects exercised under hot conditions (Sefton et al., 2016; Selkirk et al., 2004; Barwood et al., 2009; Carter, 1999). Conditions for these studies were (1) Sefton et al.: 32°C ± 0.5°C and 75% ± 3% RH, with shirt and under shirt removed during cooling, with and without misting fan; (2) Selkirk et al.: 35°C and 50% RH wearing firefighting protective clothing and breathing apparatuses during exercise and removal of protective gear during cooling periods with and without a misting fan; (3) Barwood et al.: 31°C ± 0.2°C and 70% ± 2% RH , with and without whole body fanning; and (4) Carter: 40°C and 70% RH wearing firefighting protective clothing and breathing apparatuses during exercise and removal or unbuckling of protective gear during cooling periods with and without a fan. In the study by Sefton et al. (2016), rectal temperatures rose during the cooling period, regardless of misting fan use, but heart rate was lower with misting fan use; the study authors noted that under the high humidity conditions of their study, misting fans could have increased the moisture in air, thereby reducing cooling through sweat evaporation. Other studies found fans or misting fans to be effective in improving body temperature or cardiac effects. In comparisons of normal recovery conditions (unbuckling of fire-fighting coat and no fan use during rest) to enhanced recovery conditions (fire-fighting coat was removed and fan used during rest), Carter (1999) reported lower rectal and skin temperatures, heart rate, and oxygen consumption during enhanced recovery compared to normal recovery conditions. Selkirk et al. (2004) reported that the use of a misting fan during rest breaks compared to no fan use resulted in lower rates of rectal temperature increase, and lower skin temperatures and heart rates. Barwood et al. (2009) reported that reductions in rectal and skin temperatures during rest periods were greater with fan use than without, but there was no significant effect on heart rate. Selkirk et al. (2004) also found that participants were able to exercise longer when taking rest breaks with misting fans than they were when taking rest breaks without misting fans, and Barwood et al. (2009) found that participants were able to run farther distances following whole-body fanning.

Other studies examined the use of fans during breaks in areas cooler than where exercise took place. Hostler et al. (2010) conducted a study similar to that by Selkirk et al., described above, where subjects exercised on a treadmill while wearing firefighting protective gear under hot conditions (35.1 ± 2.7°C, RH not specified), but in contrast to Selkirk et al. (2004), rest periods took place at room temperature (24.0 ± 1.4°C) instead of in the heat chamber and a non-misting fan was used. In contrast to findings from Selkirk et al. (2004), Hostler et al. (2010) reported that fanning during breaks had no significant effects on core temperature, heart rate, or exercise duration, and they speculated that this was because rest breaks took place in a cooler area. The authors conclude that active cooling devices may not be needed if the temperature of the rest area is below 24°C (75.2°F). Tokizawa et al. (2014) reported that after pre-cooling in an area that was 28°C and had 40% RH, participants walking in a heat chamber (37°C and 40% RH) wearing protective clothing had lower rectal temperatures, heart rate, and weight loss when exposed to fans and water spray in the precooling period than the control condition without fans and water spray (Tokizawa et al., 2014).

Additional studies provide information on conditions and populations for which fans may or may not be effective. Ravanelli et al. (2015; 2017) found that participants (mean age 24 ± 3 years) were able to be exposed to higher levels of humidity at temperatures of 36°C or 42°C when using fans before increases in esophageal temperatures and heart rate were observed (i.e., inflection points) (Ravanelli et al., 2015; Ravanelli et al., 2017). At 42°C, the inflection points (when core temperature increases were observed) occurred at a relative humidity level of 55% with fans compared to 48% without fans. The relative humidity levels where heart rate increases were observed with and without fans, respectively, were 83% and 62% at 36°C and 47% and 38% at 42°C. The researchers found that heart rate was significantly lower at the end of the trials with fans compared to without fans (under 36°C conditions: 74±9 bpm vs. 84±9 bpm; under 42°C conditions: 87±9 vs. 94±9). This was also true for esophageal temperatures at the end of the trials (under 36°C conditions: 36.7±0.2°C vs. 36.8±0.2°C; under 42°C conditions: 37.2±0.3°C vs. 37.4±0.2°C). Rectal temperatures were higher with no fans at the end of the trials in both conditions (36°C and 42°C), but these differences were not statistically significant (Ravanelli et al., 2017). In contrast, Gagnon et al. (2016) found that use of fans did not improve heart rate or core temperature inflection points in response to increasing humidity levels, and heart rates and core temperatures were higher with use of fans during exposure of older adults (mean age 68 ± 4 years) at 42°C. Gagnon et al. speculated that lack of benefits may have resulted from age-related impairments to sweat capacity. Morris NB et al. (2019) found that, under hot and humid conditions (40°C, 50% RH; heat index of 56°C) fans reduced core temperatures and cardiovascular strain, but were detrimental to all outcome measures under very hot but dry conditions (47°C, 10% RH; heat index of 46°C). The authors use these findings to caution against using heat index alone for recommendations on beneficial versus harmful fan use.

While the fan efficacy studies discussed in this section so far have been interventional in design, modeling studies have estimated the temperature and RH thresholds at which fans are no longer effective at reducing heat strain. Jay et al. (2015) argue that public health guidelines for when fan use is harmful are too ambiguous and/or too low (e.g., "high 90s" from the CDC (CDC, 2022). Morris et al. (2021) modeled humidity-dependent temperature thresholds at which fans (3.5 meters/second wind velocity) become detrimental using validated calorimetry equations, which calculate net heat transfer between a person and their environment. Based on these equations and assumptions on reduction in sweat rates among older individuals and individuals taking anticholinergic medications, Morris et al. recommend that fans should not be used at a humidity-dependent temperature above 39.0°C (102.2°F) for healthy young adults, 38.0°C (100.4°F) for healthy older adults above the age of 65, and 37.0°C (98.6°F) for older adults taking anticholinergic medication (Morris et al., 2021). While the authors provide more exact numbers that account for humidity, they provide these thresholds as simple and easy guidelines that only require knowing the temperature. Some limitations of these studies include the use of assumptions in their models that may not be realistic (e.g., fan producing an air velocity of 3.5-4.5 meters/second sitting 1 meter away) and the use of simplified heat-balance models, which predict the potential for heat exchange rather than outcomes such as heat and cardiovascular strain metrics (e.g., core temperature, heart rate). There are many factors that influence an individual's heat exchange potential, such as sex, hydration status, acclimatization status, and clothing, and these simplified models often do not account for these factors.

A recent article by Meade and colleagues criticized the simplified thresholds published in Morris et al. (2021) as being too high for general public health guidance (e.g., recommendations for the general public during heat waves) (Meade et al., 2024). The authors modeled core temperature changes rather than modeling potential for heat exchange, arguing that Morris and colleagues did not consider in their conclusions that the potential for greater heat exchange does not always translate into increased sweat rates, particularly if core temperatures are not high enough to elicit that sweat response. Meade and colleagues modeled fan effectiveness under various hypothetical environmental conditions and reported the expected impacts on core temperatures for a young adult (18-40 years old) at rest wearing light clothing. They estimated that fans (versus no fan) would lead to an approximately 0.1°C increase in core temperature at ambient temperatures of 37°C/98.6°F (when RH is 60-90%), 38°C/100.4°F (when RH is 50-80%), and 39°C/102.2°F (when RH is 50-80%) (Meade et al., 2024; Figure 1). Fans were estimated to be of minimal impact (core temperature change of approximately 0.0°C) or beneficial (reduction in core temperature) compared to no fans in drier conditions at these ambient temperatures (37-39°C). In their model, fans were always minimally impactful or beneficial at temperatures below 37°C. Above 39°C, fans were more often harmful (increase in core temperature greater than 0.2°C). These model results were for strong fans (3.5-4.5 m/s air velocity), but in a sensitivity analysis, Meade and colleagues present predicted core temperature changes for slower fans (1 m/s air velocity) among young adults. While these fans are less beneficial than strong fans at low temperatures (e.g., below 34°C/93.2°F), they were predicted to lead to smaller core temperature increases at higher temperatures (e.g., 38°C) and humidities than the stronger fans (Meade et al., 2024; Figure 4). In another model, the researchers predicted the effects of fans combined with skin wetting (relative to no fan or skin wetting) among young adults and found this combination was much more beneficial than fans alone—they were beneficial or neutral in all combinations of humidity and ambient temperature when ambient temperature was 40°C/104°F or below (Meade et al., 2024; Figure 6). One major limitation of these model results is the assumption that the individual is at rest, rather than working. Fans may be used in work areas, and it would be expected that they would be associated with greater heat exchange potential in these scenarios, as core temperature would be more likely to remain above levels that prompt a sweat response. In a sensitivity analysis, the authors assumed a range of metabolic rates, the highest being 90 W/m^2, which they describe as the equivalent to a seated person "performing moderate arts and crafts." In this scenario, fans were predicted to be more beneficial around 30-34°C and in drier conditions (RH less than 30%) up to 39°C. These numbers may not apply to workers, as evidenced in part by findings from a study described above (Carter, 1999), which found benefits to fans outside the range suggested by Meade et al.

Another study did evaluate fan efficacy among participants performing physical work (moderate to heavy workloads), collecting empirical evidence from fixed heart rate trials and modeling the effects of fans on heat storage at various temperatures and humidities (Foster et al., 2022a). Foster et al. conducted 300 trials among 23 participants (24 cool, 15°C reference trials, 138 hot trials with still air, and 138 hot trials with fans). The hot trials involved a range of temperatures and humidities (35–50°C in 5°C increments and 20–80% RH) and two clothing ensembles—low clothing coverage (shorts and shoes) and higher clothing coverage (full-body coverall, t-shirt, shorts, and shoes). For the fan trials, they used a fan with a speed of 3.5 meters/second. The work output from the cool reference trials was used as a baseline to calculate the change in work capacity in the hot trials, which was used to validate their biophysical model predicting change in heat storage (R-squared = 0.66). The authors created categories for the percent change in work capacity resulting from fan use relative to no fans—an increase of greater than 5% was termed “beneficial”, a decrease of greater than 5% was termed “detrimental”, and if the change was an increase or decrease of 5% or less, it was called “ineffective”. In the hot trials, the researchers found fans to be beneficial or ineffective at both 35°C and 40°C (depending on the humidity) and ineffective at 45°C for the higher clothing coverage (Figure 1 of Foster et al., 2022a). For the low clothing coverage, the researchers found that fans had the potential to be beneficial up to 45°C (at certain humidities), but also had the potential to be detrimental at temperatures as low as 35°C (specifically when RH was 20%).

The biophysical model predicting change in heat storage was only able to model the effects of fans for the low clothing coverage, however, the authors note that the effects of fans were similar across clothing groups except that fans weren’t beneficial in the high clothing coverage at temperatures equal to or above 45°C. Foster et al. used a sweat rate in the model of approximately 1 liter per hour, which was the group average from the trials. In Figure 4, the authors present the output of their model, which suggests that fans become detrimental beginning at a temperature of 39°C (102.2°F) (at certain humidities). At increasing temperatures, fan use is detrimental at a wider range of humidity levels (both high and low humidity), but beneficial or ineffective at other humidity levels. Foster et al. also present model results with varying assumptions for sweat rate and fan speed (Figure 6).

As discussed above, in their consensus statement, Morrissey et al. (2021b) recommend the use of electric fans in an occupational setting when ambient temperatures are below 40°C/104°F.

I. Conclusions for Fans.

In conclusion, OSHA preliminarily finds that these studies show that use of fans during work and/or rest breaks will be effective in reducing heat strain in the majority of working age adults. Studies also show that there are certain conditions (e.g., at a temperature of 102.2°F and above, depending on the humidity) under which fans may not be beneficial and can be harmful to workers.

D. Water.

Working and sweating in the heat put workers at risk for dehydration and HRIs. Replacing fluids lost as sweat is necessary to maintain blood volume for cardiovascular function and thermoregulation. Multiple studies have examined the efficacy of hydration interventions, while also considering various factors that may affect hydration such as the quantity of liquid consumed, timing of ingestion, and beverage temperature.

Studies in the peer-reviewed literature provide evidence that hydration interventions are effective at combating dehydration and HRI. For example, McLellan and Selkirk performed a series of heat stress trials with 15 firefighters in Canada wearing protective equipment at 35°C (95°F) and 50% relative humidity (McLellan and Selkirk, 2006). During the trials, participants conducted light exercise in a heat chamber and were provided one of four fluid replacement quantities: no fluid, one-third fluid replacement, two-thirds fluid replacement, or complete fluid replacement (based on previously determined sweat rates). Each participant completed two 20-minute exercise periods, separated by a 10-minute break for a simulated self-contained breathing apparatus (SCBA) change, and then followed by a 20-minute rest break. Cool water was provided during each break. Exercise continued until participants reached an endpoint, defined as a rectal temperature over 39.5°C (103.1°F), heart rate at 95% of maximum, experiencing dizziness or nausea, or other safety concerns. Participants who received either two-thirds or full fluid replacement tolerated approximately 20% more exposure time (including rest periods spent in the heat chamber) and approximately 25% more work time (calculated by excluding rest periods) than those without the fluid replacement. Most participants who were not provided fluids ended the trial upon experiencing lightheadedness when attempting to re-initiate exercise after a break, possibly related to low blood pressure. Those with two-thirds and full fluid replacement took significantly longer to reach an end point during work time and those with one-third, two-thirds, or full fluid replacement had significantly longer exposure time than those without fluid replacement. The full fluid replacement group also had higher rectal temperatures at their trial endpoint compared to those without fluid replacement, possibly indicating that hydration allowed them to tolerate higher rectal temperatures. The authors state that these findings are consistent with previous literature that reports cardiovascular function to be compromised without fluid replacement, leading to exhaustion at lower core temperatures.

Ioannou et al. (2021a) advised intervention groups made up of agricultural workers in Qatar and construction workers in Qatar and Spain to consume 750 milliliters (mL) of water supplemented by one tablespoon of salt per hour over their work shift. Findings in the intervention group were compared to a "business as usual" (BAU) group, where workers followed their normal routine, that were unspecified for the agricultural industry and included shaded areas, water stations, and air-conditioned rest break areas for construction workers in Spain; those same BAU conditions were implemented for construction workers in Qatar, in addition to requiring workers to carry a water bottle, and education. Results included: (1) 13% to 97% reductions in prevalence of dehydration in each intervention group; (2) no significant differences in core temperatures for agricultural workers in Qatar; (3) significant reductions in core temperature in the construction intervention groups in Qatar and Spain, and (4) mixed findings on heart rate and skin temperature across the sites. One limitation with this paper is the use of BAU as a control group, as it is not always clear how these scenarios differed from the intervention. In addition, the quantity of fluid consumed was not measured.

Drinking adequate amounts of water may also reduce the risk of syncope. Schroeder et al. assessed the effects of water quantity on orthostatic tolerance (as time to presyncope, the symptomatic period right before fainting) in healthy individuals (n=13) (Schroeder et al., 2002). The authors used a controlled, crossover design to test the effects of consuming 500 versus 50 milliliters of water prior to attempting to induce presyncope by tilting the head-up and applying negative pressure to the lower body. They found that drinking the larger amount of water improved orthostatic tolerance by 5 minutes (+/- 1 minute), increased supine (lying down face up) mean blood pressure and peripheral resistance, and was associated with smaller increases in heart rate. A recent study using a similar design found that the temperature of the water may also have an influence—cold water consumption was associated with increased systolic blood pressure, stroke volume (i.e., increased volume of blood pumped out of heart per beat), cerebral blood flow velocity, and total peripheral resistance, as well as reduced heart rate relative to consuming room temperature water (Parsons et al., 2023). They did not find differences in orthostatic tolerance between the groups. It should be noted that neither of these papers tested the participants under conditions of high heat, but as is discussed in Section IV., Health Effects, research has shown that exposure to heat independently increases the risk of syncope. In addition, both syncope from exposure to heat and the method used to induce presyncope in these studies can involve a mechanism in which blood pools in the lower body.

Public health guidance for workers (e.g., from NIOSH) often involves recommendations that workers consume 1 cup (237 mL) of water every 15-20 minutes or approximately 1 liter (711-948 mL) per hour. The goal is to replenish fluids lost through sweat and avoid a substantial loss in total body water content. Sweat rates vary between individuals and conditions. Research conducted among workers performing “moderate manual labor e.g. mining or construction work” in a controlled laboratory setting (35°C and 50% RH) demonstrated an average sweat rate of 410-470 mL per hour (depending on whether the trial was conducted in winter or summer), but a range of 100 mL to 1 liter per hour during the presumed unacclimatized trials (conducted in winter) (Bates and Miller, 2008). These recommendations are also in line with the Army's fluid replacement guidelines, which recommend 0.75-1 quart (1 quart is approximately 0.95 liters) per hour for "moderate work" (425 W) to "heavy work" (600 W) depending on the wet bulb globe temperature (Department of the Army, April 12, 2022; Table 3-2).

In a randomized crossover study, Pryor et al. (2023) had participants continuously walk for two hours at 6.4 km/hr in a heat chamber (34°C/93.2°F, 30% relative humidity) while either drinking 500 mL of water every 40 minutes or 237 mL of water every 20 minutes, followed by two hours of rest. Study authors found both hydration strategies to be similarly effective based on (1) no significant differences in body mass, percent change in plasma volume, plasma osmolality (i.e., volume of particles dissolved in plasma), body temperature, or heart rate and (2) no difference in thirst or total gastrointestinal symptom scores. The authors did note, however, that urine volume was significantly lower after the rest period in the group receiving 237 mL of water every 20 minutes compared to the group receiving 500 mL of water every 40 minutes.

Several studies have evaluated the impact of the temperature of drinking water on dehydration and other measures in occupational settings. Cold water may serve as a heat sink to cool off the body in addition to combatting dehydration. In their meta-analysis, Morris et al. (2020) (described above) considered the effect of cold fluid ingestion as a personal cooling method, distinct from maintaining hydration status. Morris and co-authors concluded that cold fluid ingestion was effective as a heat strain mitigation control.

A systematic review by Burdon et al. reported that palatability was higher for cold (32.0-50.0°F) or cool (50.0-71.6°F) beverages, as compared to warmer (greater than 71.6°F) beverages, during exercise (Burdon et al., 2012). The authors conducted a meta-analysis using data from five studies and found that participants drank roughly 50% more cold/cool beverages than warmer beverages. Another analysis of multiple studies found that when participants were provided cold/cool beverages rather than warmer ones, there was less of a mismatch between fluid intake and fluid lost through sweat (measured as percentage of body mass lost). Participants provided warmer beverages lost, on average, 1.3% more of their body mass (95% CI: 0.9%, 1.6%) (Burdon et al., 2012).

I. Conclusions for Water.

In conclusion, one experimental study reported that drinking adequate amounts of water while exercising in high heat prolonged the time of exposure before experiencing signs of heat strain or HRI (McLellan and Selkirk, 2006). In addition, studies in which participants were not exposed to high temperatures found that drinking adequate amounts of water reduced the risk of laboratory-induced presyncope (Schroeder et al., 2002), and drinking cool water improved cardiovascular function (Parsons et al., 2023). Studies have also reported increased palatability for cool or cold beverages (≤71.6°F) that is likely to increase consumption and prevent dehydration compared to warmer beverages (Burdon et al., 2012).

Based on these studies, OSHA preliminarily finds that drinking adequate amounts of water is an effective intervention for preventing heat strain that could lead to HRI, and that providing cool drinking water is especially beneficial. In addition, because cool or cold water was found to be more palatable than warm water, OSHA preliminarily finds that providing cool or cold water can lead to higher consumption of water and thereby reduce the risk of dehydration.

E. Acclimatization.

Heat acclimatization refers to the improvement in heat tolerance that occurs from gradually increasing the intensity and/or duration of work done in a hot setting. There are several studies examining the extent and effectiveness of acclimatization achieved on the job. The effects of acclimatization in allowing individuals to work safely in higher temperatures than unacclimatized individuals has been established for decades and is reflected by both the NIOSH REL and the ACGIH TLV (NIOSH, 2016; ACGIH, 2023).

Early research on the effectiveness of acclimatization was conducted in the 1950s and 1960s among gold mine workers in South Africa (Weiner, 1950; Wyndham et al., 1954, 1966). Weiner (1950) conducted three days of heat stress tests on eight acclimatized mine workers, with three to six months experience working underground, and eight new, unacclimatized workers. Workers completed a four-hour protocol of step climbing sessions (30 mins) with sitting breaks (30 mins) in a mine shaft (dry bulb temperatures: 89.8°F-90.2°F, wet bulb temperatures: 88.8°F-89.1°F, air movement: 165-280 ft/min). Multiple unacclimatized workers were not able to complete the full protocol on the first day (based on symptomology, heart rate and rectal temperature), while all acclimatized workers were able to do so. Rectal temperatures and heart rates were higher among the unacclimatized workers than the acclimatized workers and sweat rate was lower (Weiner 1950).

Wyndham et al. (1954) describe a two-stage acclimatization protocol in which workers (n=110) shoveled rock for six days in a cooler section of the mine (saturated air temperature approximately 86.5°F, wind velocity approximately 100 feet/minute), before moving to a hot section of the mine (saturated air temperature between 91.5°F and 92.0°F, wind velocity 100 to 350 feet/minute) to complete the same task for six more days (Wyndham et al., 1954). Researchers measured rectal temperatures before the shift, at 9:00am, at 11:00am, and at 1:00pm on each of the twelve days. Average rectal temperature was 101.0°F on the first day in the cooler conditions, which fell to 100.2°F on day six. When workers transitioned to the hot conditions, the average rectal temperature was 100.8°F on the first day and 100.0°F on the sixth day. The authors concluded that the acclimatization method was a success, as rectal temperatures were on average lower on the first day in full heat conditions (100.8°F) than on the first day of work in cooler conditions (101.0°F), and mean work output was also higher on the first day in the full heat (Wyndham et al., 1954). The researchers also compared the acclimatized workers to a prior cohort of eight new workers who worked immediately in hot conditions without any acclimatization—they had an average rectal temperature of 101.8°F on their first day. The authors noted that the two-stage acclimatization protocol likely resulted in complete acclimatization, as earlier monitoring of the eight new workers over 23 workdays showed that rectal temperatures did not fall much lower than

100°F, the average temperature seen after the new two-phase acclimatization protocol (Wyndham et al., 1954).

In a later study, Wyndham et al. (1966) analyzed the rectal temperatures of 18 acclimatized men and groups of 20 unacclimatized men working at a moderate rate for four hours in varying environmental conditions (Wyndham et al., 1966). The authors found that the acclimatized men, on average, could work at higher effective temperatures (a heat metric that accounts for ambient temperature, humidity, and air movement) than the unacclimatized men while still maintaining a steady rectal temperature (Wyndham et al., 1966).

Van der Walt and Strydom analyzed fatal heat stroke cases among miners in South Africa from 1930-1974 (Van der Walt and Strydom, 1975). Changes in cooling, mechanization, and acclimatization practices occurred at different points in time. Van der Walt and Strydom divided 1930-1974 into four periods based on interventions implemented during each period. They discussed changes in heat stroke fatality in relation to the interventions that were implemented. During the earliest period (1930-1939), acclimatization practices were introduced and ventilation improved, and the annual heat stroke mortality rate decreased from 93 to 44 deaths/100,000 workers. During the following period, which coincided with the war and post-war time (1940-1949), mines continued and improved the practices introduced in the first period. There was a drop in mortality rate from approximately 26 to 16 deaths/100,000 workers. During the third period (1950-1965), mines began using two-stage acclimatization, and the annual heat stroke mortality rate decreased from 15 to 5.6 deaths/100,000 workers. During the fourth period (1966-1974), mines began using climatic room acclimatization, and the annual heat stroke mortality rate decreased even further to 2.3 deaths/100,000 workers (Van der Walt and Strydom, 1975). The authors concluded that the controls they implemented over this period—namely introducing and improving their acclimatization procedures—were important in reducing the heat stroke fatality rates over time. However, they also introduced other controls during this time (ventilation and mechanization) so it is difficult to determine the efficacy of acclimatization independent of those controls (and other potential confounding factors).

Recent research on acclimatization has also included studies that assess acclimatization achieved while on the job. Lui et al. (2014) conducted a study to evaluate acclimatization among firefighters before and after a four-month wildland fire season, in May and September, respectively. The researchers assessed various physiological markers of heat acclimatization among a cohort of 12 U.S. male wildland firefighters and a group of 14 adults who were not firefighters, matched on age and fitness level. Participants completed a 60-minute walk at 50% of peak oxygen consumption (VO2) in a chamber at 43.3°C and 33% relative humidity. At 60 minutes, firefighters were found to have lower average core body temperatures after the wildfire season than before the season (after: 38.2°C ± 0.4; before: 38.5°C ± 0.3), while the comparison group showed no difference from the pre-season to post-season trials. Similarly, firefighters had significantly lower physiological strain index scores (a variable derived from core temperature and heart rate) after the wildfire season ($p<0.05$), while scores did not change for the comparison group. No pre- to post-season changes were observed for heart rate. The authors found no evidence of acclimatization in the comparison group over the study period. Study results suggest that the firefighters were acclimatized due to occupational exposures during the wildfire season rather than exposure to higher seasonal heat (Lui et al., 2014).

Dang and Dowell (2014) compared heat strain markers among acclimatized and unacclimatized potroom workers at an aluminum smelter in Texas in July as they conducted various smelting activities in high heat. Workers were defined as unacclimatized if they had not been working or had been working solely outside of the potrooms for four or more consecutive days in the prior two weeks. WBGT values in work areas ranged from 83°F to 120°F. Among the eight unacclimatized workers and 48-50 acclimatized workers with heat strain measurements, unacclimatized workers had significantly higher average heart rates than acclimatized workers (118 bpm vs. 107 bpm, $p<0.01$). Unacclimatized workers also had higher average and average maximum core temperatures, but these differences were not significantly different (average maximum core temperature: 101.0°F vs. 100.7°F; average core temperature: 99.7°F vs. 99.6°F) (Dang and Dowell, 2014).

Watkins et al. (2019) evaluated the heat tolerance of fire service instructors (FSIs), which researchers describe as fire personnel who provide firefighting training courses and have more frequent fire exposure than firefighters. The researchers conducted two heat tolerance tests, separated by two months on a cohort of 11 FSIs and 11 unexposed controls (university lecturers), matched on age, sex, and body composition. Controls had not had more than three consecutive days of heat exposure (>25°C) or taken part in heat acclimatization training in the month prior to the study. On average, FSIs experienced five fire exposures in the two weeks prior to each heat tolerance test. Each test was composed of a 10-minute rest period (22.9 ± 1.2°C, 31.2 ± 6.8% RH) followed by a 40-minute walk in a heat chamber (50 ± 1.0°C, 12.3 ± 3.3% RH) wearing fire protective equipment. At the end of the first heat tolerance test, FSIs on average had significantly lower maximum rectal temperature (−0.42°C, $p<0.05$), less change in rectal temperature (−0.33°C, $p<0.05$), and reported less thermal sensation and, among males only, a higher sweat rate (+0.25 Liters/hour, $p<0.05$) than the controls. Heart rate, skin temperature, and physiological strain index did not differ between groups. Rectal temperature at the end of the heat test was negatively correlated with the number of fire exposures experienced in the prior two weeks ($r= -0.589$, $p=0.004$) (Watkins et al., 2019).

The effectiveness of acclimatization in high heat conditions has also been an important topic for militaries. Charlot et al. (2017) studied the effects of training on acclimatization in 60 French soldiers who arrived in United Arab Emirates (UAE) in May of 2016, and were not stationed in a hot climate over the previous year. On day 1, all soldiers completed a heat stress test while running. On days 2–6, the 30 soldiers in the training group trained outdoors by running at 50% VO2 max, with durations of training sessions ranging from 32-56 minutes. Both the soldiers in the training group and 30 soldiers in a control group (no training; performed usual activities) spent approximately six hours outdoors per day conducting standard military tasks. The heat stress test was repeated on day 7, with WBGTs ranging from 1.1°C warmer to 0.9°C cooler compared to day 1. In both groups, rectal temperature, heart rate, sweat loss, sweat osmolality, perceived exertion, and thermal discomfort were lower after the stress test on day 7 compared to day 1. Compared to the control group, the training group had significantly greater decreases in heart rate (20±13 bpm lower versus 13±6 bpm lower), rate of perceived exertion, and thermal discomfort after the stress test on day 7 compared to day 1. Charlot et al. (2017) concluded that addition of short, moderate-intensity training sessions resulted in further heat acclimatization, beyond the acclimatization observed across all participants.

In another study of military trainees, Lim et al. (1997) assessed the degree to which passive heat exposure and military training resulted in the acclimatization of army recruits in Singapore across a 16-week military training program. Participants completed a heat stress test, while marching, at four time points: (1) before starting the program, (2) on the second week, (3) on the sixth week and (4) on the sixteenth/final week of the program. For the nine individuals who attended all tests, heart rate significantly decreased across the study period, while results for skin temperature, tympanic temperature (i.e., within ear canal), and average body temperature were mixed, and there were no significant differences in sweat loss or sweat rate. Researchers interpreted these findings to mean that passive heat acclimatization from living in a hot climate had resulted in partial acclimatization, but that physical conditioning was necessary for triggering beneficial cardiovascular adaptations (Lim et al., 1997).

Sports teams have also evaluated the effectiveness of heat acclimatization among their athletes. Three studies conducted among professional soccer players found that athletes training in hot outdoor conditions experienced improvements in plasma volume, heart rate, rectal and skin temperature, and/or sweat sodium concentration over the course of their training (Buchheit et al., 2011; Racinais et al., 2012, 2014).

Acclimation (i.e., improvement in heat tolerance under laboratory conditions) was also studied in heat chamber studies. In a study using 90-minute treadmill sessions designed to mimic the metabolic rate of manual laborers, Chong et al. (2020) found that over the course of a12-day acclimatization period at 28°C WBGT or 30°C WBGT, peak core temperature, heart rate, and skin temperature decreased and sweat rate increased even before the end of the 12-day period (Chong et al., 2020). Zhang and Zhu (2021) acclimated participants using 10 daily 90-minute treadmill sessions (at a speed of 5 kilometers/hour) in 38°C and 40% RH and found that after acclimation, rectal temperature and heart rate during exercise increased at a slower rate, but there was no effect on skin temperature. OSHA notes that Zhang and Zhu (2021) did not gradually increase daily heat exposure, as is typically recommended.

Shvartz et al. (1977) studied the effects of work and heat on orthostatic tolerance among 12 trained men (i.e., trained three time a week in endurance sports) and 16 untrained men, none of whom were exposed to exercising in the heat in the two months before testing (Shvartz et al., 1977). The trained participants had better orthostatic tolerance to laboratory-induced syncope compared to the untrained participants (2 vs. 8 fainting episodes after exercise in ambient conditions; 4 versus 9 fainting episodes after exercise in heat). Heat acclimation improved orthostatic response, as fainting episodes after exercise decreased in the 8 untrained participants who were later acclimated to heat for 7 additional days (4 versus 0 fainting episodes after exercising in temperate conditions and 4 versus 2 after exercising in hot conditions, before and after acclimation, respectively). At the end of the acclimation period for those 8 untrained participants, significant reductions were observed for heart rate and rectal temperature, while significant increases in sweat rate and maximum VO2 occurred. Shvartz et al. (1977) concluded that both general physical fitness and heat acclimation contributed to better orthostatic responses and fewer fainting episodes.

Parsons et al. (2023) evaluated the effects of heat acclimation in 20 endurance-trained athletes (15 males, 5 females) randomly assigned to a heat group that was acclimated for 8 days or control group that was not acclimated to heat. Heat stress testing (at approximately 32°C and 71% or 72% RH) revealed that in the post-intervention period, the heat group compared to the control group, had significantly decreased peak heart rate; resting, mean, and peak rectal temperature; and peak and mean skin temperature. No significant differences were observed in measures of sweat and hydration. Plasma volume was significantly increased in the heat compared to control group post intervention. Orthostatic tolerance (at approximately 32.0°C, 20% RH) determined by the time to laboratory-induced presyncope, was significantly increased in the heat group (pre: 28±9 min. vs. post: 40±7 min.) compared to control group (pre: 30±8 min. vs. post: 33±5 min.) post-intervention. The authors concluded that plasma volume expansion was the likely mechanism behind improved orthostatic tolerance; they further noted that participants were physically fit at baseline and that they would expect a less robust acclimation regimen would likely yield beneficial results for populations with lower physical fitness (Parsons et al., 2023).

I. Evidence of Tenure as a Risk Factor.

Multiple investigations of occupational HRIs have identified tenure in the job as a risk factor. Workers who are new on the job are often overrepresented in HRI and heat-related fatality reports. In many of these cases, this apparent increased risk presumably results from not being acclimatized to hot working conditions. Studies documenting tenure as a risk factor include case series from OSHA reports, analyses of state workers' compensation databases, and research on military populations. For reference, the most recent (2023) monthly estimates of new hires in the U.S. suggest that over the summer months (June to September), the percent of workers who have been in their job for a month or less ranges from 3.7%-4.1% (BLS JOLTS 2023). Therefore, the percent of workers who are in their first day, first week, or first two weeks on the job would be expected to be lower than 3.7%-4.1%.

Several reports have evaluated OSHA enforcement cases of HRI and heat-related fatalities. Arbury et al. identified 20 citations involving indoor or outdoor HRIs and fatalities cited under the general duty clause in 2012 and 2013 (Arbury et al., 2014). Of the 13 fatalities, 4 (31%) occurred on the worker's first day on the job or after returning from time away, while 9 (69%) occurred in the first three days of the worker's tenure on the job. Arbury et al. expanded this work in a follow-on report that included all of OSHA's heat enforcement cases in both indoor and outdoor workplaces between 2012 and 2013 (n=84). Of the 23 cases involving a heat-related fatality, 17 (74%) occurred in the worker's first three days on the job and 8 (35%) on the worker's first day (Arbury et al., 2016). Tustin et al. (2018a) identified 66 HRI cases among OSHA enforcement investigations conducted between 2011 and 2016 for which OSHA's Office of Occupational Medicine and Nursing (OOMN) was consulted. Among the fatality cases with job tenure information (n=22), 45.5% occurred on the first day of or returning to the job and 72.8% occurred during the first week. Among the non-fatal HRI cases with job tenure information (n=32), 3.1% occurred on the first day and 18.7% occurred during the first week. In a related analysis focusing on outdoor workers, Tustin et al. (2018b) evaluated 25 outdoor occupational HRI and fatalities investigated by OSHA between 2011 and 2016. Eleven (78.6%) of the 14 fatalities and one of the 11 non-fatal illnesses (9.1%) occurred in workers who had started the job within the preceding two weeks or returned from an absence of greater than one week (Tustin et al., 2018b).

Arbury et al. 2014, Arbury et al. 2016, Tustin et al. 2018a, and Tustin et al. 2018b are all retrospective case series that used OSHA databases to identify cases of HRI and heat-related fatalities. As such, they rely on previously collected information about working conditions and worker characteristics, which may not be complete or reflect all factors. In addition, there may be selection bias introduced by the type of cases referred to OSHA's OOMN for review (i.e., they may represent more severe cases).

Several studies and reports have used data from California to describe characteristics of occupational HRI and heat-related fatalities in the state. From May through November of 2005, there were 25 heat-related Cal/OSHA enforcement investigations (Prudhomme and Neidhardt, 2006). When combining fatal and non-fatal outcomes, most workers (80%) had been on the job for four or fewer days before their HRI event, and almost half (46%) occurred on the workers' first day on the job (Prudhomme and Neidhardt, 2006). In 2006, Cal/OSHA confirmed 46 cases of HRI in their 38 investigations of heat-related allegations (4 investigations involved more than 1 case) (Prudhomme and Neidhardt, 2007). 15% of the HRI events and fatalities occurred on the first day of work or the first day of a heat wave, while 30% occurred after working one to four days on the job or into a heat wave (Prudhomme and Neidhardt, 2007). It should be noted that both Cal/OSHA reports only capture cases investigated by Cal/OSHA, and as such, may reflect more severe cases of HRI. They are also not expected to be exhaustive of all occupational HRIs occurring in the state during these time periods. Heinzerling et al. (2020) investigated occupational HRIs across industry sectors in California from 2000 to 2017 using the California Workers' Compensation Information System (Heinzerling et al., 2020) and identified 15,996 cases of occupational HRI. The authors reported that 1,427 cases (8.9%) occurred within two weeks of hire and 410 (2.6%) occurred on the first day on the job.

Several analyses of Washington State Department of Labor and Industries (WA L&I) data have also investigated job tenure in relation to heat-related workers' compensation claims. Bonauto et al. identified 308 claims between 1995 and 2005 with information on employment duration, 43 (14%) of which reported job tenure of one week or less (Bonauto et al., 2007). In comparison, across all claims (i.e., not just heat-related) with employment duration information during the same period, 3.3% of claims reported a job tenure of one week or less, suggesting that this pattern is more common among heat-related claims. A more recent analysis by WA L&I reports the percent of accepted HRI claims occurring during the first one and two weeks of work in Washington between 2006 and 2021 (SHARP 2022). Across all industries, 12.5% of accepted HRI claims were filed in the first week at a job and 16.1% of accepted HRI claims occurred during the first two weeks of work. The percentage of HRI claims filed in the first week and first two weeks of working at a job was higher than the percentage among all workers' compensation claims filed in the first week (2.2%) or two weeks (3.7%) on a job. Spector et al. conducted an analysis similar to Bonauto et al. 2007, but restricted to the agriculture and forestry sectors and included claims through 2009 (Spector et al., 2014). The researchers identified 84 HRI claims in the agriculture and forestry sectors, approximately 15% of which reported that claimants had been working at their job for less than two weeks at the time of the injury. As discussed in Section V.A., Risk Assessment, occupational HRIs, particularly those not requiring medical treatment, are subject to underreporting in workers' compensation systems. Therefore, injuries and illnesses that are captured are likely to be more severe cases.

The U.S. military has also studied HRIs among its recruits extensively. Among all U.S. Marine recruits entering basic training at the Marine Corps Recruit Depot, Parris Island in South Carolina between 1988 and 1996, the number of HRI cases were higher in early training periods (processing week and weeks 1-4) compared to late training period (training weeks 5-12) for females but were similar for males (Wallace 2003). Among males, weeks 1, 8, and 9 of training had the highest numbers of HRI cases. Physical intensity of training varied each week during the 12 weeks of training, which likely had an impact on rates of HRI. Dellinger et al. reported on HRIs among more than 7,000 Army National Guard soldiers deployed to Illinois from July 5th to August 18th, 1993, in response to severe flooding (Dellinger et al., 1996). Researchers identified 23 heat-related medical claims, which excluded those treated by on-site first aid. 65% of the 23 HRI claims occurred during the first two weeks of the deployment; researchers note that this was also the period of greatest work intensity.

II. Conclusions for Acclimatization.

In conclusion, numerous studies have reported the benefits of heat acclimatization for employees in workplace settings. For example, adoption of workplace acclimatization protocols was followed by reduced rates of heat stroke-related fatalities in South African miners (Van der Walt and Strydom, 1975). Acclimatization was also reported to result in reduced signs of heat strain or improved physiological responses to heat for miners (Weiner, 1950; Wyndham et al.,1966), fire fighters (Lui et al., 2014; Watkins et al., 2019) and aluminum smelter potroom workers (Dang and Dowell, 2014). Similarly, studies in military personnel have reported responses to heat following physical training in hot climates (Charlot et al., 2017; Lim et al., 1997). Improvements in physiological responses to heat were also observed in athletes after training in hot climates (Buchheit et al., 2011; Racinais et al., 2012, 2014) and participants exercising in heat chambers (Chong et al., 2020; Zhang and Zhu, 2021). Studies have also shown that heat acclimation while exercising reduces the risk of laboratory-induced syncope (Shvartz et al., 1977) or presyncope (Parsons et al., 2023).

Additionally, retrospective examination of limited data from state and federal enforcement and surveillance cases demonstrates over-representation of workers during the first days or weeks of employment or return to work among HRI cases and fatalities (Arbury et al., 2014, 2016; Tustin et al., 2018a, b; Prudhomme and Neidhardt, 2006, 2007; Heinzerling et al., 2020; Bonauto et al., 2007; SHARP, 2022). This suggests that these workers are at increased risk of HRI and fatality, which may be (or at least in part) the result of lack of acclimatization.

Based on the evidence presented in this section, OSHA preliminarily finds acclimatization to be an effective intervention in reducing the risk of HRI and heat-related fatality by improving physiological responses to heat.

IV. Evidence on the Effectiveness of Multicomponent Interventions.

A. Civilian Workers.

OSHA identified a small number of studies that examined the effectiveness of multi-pronged interventions implemented at workplaces. Three evaluated the effectiveness of a multi-pronged intervention at reducing the risk of heat-related illness (McCarthy et al., 2019; Perkison et al., 2024) or self-reported symptoms of heat-related illness (Bodin et al., 2016) by comparing the same study population before and after an intervention was implemented. OSHA does note that the studies lacked a control group which received no intervention and would have allowed for the authors to examine the effect of potential temporal confounders that changed across the study period. In addition, there was no data to indicate how thoroughly the interventions were implemented or how much employees adhered to them. However, the studies provide strong and consistent evidence of the effectiveness of multi-intervention programs in preventing heat-related illnesses and are supported on a mechanistic basis by the laboratory and other experimental evidence presented above.

McCarthy et al. (2019) compared HRI events and costs from workers' compensation data before and after a Heat Stress Awareness Program (HSAP) intervention among workers in a mid-sized city in Central Texas that was implemented in March 2011. The study population consisted of municipal workers whose jobs involved work in hot, humid conditions with moderate to heavy physical demands, excluding firefighters. The HSAP was based on NIOSH's *Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments* (2016) and included in-person training of supervisors and workers, a medical monitoring program, and specific recommendations to supervisors such as providing unlimited access to water, sports drinks, and shade, as well as establishing acclimatization schedules, work-rest procedures, and first aid protocols. Before the intervention, workers completed a self-administered questionnaire to determine their level of HRI risk, which the researchers then used to categorize them into four risk levels (McCarthy et al., 2019). Those who reported two or more HRI risk factors (i.e., high body mass index, medication use, chronic illnesses, alcohol and energy drink use, history of prior HRI, work in a second hot job, and extensive skin pathology) but not an "unstable health condition" received individualized HRI prevention counseling or education.

McCarthy et al. (2019) compared the rates of heat-related illness across the study period of 2009-2017, before and after the HSAP intervention was implemented in 2011.

In the pre-intervention period (2009-2010), the annual average claim rate for heat-related illnesses was 25.5 claims/1,000 workers. The average annual rate of HRI claims in fell by 37% in 2012-2014 (16 claims/1,000 workers) and by 96% in 2015-2017 (1 claim/1,000 workers) compared to the pre-intervention period. No workers' compensation claims for HRI were submitted in the final 2 years of the study period.

OSHA observes the potential for healthy worker selection bias in this study that might have occurred if employees with medical conditions were more likely to leave their job and therefore the cohort during the study period.

Perkison et al. (2024) reported that the program in the central Texas Municipality employees (referred to in this study as the heat illness prevention program (HIPP)) and described by McCarthy et al. 2019) ended in 2017 and was replaced by a modified HIPP (mHIPP) that included only employee and supervisor training and employee acclimatization. In an analysis to determine the impact of dropping medical surveillance from the HIPP, the study authors reported that the rate of heat illness and injury, which averaged 19.5/1,000 employees during the first four years of the HIPP (2011-2014), fell to 1.0/1,000 employees over the next three years (2015-2017), but increased to 7.6 per 1,000 workers during the mHIPP (2018-2019). Although heat-related illness claim rates increased during implementation of the mHIPP, the rate of heat-related illness during implementation of the mHIPP (7.6/1,000) was still 70% lower than the period with no intervention (25.5/1,000).

Bodin et al. (2016) reported on productivity, HRI symptoms, and hydration practices before and after a water-rest-shade (WRS) and efficiency intervention among sugarcane cutters in El Salvador. The intervention began two months into the 5-month harvest season of 2014-2015. The WRS intervention included: 3-liter water bladders carried in backpacks and refilled during breaks; an initial 1.5 to 2-hour work interval followed by a 10 to 15-minute break, then hour-long work periods with 10 to 15-minute rest breaks and a 45-minute lunch break; and a portable shade canopy for breaks. The efficiency intervention consisted of a machete with an improved blade and handle, fewer rows cut, and a stacking method to reduce workload. Due to challenges during data collection, a relatively small sample size of 41 workers completed follow-up. Bodin et al. (2016) reported that, among those 41 sugarcane cutters, average daily water intake (5.1 liters pre-intervention, 6.3 liters post-intervention) and average daily production (5.1 tons pre, 7.3 tons post) increased after the intervention. An analysis of self-reported heat stress and dehydration-associated symptoms showed that reporting of most symptoms decreased after the intervention, such as feeling feverish (40% to 10%), exhaustion (37% to 14%), nausea (35% to 12%), very dry mouth (49% to 26%), very little urine (37% to 19%), cramps (30% to 17%), diarrhea (14% to 0%), disorientation (12% to 0%), and fainting (5% to 2%). However, self-reported rates of vomiting (9% to 10%) and dysuria (i.e., pain during urination) (42% to 45%) remained similar in pre- and post-intervention periods (Bodin et al., 2016) (Communication with David Wegman, November 2023).

B. Military Personnel.

OSHA also identified studies which examined the effectiveness of interventions in reducing risk of heat-related illness among military personnel. OSHA acknowledges differences between military personnel and typical civilian worker populations, such as health status, fitness levels, and the types of physical activities performed by military personnel (e.g., long-distance running). The military also employs certain controls that aren't typically used in workplaces, such as work stoppage criteria. However, OSHA finds the studies in military personnel useful for showing that multi-component interventions can reduce the risk of heat-related illness.

Kerstein et al. (1986) conducted a randomized control trial in military reservists exposed to hot and humid conditions and found that the incidence of heat illness was 54% lower in a group exposed to intervention measures. Those measures included a lecture on water as prevention, training on and use of portable WBGT monitors, and a special briefing for Commanding Officers. Incidence rates of HRI (defined as "any person with heat symptoms, including exhaustion, cramps, and headaches that the corpsman could clearly relate to the environment and cause the individual to be non-functional for at least one hour or more") were 13 out of 306 participants in the intervention group (4.2%) and 20 out of 220 in the control group (9.1%).

Stonehill and Keil examined the number of heat stroke cases at Lackland Air Force Base in San Antonio, Texas after they implemented a series of interventions over a period from 1956 through 1959 (Stonehill and Keil, 1961). Interventions that were implemented before 1958 included education on heat illness and prevention, pausing training based on dry bulb temperatures, shifting harder exercises to cooler hours, treating heat rash, providing clothing with better ventilation, improving personal hygiene, providing special advice for overweight individuals, and implementing immediate medical treatment for heat stroke. Despite these measures, they still observed 39 cases of heat stroke in 1957 (a rate of 0.87/1,000). After making improvements to their prevention measures in the summer of 1958 (increased water and salt tablet availability, removing fatigue shirts inside classrooms, using WBGT to determine when to pause training, and avoiding intense outdoor training in the first week of training), they observed only 2 heat stroke cases that summer (a rate of 0.05/1,000), a reduction of 95% from 1957.

Minard (1961) evaluated the effectiveness of interventions in reducing HRIs in a study of the Marine Corps Recruit Depot in Parris Island, South Carolina. During the summer of 1952, the mean weakly HRI incidence rate was 53 per 10,000 recruits. A program to address HRI was adopted in 1954 and later modified in 1956. Minard reported a lower mean weekly HRI rate with the enhanced interventions in 1956 (4.7 per 10,000 recruits) compared to the initial intervention in 1955 (12.4 per 10,000 recruits), despite higher temperatures in 1956. Initial interventions included curtailing physical activity during high heat and numerous behavioral changes, such as modifications to uniforms and leadership training; while the most substantial changes to enhance the interventions included curtailing physical activity based on WBGT and differentiating physical activity guidance for acclimatized versus unacclimatized recruits. Later enhancements to the intervention included conditioning recruits with substandard fitness, shade for outdoor classrooms, cooling for indoor classrooms, modification of the clothing policy to allow for only t-shirts, light duty status for recently vaccinated recruits, one hour rest or classroom instruction after meals, better ventilation in barracks to improve sleep, and strategies to increase water and salt intake. The mean weekly HRI rate for all summers with the enhanced intervention (1956-1960) was 4.3 per 10,000 recruits. Four fatalities from heat stroke occurred from 1951 to 1953, but no fatalities occurred since 1953.

C. Conclusions for Multicomponent Interventions in Civilian and Military Employees.

In conclusion, three studies in civilian worker populations found that multicomponent heat stress interventions reduced the incidence of HRI claims and self-reported heat strain and dehydration symptoms and increased work output. The findings of these studies are supported by studies among military personnel, which also found multicomponent interventions to be effective in reducing incidence of HRI, as well as data on the effectiveness of individual control measures reported in laboratory and experimental studies, which are summarized above. The findings of these multicomponent intervention studies are summarized in Table V-3.

Table V-3 Summary of evidence of the effectiveness of multicomponent interventions in reducing HRIs and heat-related symptoms

Evidence	Notes
Multi-component Interventions	
McCarthy et al. (2019): In a comparison of heat-related illness claims before and after the implementation of a heat stress awareness program that began in 2011 in a Texas municipality, the average annual rate of HRI claims fell [by 37%] in 2012-2014 (16 claims/1,000 workers) and [by 96%] in 2015-2017 (1 claim/1,000 workers) compared to the pre-intervention period (25.5 claims/1,000 workers).	• The program involved medical monitoring and training • Recommendations made to supervisors included unlimited access to water, sports drinks, and shade, as well as establishing acclimatization schedules, work/rest procedures, and first aid protocols • It is not known if and to what extent recommendations were implemented
Perkison et al. (2024). The program in Texas municipality workers reported by McCarthy et al. (2019) was modified in 2017 to include only training and acclimatization, and no longer include medical surveillance. Rate of heat-related	• The study authors concluded “medical surveillance may be an important component in lowering workforce heat-related illness,” but noted the small sample size and short evaluation period

illness did increase after these changes (to 7.6 claims/1,000 workers) but remained [70%] lower than when no program was implemented.	
Bodin et al. (2016) reported that three months after implementation of interventions, self-reported heat stress and dehydration-associated symptoms decreased as follows: feeling feverish (40% to 10% [↓76%]), exhaustion (37% to 14% [↓62%]), nausea (35% to 12% [↓66%]), very dry mouth (49% to 26% [↓46%]), very little urine (37% to 19% [↓ 49%]), cramps (30% to 17% [↓45%]), diarrhea (14% to 0% [↓100%]), disorientation (12% to 0% [↓100%]), and fainting (4.7% to 2.4% [49%]) Rates of vomiting and dysuria were similar.	• Most of the interventions were consistent with the main interventions of the proposed standard (i.e., providing drinking water, and shaded rest breaks and a lunch break) • Ergonomic improvements were also implemented • Non-U.S. workers (El Salvador) in sugar cane industry
Kerstein et al. (1986) reported a [54%] decrease in heat illnesses in military reservists after an intervention.	• Military study • Intervention: A lecture on water as prevention, training on and use of portable WBGT monitors, and a special briefing for Commanding Officers
Stonehill and Keil (1961) reported the number of heat stroke cases and the number of troops in the summers of 1957 and 1958, before and after additional protective measures were implemented • The heat stroke rate in summer 1958 after implementing additional protective measures was [95%] lower [0.05/1,000 troops] than the summer before [0.87/1,000 troops]	• Military study • Intervention being tested: In addition to existing prevention measures, they added increased water and salt tablet availability, removing fatigue shirts inside classrooms, using WBGT to determine when to pause training, and avoiding intense outdoor training in the first week of training
Minard (1961) study of military recruits: • The rate of HRI after implementation of the program (12.4/10,000 recruits) was [77%] lower than before the program was implemented (53/10,000) recruits • The rate of HRI after enhanced interventions (4.7 per 10,000 recruits) was [62%] lower than the	• Military study • Examples of intervention measures: curtailing physical activity during high heat, modifications to uniforms, leadership training, curtailing physical activity based on WBGT, differentiating physical activity guidance for acclimatized versus unacclimatized recruits, conditioning

rate after initial interventions (12.4 per 10,000 recruits) and [91%] lower than the period before the program (53/10,000).	recruits with substandard fitness, shade for outdoor classrooms, cooling for indoor classrooms, modification of the clothing policy to allow for only t-shirts, light duty status for recently vaccinated recruits, one hour rest or classroom instruction after meals, better ventilation in barracks to improve sleep, and strategies to increase water and salt intake.

Numbers in brackets calculated and rounded by OSHA.

V. Governmental and Non-Governmental Organizations' Requirements and Recommendations.

A number of governmental and non-governmental organizations recommend or require heat injury and illness prevention programs or multiple controls to address risks related to occupational heat exposure. This shows that OSHA's proposal continues to reflect the growing consensus that HRIs can be avoided or minimized when employers address conditions that have been shown to increase the risk of HRI. OSHA's proposal also continues to reflect a consensus that, to be most effective, an HRI prevention program should incorporate multiple interventions.

A. Governmental Requirements and Recommendations.

As of April 2024, five states had heat injury and illness prevention standards, reflecting a recognition by these states that certain measures can reduce heat-related risks posed to workers. These standards have many of the same types of controls OSHA is proposing (e.g., a written heat safety plan, emergency response protocols, rest breaks, training on HRI recognition and prevention). For a more detailed discussion of existing state standards see Section III., Background. In addition, numerous states have published heat illness and injury prevention guidance for workers.

NIOSH has issued a number of guidance products and provided expert advice on heat injury and illness prevention and developed a programmatic approach to reduce the risks associated with heat for workers. For example, in 2016, NIOSH updated its *Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments,* first published in 1972 and updated in 1986, stating, “compliance with this recommended standard should prevent or greatly reduce the risk of adverse health effects to exposed workers.” NIOSH recommends that employers “establish and implement a written program to reduce exposures to or below the applicable RAL or REL” (which considers exposure to environmental heat and metabolic heat (i.e., work intensity) for unacclimatized and acclimatized employees, respectively) with engineering and work practice controls. Examples of engineering controls include ventilation to increase air movement, air-conditioning, screening, and insulation. Examples of administrative controls include rest breaks to decrease exposure time and metabolic heat loads, increasing distance from radiant sources, and implementing acclimatization protocols, health and safety training, medical screening for heat intolerance, and a heat alert program. If engineering and administrative controls do not reduce exposure below the applicable RAL or REL, NIOSH also recommends cooling clothing/PPE. NIOSH states, “the reduction of adverse health effects can be accomplished by the proper application of engineering and work practice controls, worker training and acclimatization, measurements and assessment of heat stress, medical monitoring, and proper use of heat-protective clothing and personal protective equipment (PPE)" (NIOSH, 2016).

In another example of NIOSH guidance, NIOSH investigated a number of heat-related workplace fatalities to assess the hazards and propose recommendations for preventing similar fatalities, as part of the Fatality Assessment and Control Evaluation (FACE) Program. In four heat fatality investigations that affected landscapers (NIOSH, 2015), farm workers (NIOSH, 2007), firefighters (NIOSH, 1997), and construction laborers (NIOSH, 2004), collective recommendations related to heat included: development, implementation and training on a safety and health program that is made available to all workers; providing rest breaks and accessible hydration; training workers and supervisors on recognizing HRI; providing prompt medical assistance for HRI; monitoring of worker symptoms by supervisors; implementing acclimatization programs; informing workers of drinks (e.g., alcoholic) that can increase risk; having medical providers inform workers taking certain drugs or with certain medical conditions of their increased risk; and factoring in clothing and weather to determine firefighter workloads.

Additionally, there is a recognition amongst other federal regulatory agencies that employers can implement control measures to reduce heat-related risks and harms. The Mine Safety and Health Administration (MSHA) first published heat guidance for mines in 1976, and most recently published "Heat Stress in Mining" which provides guidance on reducing heat stress (MSHA, 2012). The report states that a combination of engineering controls, administrative controls and work practices, and PPE can reduce heat and prevent employee's core temperatures from rising. MSHA recommendations include mine planning to provide cool rest areas, implementing exhaust ventilation and air-conditioning in mines, using canopies in the sun, using skillful blasting procedures to reduce excessive heat, using automation/remote controls to reduce metabolic heat, implementing work-rest regimens with frequent breaks, pacing work tasks, performing heavy tasks in cooler areas or at cooler times, rotating personnel through hot work tasks, providing readily accessible, cooler rest areas and drinking water, acclimatizing new and returning employees, and ensuring employees and supervisors are knowledgeable about heat related topics such as risk, prevention, and symptoms.

In 1993, the EPA published "A Guide to Heat Stress Management in Agriculture" to "help private and commercial applicators and agricultural employers protect their workers from heat illness" (EPA, 1993). The guide outlines the development of a basic program to control heat stress which includes: designating one person to manage the heat stress program; training workers and supervisors on heat illness prevention; acclimatizing workers when they begin to work under hot conditions; evaluating weather conditions, workload, necessary protective equipment or garments, and the physical condition of the employee; managing work activities by setting up rest breaks, rotating tasks among workers, and scheduling heavy work for cooler hours; establishing a drinking water program; taking additional measures such as providing special cooling garments, shade or air-conditioned mobile equipment; and giving first aid when workers become ill (EPA, 1993).

In 2023, the U.S. Army updated its Training and Doctrine Command (TRADOC) Army Regulation 350–29 which "prescribes policy and provides guidance to commanders in preventing environmental (heat or cold) casualties." It includes requirements for rest in shade and water consumption according to specific WBGT levels and work intensity, and consideration of heat stress when planning training events (Department of the Army, June 15, 2023). In 2022, the U.S. Department of the Army issued the technical heat stress bulletin "TB MED 507: Heat Stress Control and Casualty Management" that contains measures to prevent indoor and outdoor HRIs in soldiers, with recommendations for acclimatization planning, work-rest cycles, fluid and electrolyte replacement, and cooling methods (e.g., shade, fans for prevention, and iced sheets and ice water immersion for treatment) (Department of the Army, April 12, 2022).

The U.S. Department of the Navy has published additional guidance on heat injury and illness prevention particular to naval conditions (Department of the Navy, 2023). When Navy personnel are "afloat", they use Physiological Heat Exposure Limits (PHEL) curves to manage heat stress based on exposure limits/stay times for acclimatized personnel under various conditions of environmental heat and work intensity. The PHEL curves were designed to allow core body temperature to rise to 102.2°F (39°C) among healthy and acclimatized individuals who have rested and recovered from prior heat exposures.

In 2023, the Heat Injury and Illness Prevention Work Group of the National Advisory Committee on Occupational Safety and Health (NACOSH) presented to OSHA recommendations on potential elements of a proposed heat injury and illness prevention standard. The Work Group recommended that OSHA include the following measures in a potential standard: a written exposure control plan (heat illness prevention plan); training on heat illness prevention; environmental monitoring; provision of water, breaks, and shade or cool-down areas; other administrative controls (e.g., rotating workers through work tasks and implementing a communication system for regular check-ins); other engineering control measures (e.g., ventilation, exhaust fans, and portable cool-down mechanisms including fans, tents, shielding/insulation, proactive misting); workplace practice controls (e.g., providing coolers with ice and scheduling work during the coolest part of day); personal protective equipment; acclimatization procedures; worker participation in planning activities; and emergency response procedures (NACOSH, May 31, 2023).

B. National Non-Governmental Organizations.

ACGIH first recommended a standard for heat stress in 1971 (ACGIH, 2021), and most recently updated it in 2023 (ACGIH, 2023). The TLV is a value that is determined with the goal of maintaining thermal equilibrium for healthy acclimatized employees and is based on WBGT adjusted for work intensity and clothing/PPE. An action limit (AL) considers those same factors for unacclimatized employees. ACGIH recommends that whenever heat stress among workers is suspected (based on factors such as environmental conditions, work demands, work-rest patterns, and acclimatization states), employers have a Heat Stress Management Program (HSMP) that includes written plans for “General Controls” and as appropriate, “Job Specific Controls” (Table 5 of the Heat Stress and Strain section of the TLV Booklet). ACGIH states “The principal objective of a HSMP is the prevention of excessive heat strain among workers that may result in heat-related disorders.” General controls include environmental surveillance, medical clearance and counseling by a healthcare provider, training, acclimatization planning, fluid replacement, symptom monitoring, breaks in the shade, and an emergency response plan. Job specific controls include engineering controls (e.g., air movement, shade, radiant heat shields), administrative controls (e.g., limiting exposure time and allowing for enough recovery time), personal cooling, and physiological monitoring.

In 2024, the American National Standards Institute/American Society of Safety Professionals A10 Committee (ANSI/ASSP) released the American National Standard A10.50 Standard for Heat Stress Management in Construction and Demolition Operations. The voluntary consensus standard "establishes procedures for the management of heat stress hazards and the selection and use of appropriate controls and practices to reduce risks presented by heat stress and prevention of heat illnesses for all work environments." The standard recommends that employers develop and implement the following: heat stress management program; acclimatization plan; workplace surveillance/risk assessment; provision of water and sodium electrolyte supplements; provision of rest breaks and shaded break locations; buddy system; first aid and emergency action plan; medical surveillance; employee participation; implementation of heat stress controls including engineering controls such as air-conditioning, radiant heat control (barrier), convection controls (cooling), evaporative controls such as misting fans, and metabolic controls (e.g., mechanical equipment or tools to reduce metabolic demands of work tasks); administrative controls such as scheduling for cooler times and allowing self-paced work; personal protective equipment; and training on heat illness prevention

(ANSI/ASSP, 2024). More specific recommendations (e.g., frequency of rest breaks; monitoring employees) are provided when certain triggers are exceeded.

In 2021, the American Society for Testing and Materials (ASTM) finalized its Standard Guide for Managing Heat Stress and Heat Strain in Foundries (E3279-21) which establishes “best practices for recognizing and managing occupational heat stress and heat strain in foundry environments.” The standard outlines employer responsibilities and recommends elements for a ‘Heat Stress and Heat Strain Management Program.’ Employer responsibilities include evaluating temperature and issuing heat alerts; ensuring control measures are in place; and reviewing heat exposure incidents to implement corrective actions. Program elements include worker preparation (i.e., only assigning workers to tasks involving heat exposure “who are prepared for work in those environments and can tolerate the heat exposure associated with the assignments”) and workplace and work preparation (i.e., implementing controls that reduce heat stress through process heat emission control and ventilation of work areas, adjusting work schedules, providing heat relief crews (e.g., crew rotation), providing personal protective equipment, employing personal and portable cooling devices, providing readily available water, and providing cooled location for work break) (ASTM, 2021). The standard also recommends employers and workers monitor heat strain and establish emergency response protocols.

C. Conclusion on Governmental and Non-Governmental Recommendations.

In closing, a number of governmental and non-governmental groups have either promulgated regulations or published recommendations for protecting workers from HRI.

Many of those regulations or recommendations contain components that are consistent with protections in the proposed rule, including plans to prevent heat stress, rest breaks in shaded or cooled areas, cool drinking water, ventilation or cooling methods (e.g., fans exhaust), acclimatization, observation of symptoms in workers, environmental monitoring, and emergency response procedures. Many of these protections have been recognized for decades as being effective in reducing the risk of HRI in workers. This shows that OSHA's proposal continues to reflect the growing consensus that HRIs can be avoided or minimized when employers address conditions that have been shown to increase the risk of HRI and incorporate these protections as part of a program that is tailored to each workplace.

VI. Conclusion.

OSHA reviewed a number of studies that provided quantitative evidence of the effectiveness of multi-component interventions in reducing heat-related illness or HRI; the results of those studies are summarized in Table V-3 above. Studies among Texas municipality employees show that a multi-component intervention approach reduced HRI claims by 37 to 96 percent compared to pre-intervention levels, depending on the period of intervention and the types of interventions applied (McCarthy et al., 2019; Perkison et al., 2024). Implementation of multi-component interventions in military studies resulted in slightly lower reductions in HRI from pre- to post-intervention (54–95 percent), again depending on the types of interventions applied in different implementation periods (Kerstein et al., 1986; Minard, 1961; Stonehill and Keil, 1961).

OSHA acknowledges that several of the interventions implemented among the Texas municipality employees and military personnel differ from the interventions in the proposed standard. However, interventions focusing on water, rest, and shade among sugar cane employees in El Salvador resulted in similar reductions for several common (i.e., occurring in 30% or more of employees pre-intervention) symptoms of heat-related illness (e.g., 45% reduction in cramps, 46% reduction in very dry mouth, 49% reduction in very little urine, 62% reduction for exhaustion, 66% reduction for nausea, 76% reduction for feeling feverish) (Bodin et al., 2016; communication with David Wegman, November 2023). Because of the small number of workers completing the study (n=41), results regarding less common symptoms (reported in less than 15% of workers pre-intervention) are more uncertain, but Bodin et al. reported a decrease in fainting and no incidents of diarrhea or disorientation after the interventions were implemented. Therefore, the study by Bodin et al. (2016) supports the finding that a multi-intervention approach that includes several interventions in common with the proposed standard is likely to result in substantial reductions in HRI symptoms.

Despite several limitations that were acknowledged for these multi-intervention studies, the results for all are of a large magnitude and consistently show effectiveness for multi-component interventions in preventing HRIs. In addition, the results are mechanistically supported by experimental studies showing the effectiveness of individual interventions in preventing signs and symptoms related to heat strain. OSHA finds the studies looking at multi-component approaches to be more relevant for looking at quantitative reductions in HRI because each individual component would contribute to the overall effect.

In addition to studies showing effectiveness of multi-component interventions in preventing HRIs, two studies also show that effective treatments are available to prevent death if heat stroke does occur. As reported in more detail under the *Explanation of Proposed Requirements for paragraph* (g)(3), *Heat illness and emergency response and planning,* studies examining the effectiveness of treating individuals suffering from exertional heat stroke reported 99.8% survival in military personnel treated with ice sheets (bed sheets soaked in water) (DeGroot et al., 2023) and 100% survival in marathon runners doused with cold water and massaged with ice bags (McDermott et al., 2009a).

OSHA preliminarily finds that the totality of the evidence reviewed supports that the approach outlined in the proposed standard, which consists of a heat injury and illness prevention plan and the application of multiple control measures, will result in a substantial reduction in HRIs (range: 37-96%) and heat-related fatalities (range: 99.8-100%) in employees who would be covered under the proposed standard.

VII. Requests for Comments.

For the controls proposed, OSHA requests information and comment on the following questions and requests that stakeholders provide any relevant data, information, or additional studies (or citations) supporting their view, and explain the reasoning or recommendations for including such studies:

- OSHA recognizes that a number of states (e.g., California, Oregon, Washington) have implemented standards to prevent HRIs and heat-related fatalities among workers. OSHA is aware that there are existing and emerging data on the efficacy of the state standards in preventing and reducing HRIs and heat-related fatalities. OSHA welcomes proposed analytical methods or analyses of existing data (see e.g., discussion in V.A., Risk Assessment of existing data sources, www.dir.ca.gov/dosh/reports/State-OSHA-Annual-Report-(SOAR)-FY-2022.pdf) or unpublished data that may be used to estimate the effects of these state standards on heat-related injury, illness, and fatality rates among workers. OSHA is also interested in comments on how to account for the differences (some of which are significant) between the state standards and OSHA's proposed standard in estimating efficacy of OSHA's proposed standard. Are there studies, data, or other evidence that demonstrate the efficacy of and/or describe employers' or workers' experiences with these heat-specific state standards?

- Has OSHA adequately identified and documented the studies and other information relevant to its conclusion regarding the effectiveness of these controls in reducing heat strain and the risk of HRIs, and are there additional studies OSHA should consider?
- Are there additional studies or evidence available that identify appropriate frequencies and durations of rest breaks for reducing heat strain and risk of HRIs?
- Are OSHA's conclusions about the effectiveness of controls in preventing HRI reasonable?

VI. Significance of Risk

As explained in Section II., Pertinent Legal Authority, prior to the issuance of a new standard, OSHA must make a threshold finding that a significant risk of material harm exists, and that issuance of the new standard will substantially reduce that risk.

In Section IV., Health Effects, OSHA presents data and information demonstrating the range of heat-related injuries and illnesses (HRIs) that can be caused by occupational exposure to heat. This discussion demonstrates that HRIs often result in material harm, as they are potentially disabling, can result in lost work time, require medical treatment or restricted work, and in certain cases, can lead to death. In Section V., Risk Assessment, OSHA presents the best available evidence on the risk of incurring these heat-related material health impairments among workers in the U.S., which clearly demonstrates that there exists a significant risk of material harm to workers from occupational exposure to heat. As OSHA's analysis of BLS data shows, there was an average of 40 heat-related deaths (2011-2022) and 3,389 HRIs involving days away from work (2011-2020) among U.S. workers per year. Additionally, based on OSHA's review of workers' compensation claim data, OSHA found that workers in sectors and industries where they are likely exposed to heat in their job (and therefore are more likely to be covered by this standard) have far higher estimated incidence of HRI than the national average, indicating that the risk to heat-exposed workers is much higher than nationwide data suggests. Furthermore, both the annual and working lifetime incidence rates underestimate the true risk for heat-exposed workers given underreporting of workplace injuries and illnesses. Thus, as explained in Sections A and B below, OSHA preliminarily determines that a significant risk of material harm from occupational exposure to hazardous heat exists, and issuance of this standard would substantially reduce that risk.

A. Material Harm.

As discussed in Section IV., Health Effects, the risks posed by exposure to workplace heat hazards are significant and can result in serious HRIs or even death. As discussed in Section IV.B., General Mechanisms of Heat-Related Health Effects, heat stress can result in increased core body temperature and blood flow being shunted towards the skin and away from major organs (e.g., brain, liver, kidneys) and muscles. Sweating, which is a healthy and normal response to heat stress, can also contribute to a reduction in circulating blood volume if fluids are not adequately replaced. This increase in core body temperature and reduced blood flow can lead to health effects like heat stroke, heat exhaustion, heat syncope, and rhabdomyolysis. If not treated promptly, heat stroke can cause permanent organ damage and lead to death. Treatment often requires hospitalization and time away from work (see discussion in Section IV.E., Heat Stroke). Other health effects, such as heat exhaustion, may also require time away from work if recommended by a medical professional. Many heat-related health effects, such as heat cramps and heat exhaustion, can impair a worker’s functional capacity while on the job. Heat syncope can pose additional dangers to workers if they are in precarious work environments, such as on rooftops or while operating machinery. Heat exhaustion can also rapidly progress to heat stroke if not recognized and treated early. As discussed in Section IV.P., Heat-Related Injuries, heat-induced impairments in functional capacity on the job can lead to traumatic injuries, which are more likely to occur on hot days.

The studies that OSHA relied on in Section V.A., Risk Assessment leverage data from multiple surveillance databases (e.g., BLS SOII, workers' compensation claims databases, and hospital discharge data) that have inclusion criteria that OSHA preliminarily concludes would clearly indicate that captured cases of HRIs represent material impairment of health. For example, the estimated number of work-related HRIs reported in the BLS SOII capture only those that involved days away from work (Note: For 2021-2022 biennial data, SOII additionally reports cases involving job restriction or transfer). Similarly, hospital discharge datasets would represent only cases that involved an emergency department visit and/or inpatient hospitalization. While workers' compensation eligibility varies, all of the claims would involve either a visit with a medical professional and/or lost worktime. HRIs resulting in lost work time and/or the need for medical care beyond first aid clearly constitute material harm.

However, HRIs constituting material harm are not limited to those rising to the level of lost work time and/or the need to seek care from a medical professional. Based on the evidence discussed in this and other sections of this preamble, OSHA has preliminarily concluded that many of the HRIs associated with workplace exposure to heat hazards constitute material harm, even if they are not captured in the databases OSHA relied on in its risk assessment. OSHA recognizes that many of these HRIs may be reversible, particularly if early intervention is provided. Nonetheless, OSHA presents evidence in Section IV., Health Effects that these HRIs can be debilitating. In addition to lost work time and the need for treatment by a medical professional, HRIs can cause reduction or loss of the worker's normal functional capacity in work tasks and loss of productivity. Additionally, where preventive action or early treatment is not provided, these disorders can rapidly progress to more serious conditions, and have the potential to result in permanent damage to organs, causing short-, medium-, and long-term health effects, or death. Thus, while some of the health effects OSHA has identified may not rise to the level of material harm in all cases, the agency believes that each can be material in severe cases.

B. Significant Risk.

Peer-reviewed studies and state or national statistics are available to demonstrate the high incidence of work-related HRIs occurring among workers exposed to heat hazards at work. Estimates of the risk of harm confronting exposed workers can be based directly on the rates of work-related HRIs currently being reported.

In Section V.A., Risk Assessment, of this preamble, OSHA evaluated the risk to workers of a heat-related injury, illness, or fatality. OSHA's analysis of BLS data indicated an annual average of 40 heat-related deaths (2011-2022) and 3,389 HRIs involving days away from work (2011-2020) among U.S. workers. These annual heat-related death and HRI numbers alone clearly constitute a significant risk and are in line with OSHA's significant risk findings in previous safety standards (see, e.g., Confined Spaces in Construction, 80 FR 25366, 25371 (May 4, 2014); Electric Power Generation, Transmission, and Distribution; Electrical Protective Equipment, 79 FR 20316, 20321-20322 (April 11, 2014); Cranes and Derricks in Construction, 75 FR 47906, 47913 (Aug. 9, 2010)). However, as discussed in Section V.A., Risk Assessment, many of the sources that OSHA reviewed reported HRI data in terms of incidence rates, and OSHA has considered these rates in assessing significant risk, to the extent they capture populations that are actually exposed to hazardous occupational heat.

Unfortunately, the available data is insufficient to precisely estimate the risk to only workers who are exposed to hazardous occupational heat. But by examining incidence estimates derived from various datasets, including state workers' compensation systems, OSHA was able to determine a range of HRI incidence rates among workplaces where employees are likely to be exposed to heat in their job. In Section V.A., Risk Assessment, OSHA identified various sector incidence estimates of HRI over a working lifetime (i.e., 45 years), including: 234 to 1,737 cases per 100,000 workers in agriculture, forestry, fishing, and hunting; 63 to 545 cases per 100,000 workers in construction; 131 to 396 cases per 100,000 workers in administrative and support and waste management and remediation services; 49.5 to 171 cases per 100,000 workers in transportation and warehousing; and 513 cases per 100,000 workers in utilities, among others. The working lifetime incident rates were even higher in specific industries, such as an estimated 3,479 cases of HRI per 100,000 workers for farm labor contractors and crew leaders and 2,439 cases per 100,000 structural steel and precast concrete workers over a working lifetime of 45 years (see Section V. A., Risk Assessment, Table V-1). OSHA preliminarily concludes that these incidence rates, though as explained below substantially underestimate actual risk, are the best available evidence and sufficient to make a finding of significant risk of HRIs among workers who are exposed to occupational heat.

While the data are not sufficient to develop a single point estimate of the risk posed to heat-exposed workers, OSHA has preliminarily determined that the available data from BLS and workers' compensation claims support an estimate of working lifetime risk of HRI ranging from 135 cases per 100,000 workers (calculated based on the BLS average estimated annual incidence of HRIs for all workers for 2011-2020) to 3,479 cases per 100,000 workers (based on workers' compensation claims). Even the lowest estimate within this range exceeds the 1/1000 threshold that OSHA has historically found to clearly constitute a significant risk.

As noted above, OSHA believes that these data from BLS and workers' compensation claims substantially understate the true risk to workers. For one, the inclusion criteria for the surveillance systems used to estimate incidence would exclude a large proportion of HRI cases. For instance, prior to this year, the BLS SOII only reported the estimated number of HRIs that involved days away from work, which may be less than 50% of all OSHA-recordable work-related HRIs (see, e.g., BLS, IIF Latest Numbers for 2022, *https://www.bls.gov/iif/latest-numbers.htm*). Additionally, the majority of incidence estimates identified by OSHA are based on the risk of HRIs confronting an entire working population (e.g., all workers in a particular industry or sector), both exposed and non-exposed. Clearly, the risk of experiencing a work-related HRI is considerably higher among the subset of workers exposed to heat hazards in their jobs than it is for the rest of the working population. For example, the annual BLS incidence estimates are susceptible to understating risk in this way because when BLS calculates annual incidence estimates, it captures the entire U.S. workforce in the denominator, which includes a large number of unexposed workers (e.g., office workers in climate-controlled buildings). Consequently, the working lifetime risk of HRI estimate based on

BLS's annual incidence estimates (i.e., 135 cases per 100,000 workers), also substantially underestimates the true risk for heat-exposed workers. There is also a large body of literature demonstrating the general underreporting of work-related injuries and illnesses, the findings of which OSHA believes would also apply to HRIs. See Section V.A., Risk Assessment, for additional discussion of underreporting of heat-related fatalities and HRIs.

As discussed in Section V.C., Risk Reduction, dozens of peer-reviewed studies and multiple authoritative bodies (e.g., NIOSH, ACGIH, ANSI/ASSP) indicate that the provisions outlined in this proposed rule would, if promulgated, substantially reduce risk to workers. A large body of data demonstrates that workplace interventions—such as rest breaks, cool drinking water, acclimatization, shade, and fans—can be very effective in reducing heat strain, which is responsible for causing HRIs. This reduction in heat strain and/or reduction in HRI risk has been shown in studies that have examined the impact of interventions in an experimental setting, as well as studies that have documented reductions in HRI prevalence following the implementation of heat injury and illness prevention measures. OSHA preliminarily concludes that implementation of the proposed standard will result in a substantial reduction in HRIs (range of estimates: 37-96%) and heat-related fatalities (range of estimates: 99.8-100%) in employees who would be covered under the proposed standard.

C. Preliminary Conclusions.

OSHA preliminarily concludes that HRIs associated with workplace exposure to heat hazards constitute material harm. Further, based on the evidence discussed in this section, the agency preliminarily concludes that heat-exposed workers are at significant risk of experiencing a work-related HRI or heat-related death, and compliance with the proposed standard would substantially reduce that risk.

VII. Explanation of Proposed Requirements

A. Paragraph (a) Scope and application.

Paragraph (a) establishes the scope of the proposed standard. Paragraph (a)(1) would require all employers subject to OSHA's jurisdiction—including general industry, construction, maritime, and agriculture—to comply with the proposed requirements, subject to the exemptions in proposed paragraphs (a)(2) and (a)(3). The scope of the proposed standard applies to a wide range of sectors that include both indoor and outdoor work areas. The proposed standard aims to provide protections while accounting for the different work areas, anticipated exposures, and other conditions in these sectors.

Paragraph (a)(2) describes the exemptions for the proposed standard based on work activities. Employers would be responsible for determining which work activities are covered by the standard. Although an employer may have some work activities exempt from the proposed standard, other activities may be covered (except for organizations whose primary function is the performance of firefighting. See the discussion of paragraph (a)(2)(iii) below). Under paragraph (a)(3), if an employer's employees exclusively perform the work activities in paragraphs (a)(2)(i)-(vi), then that employer would be exempt from this proposed standard.

Paragraph (a)(2)(i) would exclude work activities for which there is no reasonable expectation of exposure at or above the initial heat trigger. This exception recognizes that some workplaces would not reasonably be expected to reach or exceed the initial heat trigger (e.g., because of their location and/or seasonal variations in temperature). This exclusion may apply to work activities such as operating seasonal businesses outdoors (e.g., during winter months), when temperatures are lower than the initial heat trigger. For instance, if a business that exclusively operates an outdoor holiday market during the winter season in a location where daily high temperatures are always below the initial heat trigger, this standard would not apply to work activities performed at that market.

Paragraph (a)(2)(ii) would exclude short duration employee exposures at or above the initial heat trigger of 15 minutes or less in any 60-minute period. OSHA has preliminarily concluded that intermittent exposures within this duration are not likely to significantly raise core body temperature and result in heat-related injuries and illnesses (HRIs). Numerous studies (many described in Section V.C., Risk Reduction) evaluated the effect of hotter temperatures on participants' core body temperatures under various scenarios (e.g., clothing type, level of activity, work/rest periods, acclimatization status) of different durations. Overall, evidence suggests that heat exposure of 15 minutes or less does not tend to cause an elevation of at least 1°C (1.8°F) in participants’ core body temperatures, which would be indicative of potential heat stress (McLellan & Selkirk, 2006; Meade et al., 2016b; Lamarche et al., 2017; Seo et al., 2019; Kaltsatou et al., 2020; Notley et al., 2022a; Notley et al., 2022b).

This exemption recognizes that while typical work activities may take place below the initial heat trigger, employees may experience short exposures to heat at various times during their shift. For example, an employer who is otherwise exempt from the standard but has employees who occasionally walk to collect mail outside in temperatures at or above the initial heat trigger for 15 minutes or less in any 60-minute period, would still be exempt. This exemption is consistent with the scope exemptions of Colorado, Washington, and Oregon's state standards (7 Colo. Code Regs. § 1103-15:3 (2023); Wash. Admin. Code 296-307-09710 (2023); Or. Admin. R. 437-002-0156 (2024)).

In addition, in order for this exemption to apply for employees whose work activities are primarily performed in air-conditioned vehicles, employers must ensure employees are not exposed to temperatures at or above the initial heat trigger for more than 15 minutes in any 60-minute period. For instance, where an employee who drives an air-conditioned vehicle repeatedly exits the vehicle to deliver product in temperatures at or above the initial heat trigger, this activity would only be exempt from the standard if cumulative exposure in any 60-minute period at or above the initial heat trigger is for 15 minutes or less. If delivery tasks, such as unloading product from the vehicle and moving product to its destination, occur at or above the initial heat trigger for more than 15 minutes in any 60-minute period, these work activities would be covered by the standard.

Paragraph (a)(2)(iii) would exclude organizations whose primary function is the performance of firefighting. It would also exclude emergency response activities of workplace emergency response teams, emergency medical services (EMS), or technical search and rescue[7]; and any emergency response activities already covered under 29 CFR

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[7] "Technical search and rescue" refers to a type of emergency service that utilizes special knowledge and skills and specialized equipment to resolve unique or complex search and rescue situations, such as rope

1910.120, 29 CFR 1910.146, 29 CFR 1910.156, 29 CFR 1915 Subpart P, 29 CFR 1926.65, and 29 CFR 1926.1211. Fire departments, workplace emergency response teams, EMS, and technical search and rescue are covered by OSHA's proposed Emergency Response standard (89 FR 7774, Feb. 5, 2024), which would replace the existing Fire Brigades standard, 29 CFR 1910.156. The update to 29 CFR 1910.156 would expand coverage from only fire brigades, industrial fire departments, and private or contractual type fire departments, to include protections for all employees who perform firefighting, EMS, or technical search and rescue, as part of their regularly assigned duties as well as employees who are members of a workplace emergency response team. If the Emergency Response standard is finalized before this proposed standard, OSHA intends to revise this exemption to reflect the updated 29 CFR 1910.156.

The exemption would apply to all activities (including, e.g., training activities) at organizations whose primary function is the performance of firefighting. In order to comply with the proposed updates to 29 CFR 1910.156, firefighting organizations would have programs in place that address heat-related hazards for their employees.

For employers with employees who perform emergency response activities as members of workplace emergency response teams (i.e., groups of employees who prepare for and respond to emergency incidents at their workplace as a collateral duty to their regular daily work assignments; see 89 FR at 7803), or who perform emergency medical

rescue, vehicle/machinery rescue, structural collapse, trenches, and technical water rescue. OSHA intends the phrase to have the same meaning as used in the proposed Emergency Response standard (see 89 FR at 7804).

services or technical search and rescue, this exemption would only apply when employees are performing emergency response activities. This means during periods while these employees are performing other duties unrelated to emergency response, employers would be required to comply with the provisions of the standard, unless subject to another exemption. For example, employees who are part of a manufacturing plant's emergency response team would be exempt from the standard while responding to an incident, such as a medical emergency, but would be covered by the standard when performing their regular daily work assignments. All other employees not engaged in emergency response would also be covered by this proposed standard. Although OSHA is proposing to exempt fire departments entirely, the agency is not proposing to entirely exempt organizations that have employees who perform EMS or technical search and rescue. This is because many organizations who perform EMS (e.g., hospitals) or technical search and rescue also conduct many other activities unrelated to emergency response and OSHA intends these other activities to be covered by this proposed standard unless another exemption applies.

The Emergency Response proposal includes several hazard assessment and risk management requirements that would encompass heat hazards faced by emergency responders (see 89 FR at 7813-7814). Further, in the NPRM for Emergency Response, OSHA noted this rulemaking on heat illness prevention and invited comment on whether the agency should include specific requirements related to heat for some non-emergency activities of emergency responders. At the same time, the agency recognized that at times emergency responders must perform their duties regardless of environmental conditions

(89 FR at 7801). OSHA has preliminarily concluded that it is appropriate to address any heat-related hazards posed by emergency response activities in this separate rulemaking.

This proposed standard would also not apply to employees when they are undertaking emergency response activities under 29 CFR 1910.120, 29 CFR 1910.146, 29 CFR 1910.156, 29 CFR Subpart P, 29 CFR 1926.65, and 29 CFR 1926.1211. Many of these standards provide employees protection from heat exposure during emergency activities. In addition, OSHA believes that the emergency nature of these activities warrant special consideration and the agency is therefore exempting them from this proposed standard. However, this proposed standard would otherwise apply to these employees during non-emergency regular operations unless another exemption applies. For example, with regard to the Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) (29 CFR 1910.120 and 1926.65), which covers employees who are exposed or potentially exposed to hazardous substances and engaged in one of the operations as specified by 29 CFR sections 1910.120(a)(1)(i)-(v) and 1926.65(a)(1)(i)-(v), such as clean-up operations, employees would only be exempt when responding to emergency situations and would be covered by the standard when participating in general hazardous waste operations.

Paragraph (a)(2)(iv) would exclude work activities performed in indoor work areas or vehicles where air-conditioning consistently keeps the ambient temperature below 80°F. OSHA specifies using ambient temperature, as most heating, ventilation, and air-conditioning (HVAC) systems automatically report ambient temperature. Properly functioning HVAC units also regulate indoor humidity levels, which would result in similar measures of ambient temperature and heat index.

This exemption would only apply to indoor work areas and vehicles that are consistently below an ambient temperature of 80°F. The employer must ensure that the air-conditioning system consistently maintains an ambient temperature below 80°F during work activities for the exemption to apply. OSHA recognizes that there may be unexpected malfunctions of air-conditioning systems that result in periods of time without air-conditioning before a system is repaired. In these situations, OSHA would expect that the employer takes steps to expeditiously repair the air-conditioning system and return the workplace to an ambient temperature below 80°F.

Paragraph (a)(2)(v) would exclude telework (i.e., work done from home or another remote location of the employee’s choosing). OSHA generally does not hold employers liable for employees’ home offices and conditions of the telework environment (see CPL 02-00-125, available at *https://www.osha.gov/enforcement/directives/cpl-02-00-125*). However, only the work activities employees perform while teleworking would be exempt and employers would be required to comply with the standard when employees are on site if other exemptions do not apply. For example, the standard would not cover work activities conducted at an employee’s home on Tuesdays and Thursdays in a given week but would cover the employee’s work activities at their employer’s office on Mondays, Wednesdays, and Fridays (unless another exemption applies).

Paragraph (a)(2)(vi) would exclude sedentary work activities at indoor work areas that only involve some combination of the following: sitting, occasional standing and walking for brief periods of time, and occasional lifting of objects weighing less than 10 pounds. The exemption is intended to apply to work sites such as offices where employees perform sedentary work activities for extended periods of time (e.g., all or most of the workday). This exemption only applies to indoor work activities, which are not generally subject to factors such as solar radiation, which are common in outdoor exposures. OSHA preliminarily concludes that employees engaged in indoor sedentary work activities are at lower risk of heat-related injury and illness, as production of metabolic heat is not substantially elevated. Experimental studies of groups exposed to heat (111.4°F (44°C), 30% relative humidity) while resting in a seated position indicate core body temperature does not rise more than 1°C (1.8°F) over multiple hours (Kenny et al., 2017; Notley et al., 2020). In addition to sitting, the exemption allows for indoor work activities to include occasional standing and walking for brief periods of time, and occasional lifting of objects weighing less than 10 pounds. When using the term "occasional" OSHA means up to one-third of the workday (BLS, 2021), however these activities could only be performed for brief periods of time over the course of the day for the exemption to apply. For example, work activities performed at a desk indoors, where the employee is seated and performing computer work for the majority of their shift, but with occasional standing, as well as walking short distances (e.g., to use the photocopier, to collect office mail), would be exempt from the standard.

In addition, this exemption would apply to indoor operation of vehicles while seated. For example, operation of a forklift inside of a warehouse while seated would be considered an indoor sedentary work activity and would be exempt. However, if a forklift operator's duties involved loading and unloading heavy objects (greater than 10 pounds), they would not be exempt from the standard. Other examples of activities that would be exempt include indoor operation of reach trucks, tow trucks, pallet trucks, golf carts, and other vehicles where employees are seated.

This exemption would apply where employees are engaged in sedentary work activities regardless of indoor temperature. While employees performing these activities are likely at lower risk of experiencing heat-related injury and illness, OSHA seeks comment as to whether the sedentary work activities exemption should be limited to work activities performed in indoor environments below a specified threshold temperature (e.g., the high heat trigger) or whether this exemption should account for certain workplace conditions. For example, should this exemption cover an employer with employees who meet the criteria in this proposed exemption, but whose work area is near a heat generating process and impacted by radiant heat?

Paragraph (a)(3) specifies that employers whose employees all exclusively perform activities described in (a)(2)(i) through (a)(2)(vi) are exempt from this standard. Employers may have employees who would be exempt from the standard (e.g., employees working indoors where air-conditioning consistently keeps the ambient temperature below 80°F), as well as employees who would be covered by the standard (e.g., employees harvesting produce outdoors). These employers would be required to comply with the provisions of the standard for the employees who perform work activities that are covered by the standard. However, some employers may only have employees that exclusively perform work activities that are exempt from the proposed standard. For example, an employer with employees who all either telework from home or other locations of their choosing or work inside a building with air-conditioning that consistently keeps the ambient temperature below 80°F would be exempt from the standard.

I. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Whether any of the proposed exclusions of emergency response activities already covered under the standards listed in proposed paragraph (a)(2)(iii) should be covered by this proposed standard. If so, provide evidence and describe reason for why these activities should not be excluded;
- Where an employer relies on the exemption in proposed paragraph (a)(2)(iv) to exclude work activities performed in indoor work areas or vehicles where air-conditioning consistently keeps the ambient temperature below 80°F, whether the standard should address situations where the air-conditioning system does not function properly and the ambient temperature reaches or exceeds 80°F; for example, should certain requirements of the standard apply in this scenario? Additionally, whether the standard should specify how long the air-conditioning system can be out of order before the exemption no longer applies;

- Whether the description of sedentary work in the proposed standard is appropriate, and if not, what revisions would be appropriate;
- Whether the standard should exempt all sedentary work activities indoors or limit the exemption to only activities performed below an upper limit (e.g., below the high heat trigger) at or above which the exemption would no longer apply, and if so, what the upper limit should be and what evidence exists demonstrating that even sedentary work performed indoors can be a hazard to workers at or above that limit; and
- Whether the exemption for sedentary work activities should be expanded to include work performed outdoors.

B. Paragraph (b) Definitions.

Paragraph (b) defines several terms used in the proposed standard. First, it defines *Acclimatization* to mean the body's adaptation to work in the heat as a person is exposed to heat gradually over time, which reduces the strain caused by heat stress and enables a person to work with less chance of heat illness or injury.

Section V.C., Risk Reduction contains more information on effectiveness of acclimatization. This definition is included because paragraph (e)(7) of the proposed standard establishes requirements to protect new and returning employees who are not acclimatized. Proposed paragraph (e)(7) requires that employers implement one of two acclimatization protocols for new and returning employees when the initial heat trigger is met or exceeded. Under paragraph (j), employers must implement acclimatization protocols at no cost to the employee. In addition, proposed paragraph (h)(1)(iii) requires that employees be trained that lack of acclimatization is a risk factor for HRI.

Ambient temperature means the temperature of the air surrounding a body. Other terms for ambient temperature include “air temperature” or “dry bulb temperature.” Ambient temperature is measured by a standard thermometer and often what people refer to when using the term “temperature.” Ambient temperature is defined because it is used in the definitions for *heat index* and *wet bulb globe temperature,* in addition to proposed paragraphs *(a) Scope and application, (d) Identifying heat hazards, (e) Requirements at or above the initial heat trigger,* and *(f) Requirements at or above the high heat trigger*.

Cooling personal protective equipment (PPE) means equipment that is worn to protect the user against heat-related injury or illness. This definition is included to clarify the requirement under proposed paragraph (e)(1) that if the employer provides employees with cooling PPE, the cooling properties must be maintained during use.

Cooling PPE is gear designed to help maintain a safe body temperature for individuals working in hot environments or engaged in physically demanding activities. Cooling PPE typically employs various technologies to facilitate heat dissipation and enhance comfort, such as water absorption crystals or phase change materials (PCM) which draw heat away from the wearer. Cooling bandanas and neck wraps are worn around the neck and can be soaked in cold water. Additionally, other types of clothing may incorporate materials that have cooling properties.

Heat index means the National Weather Service heat index, which combines ambient temperature and humidity. It provides a number that can be used to indicate how hot it feels. There are several tools for measuring heat index in both indoor and outdoor work areas. For outdoor work areas, the OSHA – NIOSH Heat Safety Tool app and other phone-based weather apps can be used to show the heat index by location as well as hourly forecasts. For indoor work areas, employers can enter measurements of humidity and ambient temperature into the NOAA Heat Index Calculator. There are also monitoring devices that report heat index. *Heat index* is defined because the term is used in definitions of *high heat trigger* and *initial heat trigger.* The term is also used in proposed paragraphs *(c) Heat injury and illness prevention plan, (d) Identifying heat hazards,* and *(e) Requirements at or above the initial heat trigger.*

High heat trigger means a heat index of 90°F or a wet bulb globe temperature (WBGT) equal to the NIOSH Recommended Exposure Limit. See explanations for the definitions of *wet bulb globe temperature (WBGT)* and *Recommended Exposure Limit (REL)* for more information about those terms. OSHA is including a definition for high heat trigger because exposures at or above the high heat trigger would require the implementation of a number of controls, in addition to the controls that would be implemented under the initial heat trigger in proposed paragraph (e). The controls implemented under the initial heat trigger are described below under the definition for *Initial Heat Trigger*. The additional controls that would be implemented under the high heat trigger under proposed paragraph (f) include required rest breaks, observation for signs and symptoms, hazard alerts, and warning signs for excessively high heat areas. See Section VII.F., Explanation of Proposed Requirements for more information on these controls. The scientific basis supporting the establishment of the high heat trigger at a heat index of 90°F or a WBGT equal to the NIOSH REL is explained in in Section V.B., Basis for Initial and High Heat Triggers.

Indoor/indoors means an area under a ceiling or overhead covering that restricts airflow and has along its entire perimeter walls, doors, windows, dividers, or other physical barriers that restrict airflow, whether open or closed. Possible examples for indoors include work in a garage, even if the garage door is open; the interior of a warehouse, even if multiple doors are open on loading docks; and a shed with four walls and a ceiling, even if the windows are open. Construction activity is considered to be work in an indoor environment when performed inside a structure after the outside walls and roof are erected. This definition is included because the term is used in definitions for *outdoor/outdoors,* and proposed paragraphs *(a) Scope and application, (d) Identifying heat hazards, (e) Requirements at or above the initial heat trigger, (f) Requirements at or above the high heat trigger,* and *(i) Recordkeeping.*

Initial heat trigger means a heat index of 80°F or a WBGT equal to the NIOSH Recommended Alert Limit (RAL). See explanations for the definitions of *wet bulb globe temperature (WBGT)* and *Recommended Alert Limit (RAL)* for more information about those terms. OSHA is including a definition for *initial heat trigger* because exposures at or above the initial heat trigger would require the implementation of a number of controls under proposed paragraph (e), including requirements for drinking water, break area(s) for indoor and outdoor work sites, indoor work area controls, acclimatization of new and returning employees, rest breaks if needed to prevent overheating, effective communication, and maintenance of PPE cooling properties if PPE is provided. See

Section VII.E., Explanation of Proposed Requirements for more information on these controls. The scientific basis supporting the establishment of the initial heat trigger at a heat index of 80°F or a wet bulb globe temperature (WBGT) equal to the NIOSH RAL is explained in detail in Section V.B., Basis for Initial and High Heat Triggers.

Outdoor/outdoors means an area that is not indoors, as defined above. The definition also specifies that vehicles operated outdoors are considered outdoor work areas for purposes of this standard unless exempted by paragraph (a)(2). Examples of outdoor work include tasks performed in agricultural fields and under canopies and pavilions. This term is defined because it is used in proposed paragraphs *(d) Identifying heat hazards, (e) Requirements at or above the initial heat trigger,* and *(h) Training.*

Radiant heat means heat transferred by electromagnetic waves between surfaces. This definition further notes that sources of radiant heat include the sun, hot objects, hot liquids, hot surfaces, and fire.

Radiant heat is transferred from a hotter object to a cooler object. The transfer of radiant heat can occur across distances and does not require objects to touch each other. Infrared radiation is a common source of radiant heat that is encountered in foundries, and in iron, steel, and glass industries (NIOSH, 2016). Sources of exposure to radiant heat in the workplace can include furnaces, ovens, and combustion. *Radiant heat* is defined because it is included in the definition for *wet bulb globe temperature (WBGT)* and is used in paragraph *(e) Requirements at or above the initial heat trigger.*

Recommended Alert Limit (RAL) means the NIOSH-recommended heat stress alert limits for unacclimatized workers. OSHA is including a definition for RAL because the initial heat trigger incorporates the NIOSH RAL. Thus, several provisions of the standard are triggered by either a heat index of 80ºF or a wet bulb globe temperature (WBGT) equal to the NIOSH RAL. See *Explanation of Proposed Requirements* for *Definitions (initial heat trigger, wet bulb globe temperature)* and proposed paragraph (e), *Requirements at or above the Initial heat trigger* for more details.

NIOSH (2016) developed the RAL to protect most healthy non-acclimatized employees from adverse effects of heat stress, and recommends that total heat exposure for non-acclimatized employees be controlled to maintain combinations of environmental and metabolic heat below the applicable RAL in order to maintain thermal equilibrium. Environmental exposures are based on WBGT, which accounts for the contributions of ambient temperature, radiant heat, humidity, and wind speed. Metabolic heat production is estimated by workload. The RAL assumes employees are wearing "the conventional one-layer work clothing ensemble," but NIOSH provides guidance for adjusting the WBGT based on the types of clothing or PPE worn. The formula for calculating the RAL is: RAL [ºC-WBGT]=59.9-14.1 $\log_{10}$M[W], where M is metabolic rate in watts (W).

Recommended Exposure Limit (REL) means the NIOSH-recommended heat stress exposure limits for acclimatized workers. OSHA is including a definition for REL because the high heat trigger incorporates the NIOSH REL. Thus, several provisions of the standard are triggered by either a heat index of 90ºF or a wet bulb globe temperature (WBGT) equal to the NIOSH REL. See *Explanation of Proposed Requirements* for *Definitions (high heat trigger, wet bulb globe temperature)* and proposed paragraph (f), *Requirements at or above the high heat trigger* for more details.

NIOSH (2016) developed the REL to protect most healthy acclimatized employees from adverse effects of heat stress and recommends that total heat exposure for acclimatized employees be controlled to maintain combinations of environmental and metabolic heat below the applicable REL in order to maintain thermal equilibrium. Environmental exposures are based on WBGT, which accounts for the contributions of ambient temperature, radiant heat, humidity, and wind speed. Metabolic heat production is estimated by workload. The REL assume employees are wearing "the conventional one-layer work clothing ensemble," but NIOSH provides guidance for adjusting WBGT based on the types of clothing or PPE worn. The formula for calculating the REL is: REL [^{o}C-WBGT]= 56.7-11.5 $\log_{10}$M[W], where M is metabolic rate in watts (W)

Shade is defined as the blockage of direct sunlight, such that objects do not cast a shadow in the area of blocked sunlight. This definition is included to clarify the requirements for use of shade as a control in outdoor break areas under proposed paragraph (e)(3)(i). Shade can be artificial or naturally occurring. See *Explanation of Proposed Requirements* for paragraph (e)(3).

Signs and symptoms of heat-related illness means the physiological manifestations of a heat-related illness and includes headache, nausea, weakness, dizziness, elevated body temperature, muscle cramps, and muscle pain or spasms. This term is used throughout the proposal to refer to a range of signs and symptoms that may result from a variety of heat-related illnesses (see Section IV., Health Effects for a detailed discussion of heat-related illnesses and the accompanying symptoms). This term is defined to provide clarity about scenarios for which an employer must develop procedures for responding to employees experiencing signs and symptoms of heat-related illness in their heat emergency response plan, as well as the scenarios that an employer would be required to take specific actions to aid affected employees under proposed paragraph (g). This definition also provides clarity on the requirements to train employees on signs and symptoms of heat-related illness (see proposed paragraph (h)(iv)) and monitor employees for signs and symptoms of heat-related illness (see proposed paragraph (f)(3).

Signs and symptoms of a heat emergency means the physiological manifestations of a heat-related illness that require emergency response and include loss of consciousness (i.e., fainting, collapse) with excessive body temperature, which may or may not be accompanied by vertigo, nausea, headache, cerebral dysfunction, or bizarre behavior. This could also include staggering, vomiting, acting irrationally or disoriented, having convulsions, and (even after resting) having an elevated heart rate. This term is defined to provide clarity about scenarios for which an employer must develop procedures to respond to employees experiencing signs and symptoms of a heat emergency in their heat emergency response plan, as well as the scenarios in which an employer would be required to take specific actions to aid affected employees under proposed paragraph (g). This definition also provides clarity on the requirements to train employees on signs and symptoms of heat-related illness and which ones require immediate emergency action (see proposed paragraph (h)(iv)).

Vapor-impermeable clothing means full-body clothing that significantly inhibits or completely prevents sweat produced by the body from evaporating into the outside air.

The definition further indicates that examples include encapsulating suits, various forms of chemical resistant suits, and other forms of non-breathable PPE. This definition is included because under proposed paragraph (c)(3) employers that have employees who wear vapor-impermeable clothing would be required to evaluate heat stress hazards resulting from these clothing and implement policies and procedures based on reputable sources to protect employees while wearing this clothing. Vapor-impermeable clothing is also referred to as “vapor barrier” clothing. It is a type of protective clothing that employers may provide to employees to protect them from chemical, physical, or biological hazards for work tasks such as hazardous waste clean-up. Examples include metallic reflective clothing or chemical resistant clothing made from plastics such as vinyl or nylon-reinforced polyethylene (Mihal, 1981). Materials made from 100% high density polyethylene (e.g., Tyvek®) that allow water vapor and gases to pass through are not vapor-impermeable, but lamination of the materials with some substances such as polyvinyl chloride (PVC) can change the breathability of the materials and render them vapor-impermeable (DuPont, 2024; Paull and Rosenthal, 1987). Because the proposed definition indicates “full-body clothing”, it would not include vapor-impermeable PPE that covers small areas of the body (e.g., gloves, boots, aprons, leggings, gauntlets). However, clothing such as boots and gloves made from vapor-impermeable materials such as rubber may be part of whole-body, vapor-impermeable clothing ensembles (Mihal, 1981; Paull and Rosenthal, 1987). Employers could check product information provided by manufacturers to determine if clothing worn by their employees qualifies as vapor-impermeable clothing.

Vehicle means a car, truck, van, or other motorized means of transporting people or goods. Other examples may include a forklift, reach truck, tow truck, pallet truck, or bus, among others. In addition, vehicles may also include equipment such as a bulldozer, road grader, farm tractor, or crane. Under the proposed definitions, a vehicle would be a *work area* when a worker's work activities occur in the vehicle.

Wet Bulb Globe Temperature (WBGT) is a heat metric that takes into account ambient temperature, humidity, radiant heat from sunlight or artificial heat sources, and air movement. It can be measured in both indoor and outdoor work areas, however there are separate formulas depending on whether the device is being used indoors or outdoors. WBGT is used by NIOSH and ACGIH in their guidance for evaluating occupational heat stress. The term is defined because it is used in the definitions for the high and initial heat triggers and in proposed paragraphs *(c) Heat Injury and Illness Prevention Plan* and (d) *Identifying heat hazards*.

Work area means an area where one or more employees are working within a work site. This includes any area where an employee performs any work-related activity. A work area may be located at the employer's premises or other locations where an employee may be engaged in work-related activities or is present as a condition of their employment. Work area is defined because it is referenced in several provisions of the proposed standard, including *(a) Scope and application, (c) Heat Injury and Illness Prevention Plan (HIIPP), (d) Identifying heat hazards, (e) Requirements at or above the initial heat trigger, (f) Requirements at or above the high heat trigger,* and *(i) Recordkeeping.*

Work site means a physical location (e.g., fixed, mobile) where the employer's work or operations are performed. It includes outdoor and indoor areas, individual structures or groups of structures, and all areas where work or any work-related activity occurs (e.g., taking breaks, going to the restroom, eating, entering or exiting work). The work site includes the entirety of any space associated with the employer's operations (e.g., workstations, hallways, stairwells, breakrooms, bathrooms, elevators) and any other space that an employee might occupy in arriving, working, or leaving. A work site may or may not be under the employer's control. Work site is defined because it is referenced in several provisions of the proposed standard including Heat Injury and Prevention Plan (HIIPP) (proposed paragraph (c)), Identifying heat hazards (proposed paragraph (d)), Requirements at or above the initial heat trigger (proposed paragraph (e)), Requirements at or above the high heat trigger (proposed paragraph (f)), Heat illness and emergency response and planning (proposed paragraph (g)), and Training (proposed paragraph (h)).

I. Requests for Comments.

OSHA requests comments as to whether the proposed definitions are appropriate, and whether any additional terms should be defined in the standard.

C. Paragraph (c) Heat Injury and Illness Prevention Plan.

Proposed paragraph (c) includes provisions for the development and implementation of a work site heat injury and illness prevention plan, referred to as a "HIIPP" or "plan" for the remainder of this section, as well as requirements regarding what would need to be in the plan. The development of a HIIPP, including comprehensive policies and procedures, is necessary to ensure that all affected employees, including exposed workers, supervisors, and heat safety coordinators, understand where heat hazards exist at the workplace and the workplace-specific measures that must be utilized to address those hazards. The NIOSH Criteria Document provides information on the importance of a HIIPP to reduce the risk of heat-related injuries and illness (NIOSH, 2016). Requiring a HIIPP is also consistent with regulations from several of the states that have enacted or proposed heat-specific standards. There is a plan requirement in existing heat standards from California (Cal. Code of Regs. tit. 8, § 3395 (2005)), Washington (Wash. Admin. Code § 296-62-095 through 296-62-09560; § 296-307-097 through § 296-307-09760 (2023)); and Oregon (Or. Admin. R. 437-002-0156 (2022); Or. Admin. R. 437-004-1131 (2022)). Maryland and Nevada proposed heat standards that would also require a HIIPP (MD, 2024; NV, 2022). Additionally, this requirement aligns with the recommendations from the NACOSH Heat Injury and Illness Prevention Work Group, where the group provided a list of potential elements to include in a HIIPP. All the requirements in paragraph (c) would have to be included in the employer's HIIPP.

Paragraph (c)(1) would require employers to develop and implement a comprehensive HIIPP for each work site. Under proposed paragraph (b), a work site is defined as a physical location (e.g., fixed, mobile) where the employer's work or operations are performed. If an employer has multiple work sites that are substantially similar, the HIIPP may be developed by work site type rather than by individual work sites so long as any site-specific information is included in the plan (e.g., phone numbers and addresses or site-specific heat sources). For example, if an employer has developed a corporate HIIPP that includes information about job tasks or exposure scenarios that apply at multiple work sites, this information can be used in the development of HIIPPs for individual work sites. When employees are in work areas not controlled by the employer (like private residences), employers would need procedures for how they will ensure compliance with the standard (e.g., ensure that effective communication is being maintained (proposed paragraph (f)(3)(iii)) and employees are receiving hazard alerts to remind them of protections such as the importance of drinking plenty of water, their right to take breaks, and locations of break sites and drinking water (proposed paragraph (f)(4)). These employers must include such policies and procedures in their HIIPP to protect their employees entering those locations not controlled by the employer.

Proposed paragraph (c)(2) specifies the contents of the HIIPP. Proposed paragraph (c)(2)(i) would require the HIIPP to include a comprehensive list of the types of work activities covered by the plan. For example, a landscaping company could indicate that all employees conducting outdoor work at or above the initial heat trigger for at least 15 minutes in any 60-minute period (e.g., lawn care workers, gardeners, stonemasons, and general laborers) would be covered by the HIIPP. (See proposed paragraphs (a)(2)(i), (ii), and (iv) and *Explanation for Proposed Requirements* for Paragraph (a) *Scope and Application* for more detail about coverage under the standard.) Paragraph (c)(2)(ii) would require the inclusion of the policies and procedures that are necessary to comply with the requirements of this proposed standard. See *Explanation of Proposed Requirements* for paragraphs (d) through (j) for examples of how employers could comply with the proposed provisions. OSHA understands that a HIIPP must be adaptable to the physical characteristics of the work site and the job tasks performed by employees, as well as the hazards identified by the employer when designing their HIIPP. Employers could also include other policies, procedures, or information necessary to comply with any applicable federal, state, or local laws, standards, and guidelines in their HIIPPs. Paragraph (c)(2)(iii) would require that employers identify the heat metric (i.e., heat index or wet bulb globe temperature) that the employer will monitor to comply with paragraph (d). For more information on heat metrics, see *Explanation for Proposed Requirements* for Paragraph (b) *Definitions for heat index and WBGT.*

Paragraph (c)(3) would require that, in cases where employees wear vapor-impermeable clothing (also called vapor barrier clothing), employers must evaluate heat stress hazards resulting from this clothing and implement policies and procedures based on reputable sources to protect employees while wearing these clothing. The employer must include these policies and procedures and document the evaluation in the HIIPP. Under proposed paragraph (b), *vapor-impermeable clothing* is defined as full-body clothing that significantly inhibits or completely prevents sweat produced by the body from evaporating into the outside air. The definition further indicates that examples include encapsulating suits, various forms of chemical resistant suits, and other forms of non-breathable PPE. For more information on vapor-impermeable clothing, see the *Explanation for Proposed Requirements* for paragraph (b) *Definitions*. This attention to vapor-impermeable clothing is essential given that significant or complete inhibition of sweat evaporation can greatly increase the potential for heat stress and resulting heat strain and HRI (Mihal, 1981).

The requirement that employers evaluate heat stress and develop policies and procedures to protect employees based on reputable sources allows for flexibility, given that there is variability in duration of use of the vapor-impermeable clothing and that workload also varies across job tasks and occupations. Examples of reputable sources employers can consult to assess heat stress and develop policies and procedures to protect employees wearing vapor-impermeable clothing include recommendations by NIOSH (2016) and ACGIH (2023). An example of a policy employers might adopt to protect employees wearing vapor-impermeable clothing is implementing the protections in the standard at a lower temperature threshold. Such an approach has been used in state standards such as the Washington heat standard for outdoor workplaces (Wash. Admin. Code 296-307-09747 (2023)). In Washington state's heat standard, employers must implement certain controls when employees are wearing vapor barrier clothing, and the temperature is above 52°F. Paragraph (c)(3) does not apply to vapor-permeable clothing or PPE such as cotton coveralls, SMS polypropylene or polyolefin coveralls, double layer woven clothing, or wool shirts (ACGIH, 2023; ACGIH, 2017; NIOSH, 2016).

Paragraph (c)(3) would require the employer to document in the HIIPP the hazard evaluation performed to comply with this provision and to include in the HIIPP the policies and procedures developed to protect employee's wearing vapor-impermeable clothing. Although OSHA is not specifying a particular form for the required hazard evaluation, an effective hazard evaluation would include a review of environmental heat exposures, a review of the high-risk area(s), tasks, and occupations, and an evaluation of the length of time and intensity of task when wearing vapor-impermeable clothing.

Policies and procedures should include communication of the status of planned or completed actions to employees who may have to wear vapor-impermeable clothing to complete work tasks. For more information on identifying heat hazards, see *Explanation of Proposed Requirements* for paragraph (d) below.

Under proposed paragraph (c)(4), an employer with more than 10 employees would be required to develop and implement a written HIIPP. While OSHA has concluded that a HIIPP is necessary for all employers covered by the standard, OSHA has determined that only employers with more than 10 employees need to have a written plan. This cutoff of 10 employees is consistent with OSHA's practice of allowing employers with 10 or fewer employees to communicate their emergency action plans (29 CFR 1910.38) and fire prevention plans (29 CFR 1910.39) orally to employees. OSHA expects that small employers with 10 or fewer employees are likely to have less complicated HIIPPs and will communicate with employees verbally. The agency does not believe that there is a high likelihood of misunderstanding when employers communicate their HIIPPs to employees verbally. As a result, OSHA does not believe the added burden on small employers of establishing a written plan is necessary. However, small employers may opt to create a written HIIPP if they find doing so is helpful in developing and implementing their plans.

In contrast, the agency is concerned that when employers have more than 10 employees, there is likely sufficient complexity in the employer's operation that putting the HIIPP in writing is necessary to establish clear expectations and prevent miscommunication. For example, employers with more than 10 employees may have employees working in multiple locations or on multiple shifts, increasing the likelihood that verbally communicating the employer's HIIPP will be ineffective. Therefore, OSHA preliminarily finds that having a written HIIPP that employees of larger employers can easily access is essential to ensure those employees are informed about policies, programs, and protections implemented by their employers to protect them from hazardous heat exposure.

An employer may have already developed and implemented a HIIPP. Existing plans may fulfill some of the requirements in this section. It is not OSHA's intent for employers to duplicate current effective HIIPPs, but each employer with a current HIIPP would have to evaluate that plan for completeness to ensure it satisfies all the requirements of this section. Employers with existing plans would be required to modify and/or update their current HIIPP plans to incorporate any missing required elements and provide training on these new updates or modifications to all employees (see the *Explanation of Proposed Requirements* for Paragraph (h) *Training*). Employers with more than 10 employees would have to ensure their existing HIIPP is in writing.

Paragraph (c)(5) would require the employer to designate one or more workplace heat safety coordinators to implement and monitor the HIIPP. Any employee(s) capable of performing the role who receives the training required by proposed paragraphs (h)(1) and (2) can be designated heat safety coordinator(s). This employee(s) does not need to be someone with specialized training. The heat safety coordinator(s) could be a supervisor or an employee that the employer designates. The heat safety coordinator(s) must have the authority to ensure compliance with all aspects of the HIIPP. This requirement would ensure heat safety coordinators can take prompt corrective measures when hazards are identified. Proposed paragraph (c)(5) would also require that for employers with more than 10 employees, the identity of the heat safety coordinator(s) must be documented in the written HIIPP. Employers must designate a heat safety coordinator(s) to implement and monitor the HIIPP plan, but the exact responsibilities of a heat safety coordinator(s) may vary based on the employer and work site. Some possible duties of the heat safety coordinator(s) could include conducting regular inspections of the work site to ensure the HIIPP is being implemented appropriately and to monitor the ongoing effectiveness of the plan. During such inspections, the heat safety coordinator(s) could observe employees to ensure they are protecting themselves by frequently drinking water or taking rest breaks that employers would be required to provide.

Under proposed paragraph (c)(6), the employer would be required to seek the input and involvement of non-managerial employees and their representatives, if any, in the development and implementation of the HIIPP. An employer could seek feedback from employees through a variety of means, including safety meetings, a safety committee, conversations between a supervisor and non-managerial employees, a process negotiated with the exclusive bargaining agent (if any), or any other similarly interactive process. The method of soliciting employee input is flexible and may vary based on the employer and the work site. For example, a large employer with many employees may find a safety committee with representatives from various job categories combined with anonymous suggestion boxes to be more effective than individual conversations between supervisors and non-managerial employees. In the case of a unionized workplace, a safety committee established through a collective bargaining agreement may be the appropriate source for this input, based on the definition and scope of the committee's work. In contrast, a small employer might determine that an ongoing interactive process between the employer and employees (e.g., regular safety meetings) is a more effective means of soliciting employee feedback. OSHA understands employees often know the most about potential hazards associated with their jobs. As such, employee participation is a key component of effective safety and health programs.

Paragraph (c)(7) would require the employer to review and evaluate the effectiveness of the HIIPP whenever a heat-related injury or illness occurs that results in death, days away from work, medical treatment beyond first aid, or loss of consciousness, but at least annually. Following each review, the employer would be required to update the HIIPP as necessary. The employer would have to seek input and involvement of non-managerial employees and their representatives, if any, during any reviews and updates. OSHA preliminarily finds that a heat-related illness or injury that results in death, days away from work, medical treatment beyond first aid, or loss of consciousness warrants an evaluation of the HIIPP because it could potentially indicate a deficiency of the HIIPP. Additionally, the heat safety coordinator might learn of a deficiency during an inspection or from another employee. OSHA expects that employers would immediately address any identified deficiencies and update the HIIPP accordingly. Under proposed paragraph (h)(4)(iv), all employees would have to be retrained following a heat-related injury or illness that results in death, days away from work, medical treatment beyond first aid, or loss of consciousness, and under proposed paragraph (h)(4)(ii) employees would have to be retrained if identification of a deficiency results in an update to the HIIPP. OSHA preliminarily finds that effective heat injury and illness prevention plans would require periodic evaluation to ensure they are implemented as intended and continue to achieve the goal of preventing heat injury and illness and promoting workplace safety and health. This re-evaluation can result in improvements in controls to help reduce hazards.

Paragraph (c)(8) would require the employer to make the HIIPP readily available at the work site to all employees performing work at the work site. The HIIPP would have to be readily accessible during each work shift to employees when they are in their work area(s). Paper copies, electronic access (i.e., accessible via smart phone) and other alternatives to maintaining paper copies of the HIIPP are permitted as long as no barriers to immediate employee access in each work site are created by such options.

Paragraph (c)(9) would require the employer to ensure the HIIPP is available in a language each employee, supervisor, and heat safety coordinator understands. Under proposed paragraph (c)(4), this would require written translations of the plan in all languages that employees, supervisors, and heat safety coordinators understand. Employers could comply with this requirement by utilizing one of the numerous translator programs available online if the employer has a way to ensure accuracy of the translated materials. In cases where an employee, supervisor, or heat safety coordinator can read and comprehend English, but prefers to read in another language, the employer would have no obligation to provide a written translation of the plan in that individual's preferred language. If one or more employees are not literate, the employer would have to ensure that someone is available to read the written plan in a language that each employee understands. Likewise, for employers who have less than 10 employees, the employer would have to ensure that someone is available to explain the plan in a language that each employee, supervisor, and heat safety coordinator understands. OSHA expects that an individual who speaks employees' languages will be available in all workplaces since effective communication between individuals such as employers, supervisors, and employees would need to occur in order for employees to understand the details about the work tasks they need to complete.

I. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- The approaches that stakeholders are taking to assess heat stress and prevent HRI in employees wearing vapor-impermeable clothing;
- Whether OSHA should specify a temperature that would trigger all or certain requirements of the standard for employees wearing vapor-impermeable clothing;
- Additional approaches that OSHA should consider to protect employees wearing vapor-impermeable clothing;
- Whether the proposed requirement to seek input and involvement from non-managerial employees and their representatives under paragraph (c)(6) is adequate, or whether the explanation should be expanded or otherwise amended (and if so, how and why);
- Whether OSHA should define "employee representative" and, if so, whether the agency should specify that non-union employees can designate a non-employee

third-party (e.g., a safety and health specialist, a worker advocacy group, or a community organization) to provide expertise and input on their behalf;

- Whether it is reasonable to require the HIIPP be made available in a language that each employee, supervisor, and heat and safety coordinator understands;
- What methods and programs are available to provide employees documents and information in multiple languages, whether there are languages for which these resources are not available, and how employers can provide adequate quality control to ensure that the translations are done properly; and
- Whether individuals are available at workplaces to provide verbal translations of the plan for employees who are not literate or do not speak English.

D. Paragraph (d) Identifying heat hazards.

Proposed paragraph (d) sets forth requirements for assessing where and when employees are exposed to heat at or above the initial and high heat triggers. It would require employers with outdoor work sites to monitor heat conditions at outdoor work areas by tracking local heat index forecasts or measuring the heat metric of their choosing (heat index or wet bulb globe temperature (WBGT)). It would require employers with indoor work sites to identify work areas where there is a reasonable expectation that employees are or may be exposed to heat at or above the initial heat trigger and implement a plan for monitoring these areas to determine when exposures above the initial and high heat triggers occur, using the heat metric of their choosing (heat index or WBGT). Determining when employees are exposed to heat at or above the initial and high heat triggers is critical for ensuring that employees are provided with appropriate protections (outlined in paragraphs (e) and (f)).

Proposed paragraph (d)(1) would require employers whose employees perform work outdoors to monitor the heat conditions at the work areas where employees are working. Employers would have two options for complying with this requirement—tracking local heat index forecasts provided by National Weather Service (NWS) or other reputable sources or making on-site measurements using monitoring device(s).

Employers who choose to track local forecasts would need to consult a reputable source for local heat index forecasts such as their local NWS Weather Forecast Office, the OSHA-NIOSH Heat Safety Tool cell phone application, or another weather forecast website or cell phone application. When using these sources, employers would need to accurately enter the location of the work area. The OSHA-NIOSH Heat Safety Tool (and other cell phone applications) will automatically use GPS to determine the user's location, so the forecast may be inaccurate if using the tool at home and employers will need to manually enter the work area location in these situations.

Employers who choose to conduct on-site monitoring would need to set up monitoring devices at or as close as possible to the work area. This could mean setting up the device(s) on a tripod a few yards away from an employee. When there are multiple work areas at the same work site, the employer could use a single monitoring device to measure heat exposure for multiple work areas if there is no reasonable anticipation that the heat exposure will differ between work areas. For example, if employees are harvesting crops on different fields but are within a mile of one another under similar work conditions, the employer could use a single monitoring device. If there is reasonable anticipation that employees at a work site have different levels of exposure, employers could measure the exposure at the work area of the employee(s) reasonably expected to have the highest exposure and apply that value to all employees at the work site instead of measuring the exposure for each work area.

Employers using heat index as their heat metric could either use heat index monitors or measure temperature and humidity with separate devices. In the latter situation, these employers would need to use a heat index calculator, such as the one provided on the NWS website (NWS, 2023), to calculate heat index from the separate temperature and humidity readings. Employers using WBGT as their heat metric would need to take into account differences in solar radiation and wind between work areas when deciding whether a single measurement could be used for multiple work areas. For example, measurements of WBGT in a work area in the shade should not be applied to another work area that is not in the shade. Regardless of which metric they choose to use, employers conducting on-site monitoring should consult user manuals and ensure devices are calibrated and in working order. Employers should follow the device manufacturer’s manual when conducting monitoring.

Proposed paragraph (d)(2) would require employers whose employees perform work outdoors to consult the weather forecast or their monitoring device(s)—whichever they are using to comply with paragraph (d)(1)—frequently enough to determine with reasonable accuracy when conditions at the work area reach the initial and high heat triggers. Employers consulting forecasts would need to check the forecast as close to the start of the work shift as possible to determine whether and when the heat index at the work area may be at or above the initial or high heat triggers. Depending on the forecast or conditions at the work site, the employer then may or may not need to conduct further monitoring during the day. If, for example, the employer consulted the OSHA-NIOSH Heat Safety Tool before the work shift and it indicated that the heat index would exceed the initial heat trigger but not the high heat trigger during the last four hours of the work shift, the employer would need to either: 1) implement control measures in accordance with paragraph (e) for those four hours, or 2) consult the Heat Safety Tool again later in the day and implement control measures in accordance with paragraph (e) only for the hours during which real-time conditions reported by the application exceed the initial heat trigger (which may be more or less than four hours if the forecast earlier in the day underestimated or overestimated the heat index). However, if the employer consulted the OSHA-NIOSH Heat Safety Tool before the work shift and it indicated that the heat index would be close to the initial heat trigger but not exceed it, employers would need to check the forecast again later in the day to determine whether the trigger was exceeded. Employers would need to use short-term forecasts (i.e., hourly) rather than long-term forecasts (e.g., weekly, monthly) to comply with proposed paragraphs (d)(1) and (d)(2). Ultimately, the employer is responsible for ensuring that the controls required at the initial and high heat trigger are in place when those triggers are met, and they should make decisions regarding the frequency of monitoring with this in mind.

Likewise, employers who conduct on-site monitoring in order to comply with paragraph (d)(1) will need to develop a reasonable measurement strategy that is adapted to the expected conditions. If forecasts provide no suggestion that the initial heat trigger could be reached during the work shift, an employer may not need to take any measurements. Where temperatures are expected to approach the initial or high heat triggers, several measurements may be necessary, particularly as the hottest part of the day approaches. For example, if the employer measures at 10:00am and the heat index is very close but below the initial heat trigger, the employer would likely need to either check again sometime shortly thereafter or assume that the trigger is exceeded. WBGT accounts for additional parameters—air speed and radiant heat—so employers using WBGT may need to make additional measurements when these conditions change at the work site.

Proposed paragraphs (d)(3)(i) and (ii) outline the requirements for assessing heat hazards in indoor work sites, which differ slightly from the requirements for outdoor work sites, in that employers would need to identify the work areas where they reasonably expect employees to be exposed to heat at or above the initial heat trigger and then create a monitoring plan to determine when employees in those work areas are exposed to heat at or above the initial and high heat triggers.

Employers could determine which work areas are expected to have employee exposure at or above the initial heat trigger by consulting various data sources, such as previously collected monitoring data, site or process surveys, employee interviews and input, and heat injury and illness surveillance data. Work areas near heat-generating machinery are one example of where there may be a reasonable expectation of employee exposure at or above the initial heat trigger. In addition to heat-generating equipment, employers must determine whether there is a reasonable expectation that an increase in the outdoor temperature would increase temperatures in their indoor work site, thereby exposing employees to heat at or above the initial heat trigger.

Employers would be required to develop a monitoring plan that covers each work area they identified in the prior step. The monitoring plan is intended to determine when employees are exposed (e.g., specific times of day, during certain processes, certain months of the year) to heat at or above the initial and high heat triggers for each work area. When developing a monitoring plan(s), employers would need to take into account the circumstances that could impact heat conditions specific to each work area and work site. The monitoring plan(s) would need to be included in the employer's HIIPP.

In complying with proposed paragraph (d)(3)(ii), employers would need to outline in their monitoring plan how they will monitor either heat index or WBGT using on-site monitors that are set up at or as close as possible to the work area(s) identified under paragraph (d)(3)(i). OSHA intends the phrase "as close as possible" to mean the closest possible location that won't otherwise create inaccurate measurements. The employer should ensure that their monitoring plan outlines the appropriate frequency of measurements, which should be of sufficient frequency to determine with reasonable accuracy employees' exposure to heat. For example, if the employer determines there is only a reasonable expectation that employees are or may be exposed to heat at or above the initial heat trigger when a certain process is happening or during certain times of the year, then they would only need to monitor when that process is happening or during that time of the year.

Employers using heat index as their heat metric could either use heat index monitors or measure temperature and humidity with separate devices. In the latter situation, these employers would need to use a heat index calculator, such as the one provided on the NWS website (NWS, 2023), to calculate heat index from the separate temperature and humidity readings. Employers using WBGT as their heat metric would need to take into account differences in radiant heat and air movement between work areas when deciding whether a single measurement can be used for multiple work areas. For example, measurements of WBGT in a work area without a radiant heat source should not be applied to another work area that is near a radiant heat source. Regardless of which metric they choose to use, employers should consult user manuals and ensure devices are calibrated and in working order. Employers should follow the device manufacturer's manual when conducting monitoring.

If there are multiple work areas where there is a reasonable expectation that employees are or may be exposed to heat at or above the initial heat trigger at a work site, the employer could conduct representative sampling instead of taking measurements at each individual work area. If using this approach, the employer would be required to sample the work area(s) expected to be the hottest. For example, this may involve monitoring the work area closest to a heat-generating process. The employer cannot put a monitoring device in a work area known or expected to be cooler and consider that representative of other work areas.

If any changes occur that could increase employee exposure to heat (i.e., a change in production, processes, equipment, controls, or a substantial increase in outdoor temperature which has the potential to increase heat exposure indoors), proposed paragraph (d)(3)(iii) would require that the employer must evaluate any affected work area(s) to identify where there is reasonable expectation that employees are or may be exposed to heat at or above the initial heat trigger. Examples of changes that could increase employee exposure to heat include the installation of new equipment that generates heat in a work area that didn't previously have heat-generating equipment or a local heat wave that increases the heat index in a warehouse without air-conditioning. The employer would be required to update their monitoring plan or develop and implement a monitoring plan, in accordance with paragraph (d)(3)(ii), to account for any increases in heat exposure.

Proposed paragraph (d)(3)(iv) would require employers to involve non-managerial employees (and their representatives, if applicable) in the determination of which work areas have a reasonable expectation of exposing employees to heat at or above the initial heat trigger (which is described in paragraph (d)(3)(i)). Employers would also be required to involve non-managerial employees (and their representatives, if applicable) in developing and updating the monitoring plan(s) outlined in paragraph (d)(3)(ii) through (iii). One example of this involvement would be employees providing input in identifying processes or equipment that give off heat and times of the day or year when certain areas of the building feel uncomfortably hot and warrant monitoring. Employees are often the most knowledgeable about the conditions in which they work and their involvement will help ensure the accuracy and sufficiency of the employer's monitoring plan(s).

Proposed paragraph (d)(4) specifies that the heat metric (i.e., heat index or WBGT) that the employer chooses to monitor determines the applicable initial and high heat triggers under the standard. Specifically, as defined in paragraph (b), if the employer chooses to monitor heat index, they would be required to use the initial heat trigger of 80°F (heat index) and the high heat trigger of 90°F (heat index). If the employer chooses to use WBGT, they would be required to use the NIOSH Recommended Alert Limit (RAL) as the initial heat trigger and the NIOSH Recommended Exposure Limit (REL) as the high heat trigger. As outlined in paragraph (c), the employer would be required to identify which heat metric they are monitoring in their HIIPP. If they do not do this, proposed paragraph (d)(4) specifies that the initial and high heat trigger will be based on the heat index.

Proposed paragraph (d)(5) would provide an exemption from monitoring requirements for employers who choose to assume that their employees are exposed to heat at or above both the initial and high heat triggers. In these cases, employers would not need to conduct monitoring, but they would be required to provide all controls outlined in paragraphs (e) and (f) while making this assumption. For the period of time that employers choose to make this assumption and are therefore exempt from monitoring requirements, they would not be required to keep records of monitoring data (see paragraph (i), Recordkeeping).

I. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Whether the proposed requirement to monitor outdoor work areas with "sufficient frequency to determine with reasonable accuracy employees' exposure to heat" is adequate or whether the standard should specify an interval of monitoring (and if so, what frequency and why);
- Whether OSHA should specify an interval of monitoring for indoor work areas (and if so, what frequency and why);
- Whether the standard should include a specific increase in outdoor temperature that would trigger the requirements in paragraph (d)(3)(iii) for indoor work areas, rather than the trigger being a "substantial increase", and if so, what magnitude of increase;
- Whether there could be situations in which a lack of cellular service prevents an employer from using weather forecasts or real-time predictions, and if so, what alternatives would be appropriate;
- Whether the standard should require specifications related to monitoring devices (e.g., in accordance with user manuals, properly calibrated) and whether the standard should specify a permissible accuracy level for monitoring devices; and
- Whether the standard should further specify which sources of forecast data employers can use to comply with paragraph (d)(1)(i) and if so, what criteria should be used.

E. Paragraph (e) Requirements at or above the initial heat trigger.

I. Timing.

Paragraph (e) of the proposed standard would establish requirements when employees are exposed to heat at or above the initial heat trigger. As discussed in Section V.B., Basis for Initial and High Heat Triggers, OSHA has preliminarily determined that the experimental and observational evidence support that heat index triggers of 80°F and 90°F are highly sensitive and therefore highly protective of employees. Exposures at or above the initial heat trigger, a heat index of 80°F or a corresponding wet bulb globe temperature equal to the NIOSH Recommended Alert Limit, would require the employer to provide the protections outlined in paragraphs (e)(2) through (e)(10).

The employer would only be required to provide the specified protections during the time period when employees are exposed to heat at or above the initial heat trigger. In many cases, employees may only be exposed at or above the initial heat trigger for part of their work shift. For example, employees who work outdoors may begin work at 9:00 a.m. and finish work at 5:00 p.m.. If their exposure is below the initial heat trigger from 9:00 a.m. until 12:00 p.m., and at or above the initial heat trigger from 12:00 p.m. to 5:00 p.m., the employer would only be required to provide the protections specified in this paragraph from 12:00 p.m. to 5:00 p.m.. Additional protective measures, outlined in paragraph (f) *Requirements at or above the high heat trigger,* would be required when employees are exposed to heat at or above the high heat trigger.

II. Drinking water.

Paragraph (e)(2) of the proposed standard would establish requirements for drinking water when employees are exposed to heat at or above the initial trigger. The proposed requirements of (e)(2) are in addition to the requirements in existing OSHA sanitation standards applicable to the employer, including the general industry sanitation standard (29 CFR 1910.141); construction industry sanitation standard (29 CFR 1926.51); field sanitation standard (29 CFR 1928.110); shipyard employment sanitation standard (29 CFR 1915.88); marine terminals sanitation standard (29 CFR 1917.127); and temporary labor camp standard (29 CFR 1910.142). In addition to requirements for drinking water, these standards require access to toilet facilities, which is important to ensure that employees are not discouraged from drinking adequate amounts of drinking water. As discussed in Risk Reduction, Section V.C., drinking water has been shown to be an effective intervention for preventing dehydration, heat strain, and HRI. It allows employees to replace fluids lost by sweat and is necessary to maintain blood volume for cardiovascular function and thermoregulation.

Proposed paragraph (e)(2)(i) would require that employers provide access to potable water that is placed in locations readily accessible to employees. To ensure employees have sufficient drinking water whenever needed, the drinking water should be located as close as possible to employees, to facilitate rapid access. Employers could comply with this provision by providing water coolers or food grade jugs on vehicles if drinking water fountains or taps are not nearby, or by providing bottled water or refillable water bottles so that employees always have access to water. Employers supplying water through a common source such as a tap or jug would have to provide a means for employees to drink the water. This could include providing disposable cups or single-user refillable water bottles. Under OSHA’s sanitation standards, common drinking cups or other shared utensils are prohibited. Open containers such as barrels, pails, or tanks for drinking water from which water must be dipped or poured, whether or not they are fitted with a cover, are also prohibited under these standards. In cases where employers provide single-user, refillable water bottles, they should keep extra bottles or disposable cups on hand in case employees misplace or forget to bring the bottle the employer provided them.

OSHA notes that water would not be readily accessible if it is in a location inaccessible to employees (e.g., the drinking water fountain is inside a locked building or trailer). Water would also not be readily accessible if it is placed at a distant or inconvenient location in relation to where employees work. OSHA expects that employers will have incentive to place the drinking water as close to employees as feasible to minimize the amount of time needed to access water, which must be paid. Explanation of Proposed Requirements for paragraph (j) *Requirements implemented at no cost to employees*).

Proposed paragraph (e)(2)(ii) would require that employers provide access to potable water that is suitably cool. As discussed in Risk Reduction, Section V.C., the temperature of drinking water impacts hydration levels, as cool or cold water has been found to be more palatable than warm water, thus leading to higher consumption of cool water and decreased risk of dehydration. Additional evidence highlighted in Risk Reduction, Section V.C., shows that cool fluid ingestion has beneficial effects for reducing heat strain. The requirement that drinking water be “suitably cool” is consistent with OSHA’s existing field sanitation standard (29 CFR 1928.110(c)(1)(ii)) and with California’s heat standard for outdoor workplaces (Cal. Code Regs. tit. 8, § 3395). OSHA has previously stated that to be suitably cool, the temperature of the water “must be low enough to encourage employees to drink it and to cool the core body temperature" (Field Sanitation, 52 FR 16050, 16087 (May 1, 1987)). Employers could comply with this provision by providing drinking water from a tap or fountain that maintains a cooler temperature, providing water in coolers or by providing ice or ice packs to keep drinks cool.

In addition to providing palatable and potable water, the NACOSH Heat Injury and Illness Prevention Work Group recommended that employers consider providing electrolyte supplemental packets that can be added to water or electrolyte-containing sports drinks (NACOSH Working Group on Heat, 2023). While employers could choose to offer electrolyte supplements or electrolyte-containing sports drinks, they would not be required under the standard. Providing electrolyte supplements or sports drinks alone would not meet the proposed requirement. OSHA has preliminarily determined that electrolyte supplementation may not be necessary in a majority of situations if workers are consuming adequate and regular meals (NIOSH, 2017a). OSHA has also received feedback from stakeholders that some workers may be unable to consume certain electrolyte supplements or solutions due to their sugar content.

Proposed paragraph (e)(2)(iii) would require that employers provide access to one quart of drinking water per employee per hour. Employers could comply with this provision by providing access to a drinking water tap or fountain that has a continuous supply of drinking water, or providing coolers or jugs that are replenished with water as the quantity diminishes. As discussed in more detail in Section V.C., Risk Reduction, that volume of water intake ensures adequate replenishment of fluids lost through sweat to avoid a substantial loss in total body water content for employees working in the heat. OSHA is specifying the amount of water that employers need to provide to employees, not an amount that employees need to drink. However, as discussed in the Explanation of Proposed Requirements for paragraphs (f)(3) and (h), the employer must inform employees of the importance of drinking water to prevent HRIs during initial training, annual refresher training, and whenever the high heat trigger is met.

Finally, in accordance with paragraph (j) of the proposed standard, all drinking water requirements must be implemented at no cost to employees. Accordingly, employers may not charge employees for the drinking water required by paragraph (e)(2) nor for the equipment or supplies needed to access it.

A. Requests for Comments.

OSHA requests comments and information on the following:

- Whether OSHA should require a specific temperature or ranges of temperature for drinking water as some state regulations do (e.g., Colorado requires that drinking water is kept 60°F or cooler);
- Whether the agency should require the provision of electrolyte supplements/solutions in addition to water;
- Whether the requirement to provide a minimum of 1 quart per hour per employee is appropriate; and
- Whether there are any challenges to providing the required amount of drinking water (e.g., for employees who work on foot in remote areas) and, if so, alternatives that OSHA should consider.

III. Break area(s) at outdoor work sites.

Paragraph (e)(3) contains the proposed requirements for outdoor break areas when temperatures meet or exceed the initial heat trigger. Adequate break areas where employees can hydrate, remove PPE, and cool down is considered a vital component in preventing HRIs and necessary part of a multilayered strategy to control exposure to high heat. The requirements for both outdoor and indoor break areas in this proposed standard are in addition to employers' obligations under OSHA's sanitation standards (29 CFR 1910.141, 1915.88, 1917.127, 1918.95, 1926.51, 1928.110). Because the sanitation standards address workplace hazards other than heat exposure, employers must continue to comply with their obligations under those standards. OSHA highlights these sanitations standards because employees are likely to eat and drink water in the indoor break areas, which may implicate certain provisions of these standards.

Specifically, proposed paragraph (e)(3) requires employers to provide one or more employee break areas at outdoor work sites that can accommodate the number of employees on break, is readily accessible to the work area(s) and has either shade (paragraph (e)(3)(i)), or air-conditioning if in an enclosed space (paragraph (e)(3)(ii))). As explained more in detail in Section V.C., Risk Reduction, shade reduces exposure to radiant heat which can contribute to heat stress and lead to heat strain and HRI. Further, air-conditioning is effective in reducing heat stress and resulting heat strain because it reduces exposure to heat. Accordingly, OSHA has preliminarily determined that requirements for break areas, including the use of controls to facilitate cooling while employees are on break, are effective at preventing HRIs among workers and should be included in the proposed standard. This determination is supported by NIOSH's criteria for a recommended standard, several state standards, and existing guidance (Cal. Code Regs. tit. 8, § 3395 (2024); 7 Colo. Code Regs. § 1103-15:3 (2023); Or. Admin. R. 437-002-0156 (2024); Or. Admin. R. 437-004-1131 (2024); Wash. Admin. Code 296-307-09747 (2023); NIOSH, 2016).

Proposed paragraph (e)(3) would require the employer to ensure the break area(s) can accommodate all employees on break. This provision is intended to ensure that all employees taking rest breaks that employers would need to provide under proposed paragraphs (e)(8) and (f)(2) are able to do so in an appropriate break area(s). If the break area cannot accommodate the number of employees on break, some employees may not have access to adequate cooling controls while on break, increasing their risk of HRIs. In addition, adequate space allows for ventilation and airflow, contributing to a more effective cooling.

While OSHA is not proposing a minimum square footage requirement per employee, break areas that can only fit the anticipated number of employees on break if employees stand shoulder to shoulder, or in such close proximity that heat cannot dissipate, would not be large enough to accommodate the number of employees on break. Break areas that are not large enough to allow employees to move in and out freely or access necessary amenities, such as water and air-conditioning or shade, would also not be considered large enough to accommodate the number of employees on break.

Proposed paragraph (e)(3) does not require that the break area(s) be able to accommodate an employer's entire workforce at the same time. However, the employer must evaluate the needs of the work site and ensure the break area(s) is large enough to accommodate all employees reasonably expected to be on break at the same time. When making this determination, employers would need to consider factors such as how many employees are reasonably expected to be taking breaks to prevent overheating under proposed paragraph (e)(8) at any given time, as well as the breaks required under proposed paragraph (f)(2) (e.g., are (f)(2) breaks staggered or will large groups of employees be taking them at the same time?). However, the minimum frequency and duration of breaks under paragraph (f)(2) must be met.

Similarly, where an employer has multiple break areas on-site, OSHA does not expect each of these multiple break areas to be able to accommodate an employer's entire workforce. Instead, OSHA expects that employers who utilize multiple break areas will determine the number of employees anticipated to access each break area and ensure the break areas are sufficient in size to accommodate the need for break space in each location. When making this determination, employers would need to consider factors such as the distribution of employees across different areas and any employee movement throughout the areas during a work shift.

OSHA also acknowledges that some employers may have facilities where both outdoor and indoor work occurs. OSHA requests comments on whether the agency should permit all employees in these facilities to utilize indoor break areas.

Proposed paragraph (e)(3) would require that break areas be readily accessible to the work area(s). It is important that break areas be readily accessible to ensure that employees can take breaks promptly, particularly in situations where employees are experiencing early symptoms of HRIs, as quick access to a break area can help limit the further progression of illness. In addition, break areas within close proximity to employees encourages use. OSHA does not expect the employer to have break areas located immediately adjacent to every employee and understands that exact distance may vary depending on factors such as the size and layout of the workplace, the number of employees, and the nature of the work being performed.

Locations that are so far from work area(s) that they deter employees from taking breaks would not be considered readily accessible. When determining the location of the break area(s), the employer would be expected to evaluate the duration of travel to the area. Break areas requiring more than a few minutes to reach would increase the heat stress on employees as they walk to the area and thus not be considered reasonably accessible. The break area must be situated close enough to work areas to minimize the time and effort required for employees to access it. Break areas should be as close as possible to employees so that an employee in distress could easily access the area to promptly cool down. OSHA expects that employers will have incentive to place the break areas as close as practical to the work areas to minimize travel time, which must be paid (see Explanation of Proposed Requirement for paragraph (j) *Requirements implemented at no cost to employees*).

For mobile work sites, such as in road construction or utility work, the employer would be expected to relocate the break area as needed to ensure it is readily accessible to employees or ensure each work site has its own break area for use. This requirement would also apply to large work sites where employees are continually changing their work area, such as in agricultural work. The employer would be required to pay employees their normal rate of pay for time to get to the break area, as well as the time on break (see the *Explanation of the Proposed Requirements* for paragraph (j)).

In addition to ensuring the break area(s) is large enough to accommodate all employees on break and readily accessible to the work area(s), employers would have to provide at least one of the following: shade (paragraph (e)(3)(i)); or air-conditioning, if in an enclosed space (paragraph (e)(3)(ii)). As discussed above, break areas are intended to provide employees a spot to cool down and reduce body temperature. Also, controls such as shade and air-conditioning are proven methods to prevent HRIs. Without controls such as these in place, break areas could become uncomfortable and even continue to expose individuals to the risk of HRI. OSHA understands that the scope of the standard includes a broad variety of outdoor industries, and that even within one industry, workplaces can be vastly different. The proposed requirements for outdoor break areas give employers flexibility in their compliance.

Paragraph (e)(3)(i) of the proposal outlines the requirements for employers who use shade. The provision would require that the break area have artificial shade (e.g., tent, pavilion) or natural shade (e.g., trees), but not shade from equipment, that provides blockage of direct sunlight and is open to the outside air. By incorporating shade into break areas, whether through natural foliage, awnings, or umbrellas, employees are able to reduce exposure to radiant heat and benefit from conditions that are more conducive to increasing evaporative cooling as air moves across the skin. The benefits of shaded break areas have also been recognized by several states and incorporated into state standards, including California, Colorado, Oregon, and Washington (Cal. Code Regs. tit. 8, § 3395 (2024); 7 Colo. Code Regs. § 1103-15:3 (2023); Or. Admin. R. 437-002-0156 (2024); Or. Admin. R. 437-004-1131 (2024); Wash. Admin. Code 296-307-09747 (2023)).

To ensure shade is effective, OSHA would require the shade to block direct sunlight for the break area. OSHA does not expect employers to measure shade density using shade meters or solarimeters. As defined under proposed paragraph (b) *Shade* means the blockage of direct sunlight, such that objects do not cast a shadow in the area of blocked sunlight. Therefore, verifying that employees' shadows are obstructed from being visible due to the presence of shade would be sufficient. In addition, shaded break area(s) must be open to the outside air. To satisfy this requirement, the shaded break area must be sufficiently open to the outside air to ensure that air movement across the skin (promoting the evaporation of sweat) can occur and to prevent the buildup of humidity and heat that can become trapped due to limited airflow and stagnant air. For example, a pop-up canopy with one enclosed side would comply with the provisions for a shade structure; however, a closed trailer having four sides and a roof would not. Employers could also incorporate other cooling measures, such as fans or misting devices, in their shaded break area, although the proposed standard does not require them to do so.

Both portable and fixed shade would be permitted to comply with the proposed requirements under (e)(3)(i). However, as stated above, employers must ensure shaded break areas remain readily accessible to employees. At mobile work sites or work sites where employee move to various locations throughout the day, such as, but not limited to those commonly found in agriculture, landscaping, forestry, and utility work, employers would need to ensure that shade structures are relocated near the work area as needed or that natural sources of shade (e.g., from trees) are readily available at each work location. OSHA understands that in some mobile outdoor work environments shade structures may not be practical and employers may wish to utilize the flexibility of shade provided by large vehicles that are already on-site. Large vehicles such as trucks and vans which are used to transport employees or goods to the work site, but not as part of the work itself could be used as shade as long as the vehicle is not running. OSHA is not allowing the use of equipment used in work process, such as tractors, for shade due to the risk of accidental run-overs caused by the start-up and movement from operators who are not aware of the presence of workers nearby. Additionally, equipment used in work processes is likely to emit radiant heat after use, which may impede employee cooling. However, shade provided by buildings could be used, provided it is reasonably accessible to employee work areas. Additionally, as previously explained, the break area(s) must be large enough to accommodate all employees on break. Therefore, employers utilizing shade cast by buildings or trees would need to consider the path of shade movement throughout the day to ensure adequate areas of shade coverage are maintained and the shade is able to accommodate all employees on break.

Paragraph (e)(3)(ii) of the proposal describes the requirements for the use of air-conditioned break areas. Specifically, the proposed provision indicates that a break area could be an area that has air-conditioning if that area is in an enclosed space like a trailer, vehicle, or structure. As with the shaded areas, the air-conditioned break area would need to be large enough to accommodate the number of employees on rest breaks and be readily available. The use of air-conditioned spaces is consistent with state requirements and existing guidance. In their state regulations, both Colorado and Washington include the use of an air-conditioned site, such as a vehicle or structure, as an alternative to providing shade for employee rest breaks (7 Colo. Code Regs. § 1103-15:3 (2023); WA, 2008b; Wash. Admin. Code 296-307-09747 (2023). It is well established that the use of air-conditioned spaces reduces the air temperature employees are exposed to (NIOSH, 2016).

Employers using air-conditioned vehicles as a break area would need to ensure that the vehicle remains readily available during work periods when the initial heat trigger is met or exceeded. For mobile employees, such as delivery drivers, employers could have employees take breaks in an air-conditioned convenience store, restaurant, or similar establishment as long as all other requirements for break areas are met.

A. Requests for Comments.

OSHA seeks comments and additional information whether it should further specify break area requirements (e.g., square footage per employee), and what those requirements should be. Also, OSHA seeks additional comments on break areas where employers have both indoor and outdoor work areas including:

- Whether OSHA should maintain separate break area requirements for these employees;
- Whether OSHA should allow outdoor employees in these facilities to utilize indoor break areas under paragraph (e)(4); and
- Whether OSHA should limit the use of indoor break areas to those that are

equipped with air-conditioning.

OSHA seeks comments and additional information regarding the use of shade, including:

- Whether OSHA appropriately defined shade; if not, how should OSHA define shade for outdoor break areas;
- Whether there are situations where shade is not protective and should not be permitted; and in these cases, what should be required for break areas;
- Whether there are additional options for shade that are protective, but which OSHA has not included;
- Whether there are situations when trees are not appropriate for use as shade and other measures should be required;
- Whether there are situations when employers should be permitted to use equipment as shade; in those situations, how would employers mitigate other safety concerns such as run-over incidents;
- Whether there are situations when employers should not be able to use large vehicles as shade or concerns, including those related to safety, with generally allowing the use of large vehicles for shade; and
- Whether there are situations when artificial shade should not be permitted, such as during high winds.

OSHA seeks comments and additional information regarding the use of air-conditioned spaces, including:

- Whether OSHA should define or specify the levels at which air-conditioning must operate; and
- Whether OSHA should require that break rooms and vehicles used for breaks be pre-cooled prior to the start of the employee's break.

OSHA seeks comments and additional information regarding the use of other cooling strategies (beside shade and air-conditioning) that could be used in break areas, including:

- Whether there are other control options that would be both as effective as shade at reducing heat strain and feasible to implement;

OSHA seeks comments and additional information regarding break area requirements for mobile workers:

- OSHA did not include separate requirements and seeks additional information on the feasibility and effectiveness of the proposed controls listed under paragraph (e)(3) including the use of vehicles as a break area; and
- Whether there are control options OSHA should require for vehicles, either when used for work activities or when used as a break area.

IV. Break area(s) at indoor work sites.

Paragraph (e)(4) of the proposed standard outlines the requirements for break areas at indoor work sites. Specifically, it would require that the employer provide one or more area(s) for employees to take breaks (e.g., break room) that is air-conditioned or has increased air movement and, if appropriate, de-humidification; can accommodate the number of employees on break; and is readily accessible to the work area(s). As explained above in the *Explanation of Proposed Requirements* for paragraph (e)(3), the requirements for both outdoor and indoor break areas in this proposed standard are in addition to employers' obligations under OSHA's sanitation standards (29 CFR 1910.141, 1915.88, 1917.127, 1918.95, 1926.51, 1928.110).

Information regarding compliance with the requirements that break area(s) be large enough to accommodate all employees on break and readily accessible can be found in the *Explanation of Proposed Requirements* for paragraph (e)(3). Break area(s) at indoor work sites will often likely be specific rooms in a facility (e.g., a break room). To ensure that the break areas are readily accessible, employers would need to make sure that employees can enter the break areas for heat-related breaks (e.g., keep the break room unlocked).

At indoor work sites, the break area(s) must be air-conditioned or have a combination of increased air movement and, if appropriate, de-humidification. The importance and effectiveness of air-conditioning and air movement in preventing HRIs were explained above in the *Explanation of Proposed Requirements* for paragraph (e)(3). OSHA is requiring de-humidification, if appropriate, in addition to increased air movement because humidity levels directly impact the body's ability to cool itself through evaporation. Humidity control is integrated into modern air-conditioning units and therefore OSHA is only requiring de-humidification to be implemented in high temperature and high humidity environments when employers are relying on increased air movement to comply with this requirement. To determine when de-humidification may be appropriate in the context of fan use, employers should consult the *Explanation of Proposed Requirements* for paragraph (e)(6).

To comply with the requirements under proposed paragraph (e)(4), employers who operate in arid environments could use evaporative or "swamp" coolers as a form of air-conditioning. Note, however, that such coolers are not effective in humid environments. It is also important to note that OSHA is not requiring employers install a permanent cooling system. The use of portable air-conditioning units or high-powered fans and portable dehumidifiers in designated break areas could also be used to comply with requirements for break areas under the proposed standard. As discussed in the *Explanation of Proposed Requirements* for paragraph (e)(6), fan use when ambient temperatures exceed 102°F has been demonstrated to be harmful under some conditions and employers must evaluate humidity levels to determine if fan use should be avoided.

Under the proposal, indoor break area(s) do not necessarily need to be located in a separate room but can be integrated within the main workspace. For example, in a manufacturing facility, there could be a designated corner or section within the main production area where employees could take their breaks. This break area could be demarcated by partitions, screens, or signage to distinguish it from the active work zones and be equipped with fans. Alternatively, an employer, who is unable to establish a break area in their main workroom because of sensitive or hazardous work equipment or processes, can establish a break area in a separate area away from the work zone, provided that area is readily accessible to employees. Regardless of where a break area is located, the break area must allow employees to cool down effectively and drink water to hydrate.

For indoor workplaces that experience temperatures above the heat triggers but have employees who spend part of their time in air-conditioned control booths or control rooms and part of their time in other, hotter areas of the facility, the employer could utilize the control booth/room as a break area and would not need to provide a separate break area for those employees. Control booths/rooms are commonly found in industries such as manufacturing, food processing, electronics assembly, processing facilities, power plants, water treatment plants, and more. Furthermore, these spaces would qualify as break areas for other employees provided that the requirements for size and location are met. Control booths/rooms that are locked or have restricted accessibility would not be acceptable under the proposal.

A. Requests for Comments.

OSHA seeks comments and additional information regarding the use of engineering controls for indoor break areas, including:

- Whether OSHA should specify how effective engineering controls need to be in cooling the break area(s), including other measures determining effectiveness beyond temperature and humidity;
- Whether OSHA should define a temperature differential between work areas and break areas; and
- Whether OSHA should specify a temperature that break areas must be kept below.

OSHA seeks comments and additional information regarding the use of other cooling strategies (besides fans and air-conditioning) that could be used in break areas, including:

- Whether there are other control options that would be both effective at reducing heat strain and feasible to implement.

OSHA did not include an option for the use of outdoor break areas for indoor work sites and seeks comment and information on the use of outdoor break areas for employees in indoor work sites, including:

- Whether there are situations where an outdoor break area could be more effective at cooling and should be permitted; and
- Whether certain conditions must be provided for these outdoor break areas.

OSHA seeks additional comments on break areas where employers have both indoor and outdoor work areas. See *Explanation of Proposed Requirements* paragraph (e)(3), *Requests for Comments.*

V. Indoor work area controls.

Paragraph (e)(5) contains the proposed requirements for indoor work area controls when temperatures meet or exceed the initial heat trigger. Indoor work areas would be required to be equipped with a combination of increased air movement and, if appropriate, de-humidification (paragraph (e)(5)(i)); air-conditioning (paragraph (e)(5)(ii)); or, in the case of radiant heat sources, other cooling measures that effectively reduce employee exposure to radiant heat in the work area (paragraph (e)(5)(iii)). The importance and effectiveness of air-conditioning and air movement (including dehumidification) in preventing HRIs were explained above in the *Explanation of Proposed Requirements* for paragraphs (e)(3). In addition to these, OSHA is permitting the use of other control measures for radiant heat sources because these controls result in less heat being radiated to employees.

As discussed above in the *Explanation of Proposed Requirements* for paragraph (d)(3)(i), employers would be expected to determine which work areas of indoor work sites, if any, are reasonably expected to meet or exceed the initial heat trigger. For work areas at or above the trigger, such as those near heat-generating machinery, paragraph (e)(5) would require employers to implement work area controls. OSHA understands that effective control methods can vary based on workspace circumstances and the nature of the heat source and is therefore giving employers options regarding indoor work area controls. However, each work area with exposures at or above the initial heat trigger would need be to be equipped with at least one control option. Additionally, employers could choose to use a combination of control measures.

Employers could use increased air movement (e.g., fans) and, if appropriate, de-humidification, or air-conditioning to cool the work area under paragraphs (e)(5)(i) and (e)(5)(ii). Under paragraph (e)(5)(i), fans could be used to increase the air movement in the work area. Employers could use overhead ceiling fans, portable floor fans, or other industrial fans to comply. Employers could also increase the air flow using natural ventilation by opening doors and windows, or vents, to allow fresh air to flow into the space, but only when doing so would be comparable to the use of fans. Natural ventilation would not be acceptable if it does not produce air movement equivalent to a fan, or if the outdoor temperature is such that natural ventilation increases the work area temperature.

Depending on the type of work being done and the location of employees in a facility, employers could choose to use ventilation to cool the entire space or just those areas where employees are present. Although paragraph (e)(5) only applies to work areas, it may be more efficient for the employer to implement the control for an entire space. With either strategy, the employer should consider the facility layout, equipment placement, and potential obstructions to ensure optimal airflow when determining where to place fans. For example, an employer could use fans to cool a warehouse by strategically positioning them near entrances and exits to create airflow and facilitate the circulation of fresh air into the warehouse. Additionally, utilizing high-velocity fans along aisles or in areas where employees are concentrated can help dissipate heat and provide a cooling effect. Conversely, if employees only work in a discrete area(s) of a facility, an employer may choose to only provide fans in those work areas. For example, the employer could place fans in the area where employees are stationed. Adjustable fans or fans with oscillating features could be used in those areas to allow employers to direct airflow where it is most needed. Additionally, employers could consider installing overhead fans or mounting fans on adjustable stands to ensure optimal coverage and airflow distribution.

As discussed in the *Explanation of Proposed Requirements* for paragraph (e)(4), employers using fans or relying on natural ventilation in humid environments would still be expected to decrease humidity levels where appropriate. OSHA is not proposing a specific temperature or humidity level be maintained in the work areas; however, employers should ensure that the combination of air movement and humidity level effectively reduces employees' heat strain. As discussed in the *Explanation of Proposed Requirements* for paragraph (e)(6), OSHA has preliminarily determined that under some conditions, fan use may be harmful when ambient temperatures exceed 102°F and employers must evaluate humidity levels to determine if fan use is harmful when temperatures reach this threshold. Employers should consult the *Explanation of Proposed Requirements* for paragraph (e)(6) to determine when de-humidification may be appropriate in the context of fan use.

Under paragraph (e)(5)(ii) employers could use air-conditioning to meet the requirement for controlling heat exposures in indoor work areas. In arid environments, evaporative coolers, also known as "swamp coolers," could be used and would be considered air-conditioners, even if portable. It is important to note that while an employer may choose to provide air-conditioning to the entire facility, they would not be required to do so under the proposed standard. Employers who choose to provide air-conditioning under paragraph (e)(5)(ii) would only need to implement it in areas where employees work and are exposed to temperatures above the initial heat trigger. Similar to fan use, if employees only work from fixed or designated locations in the workplace, the employer would only need to provide air-conditioning to those spaces under paragraph (e)(5)(ii). For example, if employees work only from a control booth or control room, employers could choose to install air-conditioning in the control booth or control room to comply with paragraph (e)(5)(ii). Similarly, portable air-conditioning units could be used throughout the facility to cool smaller areas where employees work. For example, an employer could position portable evaporative coolers near the entrance of a loading dock to provide immediate relief from the heat when an employee is loading or unloading goods inside the building, or a machine shop may choose to use portable air-conditioners around the workstation to cool the employee. Alternatively, a manufacturing facility may choose to install a small, air-conditioned control booth for operators to work from. All of these options would be acceptable under the proposal.

Under paragraph (e)(5)(iii), in indoor work areas with radiant heat sources, employers could choose to implement other measures that effectively reduce employee exposure to radiant heat in the workplace. Paragraph (e)(5)(iii) would allow the use of controls such as shielding or barriers, isolation, or other measures that effectively reduce employee exposure to radiant heat, in areas where employees are exposed to radiant heat created by heat-generating processes. The use of control methods for radiant heat is consistent with guidance issued by Minnesota regarding the implementation of their heat standard (MNOSHA, 2009). Options for complying with this proposed provision could include installing shielding or barriers that are radiant-reflecting to reduce the amount of radiant heat to which employees would otherwise be exposed; isolating the source of radiant heat, such as using thermal insulation on hot pipes and surfaces; increasing the distance between employees and the heat source; and modifying the hot process or operation.

If the employer chooses to utilize radiant heat controls under paragraph (e)(5)(iii) in lieu of air-conditioning or fan use, the controls would need to effectively reduce employee exposure to radiant heat. For example, in facilities with industrial ovens, kilns, or process heat, employees may be exposed to radiant heat during loading, unloading, or maintenance tasks. Installing shielding around these heat sources can help protect employees from radiant heat during these tasks. In another example, an employer may choose to install heat-resistant barriers or insulating materials around welding stations to contain heat and prevent its transmission to adjacent work areas.

A. Requests for Comments.

OSHA seeks comments and additional information regarding the use of engineering controls for indoor work areas, including:

- Whether the standard should specify how effective engineering controls need to be in cooling the work area(s);
- Whether there are other control options (besides fan use or air-conditioning) that would be both effective at reducing heat strain and feasible to implement in cases where indoor employees are exposed to ambient heat; and
- Whether there are work areas where maintaining a high ambient temperature is necessary for the work process and, if so, how OSHA should address these work areas in the standard.

VI. Evaluation of fan use.

Paragraph (e)(6) of the proposed standard would require employers using fans under certain conditions to determine if fan use is harmful. Specifically, when ambient temperatures exceed 102°F (39.0°C), employers using fans to comply with paragraphs (e)(4) or (e)(5) would be required to evaluate the humidity levels at the work site and discontinue the use of fans if the employer determines that fan use is harmful.

As discussed in Section V.C., Risk Reduction, researchers in the past 10 years have increasingly evaluated the conditions under which fan use becomes harmful, using both experimental and modeling approaches. Most of this work has assumed individuals are seated and at rest; to OSHA's knowledge, only one paper has evaluated the threshold at which fans become harmful for individuals performing physical work (Foster et al., 2022a). The impact of fans is determined by both air temperature and humidity, as well as factors influencing sweat rates. Researchers have demonstrated that neither heat index nor ambient temperature alone can be used to determine beneficial versus harmful fan use; instead, ambient temperature and relative humidity must both be known (Morris NB et al., 2019; Foster et al., 2022a).

The 102°F threshold in proposed paragraph (e)(6) is derived from Figure 4 of Foster et al. 2022a and represents the lowest ambient temperature at which fan use has been demonstrated to be harmful in the researchers' model. As proposed, paragraph (e)(6) does not specify how employers must make the determination whether fan use is harmful above this threshold. However, using the other results from Figure 4 of Foster et al. 2022a, OSHA has developed the following table which identifies scenarios where the agency believes fan use would or would not be harmful:

	Fan Speed: 3.5 m/s	
Ambient Temperature	**Humidity Range:**	**Humidity Range:** ***Turn Off Fans***

	Fan Use Allowed	
102.2°F (39°C)	15-85%	< 15% or > 85%
104.0°F (40°C)	20-80%	< 20% or > 80%
105.8°F (41°C)	30-65%	< 30% or > 65%
107.6°F (42°C)	30-65%	< 30% or > 65%
109.4°F (43°C)	35-60%	< 35% or > 60%
111.2°F (44°C)	35-55%	< 35% or > 55%
113.0°F (45°C)	40-55%	< 40% or > 55%
>113.0°F (>45°C)	Discontinue all fan use	Discontinue all fan use

Using the information from this table, an employer could identify the row most closely matching the ambient temperature of the work or break area and then find the corresponding humidity range for when fans are acceptable to use. For example, if the ambient temperature of the work or break area is 104°F and the relative humidity is 50%, fans could be used. However, if the ambient temperature of the work or break area is 108°F and the relative humidity is 70%, fans should not be used.

A. Requests for Comments.

OSHA recognizes that there are several limitations with the analyses by Foster et al. 2022a, and the application of those results for this purpose. For one, the model results reported by Foster et al. assume “light clothing” only and not “work clothing,” which would be more similar to a typical work uniform than the “light clothing.” While the empirical evidence that the researchers collected on individuals wearing “work clothing” is largely consistent with the modeled results presented for “light clothing,” there are some differences, such as the finding that fans are never beneficial at or above an ambient temperature of 45°C (113.0°F) when wearing “work clothing” (which OSHA has reflected in the table). The authors' recommendations for fan use also included a category that represented scenarios in which fans have a "minimal impact" (i.e., the effect of fans on body heat storage is close to zero). OSHA has combined this category with the category for scenarios in which fans are beneficial to produce the table above. Another limitation is the assumption of a sweat rate of approximately 1 liter per hour (the group average from empirical trials in the same study). However, factors such as acclimatization status, age, and medical history can influence sweat rates, which would influence when fan use is beneficial (see Figure 6 [panels a and b] from Foster et al., 2022a). Finally, Foster et al. tested a fan with a velocity of 3.5 meters per second. OSHA has preliminarily determined that this is a reasonable assumption but acknowledges that varying wind velocity would also influence when fan use is beneficial (see Figure 6 [panel c] from Foster et al., 2022a).

OSHA understands the complexity and uncertainty around an evaluation of fan use and is therefore considering a simplified approach for employers to use. OSHA is requesting comments on this simplified approach and the assumptions underlying it.

More specifically, OSHA requests comments regarding its preliminary determinations on fan use and seeks the following information:

- Whether OSHA has appropriately derived recommendations for fan use from Foster et al., 2022a, and whether additional data or research should be used to supplement or revise the recommendations;

- Whether OSHA should include the above table derived from Foster et al., 2022a, or a similar table, in paragraph (e)(6), either as a mandatory requirement or as a compliance option; and,
- Whether the standard should require alternative methods for cooling employees when fans are harmful, and if so, what alternative control measures should be used.

VII. Acclimatization.

Paragraph (e)(7) of the proposed standard would establish requirements to protect new and returning employees who are not acclimatized. Evidence indicates that new and returning employees are at increased risk for HRIs. As explained in Section V.C., Risk Reduction, employees who are new on the job are often overrepresented in HRI and heat-related fatality reports. Additionally, the NACOSH Heat Injury and Illness Prevention Work Group recommended acclimatization protections for new and returning employees, such as heightened monitoring (NACOSH Working Group on Heat, 2023), and NIOSH recommends an acclimatization plan that gradually increases new employees' work in the heat starting with 20% of the usual work duration and increasing by no more than 20% on each subsequent day (NIOSH, 2016). For returning employees, NIOSH recommends an acclimatization plan that starts with no more than 50% of the usual work duration of heat exposure that then gradually increases on each subsequent day (NIOSH, 2016). Therefore, OSHA has preliminarily determined that the requirements in paragraph (e)(7) are important for preventing HRIs and fatalities from occupational heat exposures among these employees.

Proposed paragraph (e)(7)(i) would require that employers implement one of two options for an acclimatization protocol for new employees during their first week on the job. The first option that an employer may choose, under proposed paragraph (e)(7)(i)(A) (Option A), is a plan that, at a minimum, includes the measures required at the high heat trigger set forth in paragraph (f), when the heat index is at or above the initial heat trigger during the employee's first week of work. Proposed paragraph (f)(2) requires a minimum 15-minute paid rest break at least every two hours in the break area that meets the requirements of the proposed standard, proposed paragraph (f)(3) requires observation for signs and symptoms of heat-related illness, and proposed paragraph (f)(4) requires providing hazard alerts with specified information about heat illness prevention and how to seek help if needed. See the *Explanation of Proposed Requirements* for paragraph (f), *Requirements at the high heat trigger*, for a detailed explanation of the requirements of that section. Option A gives employers flexibility to choose an option that works best for their work site while still making sure that employees are informed, are under observation, and receive breaks, all of which will help better equip employers and employees to monitor and mitigate the effects of heat exposure in situations where the gradual acclimatization option may not be practical. While this option does not require gradual exposure, OSHA believes that, in situations where gradual exposure may not be practical, rest breaks, observation, and hazard alerts will help protect new workers as they adjust to heat during their first week of work.

The second option that an employer may choose, under proposed paragraph (e)(7)(i)(B) (Option B), would require a gradual exposure to the heat at or above the initial heat trigger to allow for acclimatization to the heat conditions of the workplace. The gradual exposure protocol would involve restricting employee exposure to heat to no more than 20% of a normal work shift exposure duration on the first day of work and increasing exposure by 20% of the work shift exposure duration on each subsequent day from day 2 through 4. This is consistent with NIOSH's recommended acclimatization plan for new employees (NIOSH, 2016).

Employers may satisfy Option B requirements by utilizing some of the employees' work time in ways that do not require exposure to heat at or above the initial heat trigger. Examples include completing training activities or filling out work-related paperwork in an air-conditioned building. Employers may also fulfill this requirement through task replacement, whereby an employee completes another necessary task in an area that does not require exposure at or above the initial heat trigger (e.g., office work).

Additionally, if the temperature of the work site fluctuates such that the initial heat trigger is only exceeded for a portion (e.g., 2 hours) of the work shift on some or all of the days during the initial week of work, employers choosing Option A would only be required to implement the requirements of paragraph (f) during those time periods. If they choose the gradual heat exposure option for acclimatization, employers would need to coordinate the employees' heat exposure for those days with the parts of the day that are expected to meet or exceed the initial heat trigger.

Under proposed paragraph (j), employers would be required to implement the acclimatization protocols at no cost to employees. This means that employers could not relieve employees from duty after the allotted time of heat exposure under the acclimatization protocol and not pay them for the remainder of the work shift. Because benefits would also be considered compensation, this would mean that an employer could not use an employee's paid leave to cover the hours not worked during the acclimatization period.

Proposed paragraph (e)(7)(ii) would require that employers implement one of two options for an acclimatization protocol for returning employees who have been away from the job for more than 14 days, during their first week back on the job.

The first option that an employer may choose, under proposed paragraph (e)(7)(ii)(A) (Option A), is an employer-developed plan, that at a minimum, includes the measures that would be required under proposed paragraph (f) whenever the initial heat trigger is met or exceeded, during the employee's first week of returning to work. See explanation above for new employees and the *Explanation of Proposed Requirements* for paragraph (f), *Requirements at the High Heat Trigger*, of the proposed standard for a detailed explanation of the requirements of that section.

The second option that an employer may choose under proposed paragraph (e)(7)(ii)(B) (Option B), is a protocol that requires a gradual exposure to heat at or above the initial heat trigger to allow for acclimatization to the heat conditions of the workplace. The gradual exposure protocol would restrict employee exposure to heat to no more than 50% of a normal work shift exposure duration on the first day of work, 60% on the second day of work, and 80% of the third day of work. This is consistent with NIOSH's recommended acclimatization plan for returning employees (NIOSH, 2016). Employers may satisfy these requirements by utilizing employees' work time in ways that do not require heat exposure at or above the initial heat trigger, as described above for new employees.

For occupations where returning employees may have shift schedules such as two weeks on and then two weeks off, the acclimatization protocol requirement would not go into effect because the two weeks off would not exceed 14 days. However, in situations where time off exceeds 14 days, the requirement would apply.

Proposed paragraph (e)(7)(iii) would set forth an exception to acclimatization requirements of (e)(7)(i) and (ii) if the employer can demonstrate that the employee consistently worked under the same or similar conditions as the employer's working conditions within the previous 14 days. Same or similar conditions means that new employees must have been doing work tasks that are similar or higher in level of exertion to the tasks that are required in the new job and that they conducted these tasks in similar or hotter heat conditions than the new job (e.g., at or above the heat index for current conditions in the new job). Employers should not assume that employees who recently came from climates that are perceived to be similar or hotter (e.g., Mexico) were actually exposed to similar or hotter conditions because climate can vary dramatically based on factors such as elevation levels and humidity. Therefore, employers could check weather records to determine heat indices for the location that the employee worked at during the previous two weeks to determine if the employee was actually exposed to conditions at least as hot as in the new position.

In determining if tasks the employee conducted in the past two weeks were similar or higher in level of exertion to the tasks that are required in the new job, employers could generally consider factors such as weight carried and intensity of activity (e.g., walking versus climbing). For example, picking tomatoes and picking watermelons would generally not be considered similar tasks because of the heavier weight of the watermelons. However, picking tomatoes and picking cucumbers could generally be considered similar tasks if other job conditions are similar. Installing telephone wires on poles and laying out communication wires in a trench dug using machinery would generally not be considered similar to laying out communication wires in a trench dug manually because of the greater work intensity involved with digging a trench manually. Laying communication wire in a pre-dug trench and conducting inspections on the ground might be considered similar tasks if both tasks primarily involve walking. Landscaping work involving weeding and laying out mulch versus hand digging trenches for drainage systems would generally not be considered similar tasks because of the greater work involved in digging trenches. However, hand digging trenches for drainage and hand digging holes to install trees and shrubs could generally be considered similar tasks if those are the primary tasked performed throughout the workday.

The employee must have engaged in similar work activities in the similar heat conditions consistently over the preceding 14 days. OSHA intends “consistently” to mean the employee engaged in the task for at least two hours per day on a majority of the preceding 14 days. This aligns with recommendations from NIOSH (NIOSH, 2016).

Examples of when this exception would not apply include when new employees’ previous positions, which included similar heat conditions and exertion levels, ended longer than 14 days ago, when new employees' previous positions ended within the last 14 days and involved similar work tasks but in cooler conditions, or when new employees' previous positions ended within the last 14 days and involved hotter conditions but less exertion. The exemption would also not apply if new employees' previous positions ended less than 14 days ago but they were not performing similar work tasks in similar heat conditions for at least two hours per day on a majority of the preceding 14 days.

To demonstrate that a new employee consistently worked under the same or similar conditions as the employer's working conditions within the prior 14 days, the employer could obtain information directly from the new employee to confirm the requirements of proposed paragraph (e)(7) are met considering the explanation of same or similar working conditions provided above. The employer could ask questions verbally or in writing about the prior work (i.e., timing, location, duration, type of work). If an employer asked new employees "in the past 14 days, did you consistently work under the same or similar conditions as the employer" but did not ask for any supporting details, the requirement would not be satisfied.

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Data or examples of successful implementation of an acclimatization program;
- Whether the term "same or similar conditions" is sufficiently clear so that employers know when the exception to the acclimatization requirement would apply for new employees, and if not, how should OSHA clarify the requirement;

- Whether a minimum amount of heat exposure to achieve acclimatization should be specified under Option B, the gradual acclimatization option;
- Whether the requirement to demonstrate that an employee consistently worked under the same or similar conditions as the employer's working conditions within the prior 14 days is sufficiently clear, and if not, how should OSHA clarify the requirement;
- Whether the standard should require acclimatization protocols during local heat waves, and if so, how OSHA should define heat waves;
- Whether the standard should require annual acclimatization of all employees at the beginning of each heat season (e.g., the first hot week of the year) and approaches for doing so;
- Examples that OSHA should consider of acclimatization protocols for industries or occupations where it may not be appropriate for an employee to conduct heat-exposed work tasks during the first week on the job (e.g., what activities would be appropriate for these workers to achieve acclimatization);
- Data or examples that OSHA should consider in determining if acclimatization should be required in certain situations for existing employees and examples of successful acclimatization programs for such employees;
- Which option (i.e., following requirements of the high heat trigger or gradual increase in exposure to work in heat) presented in the proposal would employers implement and whether the standard should include other options;

- Whether the standard should include any additional acclimatization requirements for employees returning after less than 14 days away from work after acute illnesses that may put them at increased risk of heat-related illness (i.e., illnesses involving fever or gastrointestinal infections), and if so, suggestions and evidence for the additional requirements; and
- Considering that employees starting or returning when the heat index is above 90°F would not receive unique acclimatization benefits if the employer chose Option A, whether the standard should specify additional requirements for these scenarios, such as breaks that are more frequent or of longer duration.

OSHA has concerns that the proposed exception in paragraph (e)(7)(iii) could create incentives for employees to lie and/or employers to pressure employees to lie about their acclimatization status. For example, an employer could pressure an employee to report that they consistently worked under the same or similar conditions within the prior 14 days, so that the employer does not need to comply with paragraph (e)(7) during the employee's first week on the job. These incentives could put new and returning employees at increased risk because they are not receiving appropriate protection based on their acclimatization status. OSHA seeks comments and evidence on the likelihood of this happening and what OSHA could do to address these potential troubling incentives.

VIII. Rest breaks if needed.

Proposed paragraph (e)(8) would require employers to allow and encourage employees to take paid rest breaks in break areas that would be required under paragraphs (e)(3) or (e)(4) if needed to prevent overheating. As discussed in Section V.C., Risk

Reduction, rest breaks have been shown to be an effective intervention for preventing HRI by allowing employees to reduce their work rate and body temperature. Rest breaks allow employees time to hydrate and cool down in areas that are shaded, air-conditioned, or cooled with other measures. Therefore, OSHA preliminary finds that allowing employees to take rest breaks when they are needed to prevent overheating is an important control for preventing or reducing HRIs in the workplace.

Providing employees the opportunity to take unscheduled rest breaks to prevent overheating helps to account for protecting employees who vary in susceptibility to HRI and address scenarios where employees might experience increased heat strain. For example, unscheduled rest breaks may help to protect employees who are more susceptible to HRI for reasons such as chronic health conditions, recent recovery from illness, pregnancy, prior heat-related illness, or use of certain medications (see Section IV.O., Factors that Affect Risk for Heat-Related Health Effects). Unscheduled rest breaks may also help reduce heat strain in employees who are assigned new job tasks that are more strenuous than the tasks they were performing. Additionally, rest breaks would allow employees an opportunity to remove any PPE that may be contributing to heat strain.

Under proposed paragraph (e)(8), employees would be allowed to decide on the timing and frequency of unscheduled rest breaks to prevent overheating. However, unscheduled rest breaks must be heat-related (i.e., only if needed to prevent overheating). In addition, if the work process is such that allowing employees to leave their work station at their election would present a hazard to the employee or others, or if it would result in harm to the employer's equipment or product, the employer could require the employee to notify a supervisor and wait to be relieved, provided a supervisor is immediately available and relieves the employee as quickly as possible.

An example of a scenario where an employee may decide they need a rest break is if the employee experiences certain symptoms that suggests the employee is suffering from excessive heat strain but does not have an HRI that would need to be addressed under proposed paragraph (g)(2) (e.g., excessive thirst, excessive sweating, or a general feeling of unwellness that the employee attributes to heat exposure). However, rest breaks to prevent overheating do not need to be tied to onset of symptoms. For example, if an employee starts to have trouble performing a task on a hot day that they do not normally have trouble performing, that may be a sign they need a break. OSHA expects that most unscheduled rest breaks to prevent overheating would typically last less than 15 minutes. In some cases, a rest break that extends beyond 15 minutes or frequent unscheduled rest breaks may be a sign that the employee may be experiencing an HRI.

As noted, proposed paragraph (e)(8) requires employers to both encourage and allow employees to take a paid rest break if needed. Employers can encourage employees to take rest breaks by periodically reminding them of that option. Although employers must allow employees to take breaks if the employee determines one is needed, nothing precludes an employer from asking or directing an employee to take an unscheduled paid rest break if the employer notices signs of excessive heat strain in an employee.

Slowing the pace of work would not be considered a rest break, and as specified in proposed paragraph (e)(8), rest breaks if needed must be provided in break areas required under paragraph (e)(3) or (e)(4) (see *Explanation of Proposed Requirements* for paragraphs (e)(3), *Break area(s) at outdoor work sites* and (e)(4), *Break area(s) at indoor work sites* for additional discussion of break areas and *Explanation of Proposed Requirements* for paragraph (f)(2), *Rest breaks*, for additional discussion related to rest breaks.)

Proposed paragraph (e)(8) would require that employees be paid during the time they take rest breaks needed to prevent overheating. OSHA preliminary finds it is important that these breaks be paid so that employees are not discouraged from taking them. The reason for requiring these breaks be paid is further explained in the *Explanation of Proposed Requirements* for paragraph (j), *Requirements implemented at no cost to employees*, including the importance of the requirement and how employers can ensure that employees are compensated to ensure they are not financially penalized for taking breaks that would be allowed or required under the proposed standard.

Evidence indicates that employees are often reluctant to take breaks and thus, are not likely to abuse the right to take rest breaks if needed to prevent overheating; to the contrary, the evidence shows that employees are more likely to continue working when they should take a rest break to prevent overheating. A review of the evidence showing that many employees are reluctant to take rest breaks is included in the *Explanation of Proposed Requirements* for paragraph (f)(2) *Rest breaks*.

A. Requests for Comments.

OSHA seeks comments and information on the proposed requirement to provide employees with rest breaks if needed to prevent overheating, including:

- If there are specific signs or symptoms that indicate employees need a rest break to prevent overheating;
- If employers currently offer rest breaks if needed to prevent overheating, and if so, whether employees take rest breaks when needed to prevent overheating;
- The typical duration of needed rest breaks taken to prevent overheating; and
- Any challenges to providing rest breaks if needed to prevent overheating.

In addition, OSHA encourages stakeholders to provide information and comments on the questions regarding compensation of employees during rest breaks in the *Explanation of Proposed Requirements* for paragraph (j), *Requirements implemented at no cost to employees*.

IX. Effective communication.

Paragraph (e)(9) of the proposed standard establishes requirements for effective communication at the initial heat trigger. Early detection and treatment of heat-related illness is critical to preventing the development of potentially fatal heat-related conditions, such as heat stroke (see Section V., Health Effects). Effective two-way communication provides a mechanism for education and notification of heat-related hazards so that appropriate precautions can be taken. It also provides a way for employees to communicate with the employer about signs and symptoms of heat-related illness, as well as appropriate response measures (e.g., first aid, emergency response).

The NACOSH Heat Injury and Illness Prevention Work Group recommended that elements of a proposed standard for prevention of HRIs address communication needs to meet the objective of monitoring the work site to accurately assess conditions and apply controls based on those conditions. The Work Group recommended addressing communications needs for tracking to facilitate monitoring and check-ins so that employees can report back to employers (NACOSH Working Group on Heat, 2023).

OSHA preliminarily finds that two-way, regular communication is a critical element of HRI prevention. Paragraph (e)(9) requires the employer maintain effective, two-way communication with employees and regularly communicate with employees. The means of communication must be effective. In some cases, voice (or hand signals) may be effective, but if that is not effective at a particular workplace (e.g., if employees are not close together and/or not near a supervisor), then electronic means may be needed to maintain effective communication (e.g., handheld transceiver, phone, or radio). If the employer is communicating with employees by electronic means, the employer must respond in a timely manner for communication to be effective (e.g., providing a phone number for employees to call would not be effective if no one answers or responds in a timely manner).

The means of communication must also be "two-way" (i.e., a way for the employer to communicate with employees, and for employees to communicate with the employer). This is important because this provides a means for employees to reach the employer when someone is exhibiting the signs and symptoms of heat-related illness.

Paragraph (e)(9) also requires that employers regularly communicate with employees. The employer could comply with this requirement by regularly reaching out to employees, or setting up a system by which employees are required to make contact, or check in, with the employer. However, it is the employer’s responsibility to ensure that regular communication is maintained with employees (e.g., every few hours). If a system is chosen whereby the employer requires employees to initiate communication with the employer, and if the employer does not hear from the employee in a reasonable amount of time, the employer must reach out to the employee to ensure that they are not experiencing heat-related illness symptoms. Employers must ensure that when it is necessary for an employee to leave a message (e.g., text) with the employer, the employer will respond, if necessary, in a reasonable amount of time.

This proposed requirement also applies for employees who work alone on the work site. This means that the communication system chosen by the employer must allow for communication between these employees and the employer, although the means may be different than for employees who work on a work site with multiple employees (e.g., by electronic means).

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- How employers currently communicate with employees working alone, including any challenges for effectively communicating with employees working alone and any situations where communication with employees working alone may not be feasible; and
- Whether OSHA should specify a specific time interval at which employers must communicate with employees and, if so, what the interval should be, and the basis for such a requirement.

X. Personal Protective Equipment (PPE).

Paragraph (e)(10) of the proposed standard would require employers to maintain the cooling properties of cooling PPE if provided to employees. The proposed standard does not require employers to provide employees with cooling PPE. However, if employers do provide cooling PPE, they must ensure the PPE's cooling properties are maintained at all times during use. It is critical that employers who provide cooling PPE maintain the equipment's cooling properties; when these properties are not maintained, the defective equipment can heighten the risk of heat injury or illness with continued use. Reports from employees indicate that the use of cooling PPE, such as cooling vests, is burdensome and increases heat retention once the cooling properties are lost or ice packs have melted (Chicas et al., 2021).

A. Requests for Comments.

OSHA requests comments and evidence as to whether there are any scenarios in which wearing cooling PPE is warranted and feasible and OSHA should require its use.

F. Paragraph (f) Requirements at or above the high heat trigger.

I. Timing.

Paragraph (f) of the proposed standard would establish requirements when employees are exposed to heat at or above the high heat trigger. As discussed in Section V.B., Basis for Initial and High Heat Triggers, OSHA has preliminarily determined that the experimental and observational evidence support that heat index triggers of 80°F and 90°F are highly sensitive and therefore highly protective of employees. Exposures at or above the high heat trigger, a heat index of 90°F, or a corresponding wet bulb globe temperature equal to the NIOSH Recommended Exposure Limit, would require the employer to provide the protections outlined in paragraphs (f)(2) through (f)(5). These protections would be in addition to the measures required by paragraph (e) *Requirements at or above the initial heat trigger*, which remain in effect after the high heat trigger is met.

The employer would only be required to provide the protections specified in paragraph (f) during the time period when employees are exposed to heat at or above the high heat trigger. In many cases, employees may only be exposed at or above the high heat trigger for part of their work shift. For example, employees may begin work at 9:00 a.m. and finish work at 5:00 p.m. If their exposure is below the high heat trigger from 9:00 a.m. until 2:00 p.m., and at or above the high heat trigger from 2:00 p.m. to 5:00 p.m., the employer would only be required to provide the protections specified in this paragraph from 2:00 p.m. to 5:00 p.m. Protective measures outlined in paragraph (e) *Requirements at or above the initial heat trigger,* would be required at any time when employees are exposed to heat at or above the initial heat trigger.

II. Rest breaks.

Proposed paragraph (f)(2) specifies the minimum frequency and duration for rest breaks that would be required (i.e., 15 minutes every two hours) when the high heat trigger is met or exceeded and provides clarification on requirements for those rest breaks.

A. Background on the provision.

As discussed in Section V.C., Risk Reduction, rest breaks have been shown to be an effective intervention for preventing HRI by allowing employees to reduce their work rate and body temperature. Rest breaks also allow employees time to hydrate and cool down in areas that are shaded, air-conditioned, or cooled with other measures. OSHA preliminarily finds there are at least two reasons that warrant the inclusion of rest breaks at a minimum frequency and duration when the high heat trigger is met or exceeded. The first is that heat strain is greater in employees exposed to higher levels of heat. (See Section IV., Health Effects).

The second is that the available evidence shows many employees are not taking adequate or enough rest breaks. This evidence shows that while workers paid on a piece-rate basis (e.g., compensated based on factors such as quantity of produce picked, jobs completed, or products produced) may be especially reluctant to take breaks because of financial concerns (Lam et al., 2013; Mizelle et al., 2022; Iglesias-Rios et al., 2023; Spector et al., 2015; Wadsworth et al., 2019), a significant portion of employees paid on an hourly basis are also not taking adequate breaks for other reasons such as pressure from co-workers or supervisors, high work demands, or attitudes related to work ethics (Arnold et al., 2020; Wadsworth et al., 2019). For example, Langer et al. (2021) surveyed 507 Latinx California farmworkers (77% paid hourly) during the summers of 2014 and 2015, when California regulations to protect employees from heat required employers to provide rest breaks if needed but did not require rest breaks at a minimum frequency and duration; 39% of surveyed employees reported taking fewer than 2 rest breaks (not including lunch) per day. Additionally, in a study of 165 legally employed child Latinx farm employees (64% hourly workers) ranging in age from 10–17 years in North Carolina, 88% reported taking breaks in shade, but based on some interviews, the breaks appeared to be of short duration (e.g., “for some five minutes;” “you can take a break whenever you want. . . not for a long time. . . if you wanna get a drink of water only for a couple of minutes, three or five”) (Arnold et al., 2020). The children who were interviewed by Arnold et al. (2020) reported pressure to keep up with the pace of work and being discouraged to take breaks by co-workers or supervisors. In interviews of 405 migrant farmworkers in Georgia, 20% reported taking breaks in the shade (Fleischer et al., 2013).

In a study of 101 farmworkers (61% paid hourly) in the Florida/Georgia region, Luque et al. (2020) reported that only 23% took breaks in the shade. The need for breaks was supported by observations that while some employees carried water bottles, most were only seen drinking during rest breaks. In another study, focus group discussions with piece-rate farm employees revealed that many expressed concerns about possible losses in earnings and that they might be replaced by another employee if they took breaks. Many such employees brought their own water to work to reduce the time they are not picking produce (Wadsworth et al., 2019). In that same study by Wadsworth et al. (2019), piece rate farmworkers also described “their desire to be seen as a good worker, with great fortitude.” Good workers were described by the farmworkers as those who “work fast and do not slow things down and jeopardize success for the group. They continue working in spite of the conditions or how they feel.” (Wadsworth et al., 2019, p. 224). A case study highlighted in the NIOSH criteria document discusses a migrant farmworker who died from HRI after he continued to work despite a supervisor instructing him to take a break because he was working slowly (NIOSH 2016, pp. 46-47). On the day of his death, the heat index ranged from 86 to 112º F.

Evidence supporting the need for required rest breaks is not limited to farmworkers. For example, a NIOSH health hazard evaluation (HHE) indicated that truck drivers for an airline catering facility often skipped breaks they were allowed to take between deliveries in an air-conditioned room at the catering facility to keep up with job demands (NIOSH, 2016, p. 44). Such attitudes appear common in employees of all sectors. Phan and Beck (2023) surveyed 107 office workers, and 25-33% of those employees reported they skipped breaks because of a high workload, not wanting to lose momentum, or to reduce the amount of work to be completed in the future. A number of informal surveys reported similar findings for office and remote workers. In those surveys, many employees (approximately 40%) skip some breaks, particularly lunch breaks (Tork, June 14, 2021; Joblist, July 5, 2022). Common reasons for skipping lunch breaks included work demands and feelings of guilt or being judged for taking a break (Tork, June 14, 2021; Joblist, July 5, 2022). One survey also reported that a major reason why many employees do not take paid time off is because of concerns for coworkers (Joblist, July 5, 2022). Although these informal surveys cover employees who would likely not be covered by the scope of this proposed standard, these informal surveys echo the findings of the studies in the preceding paragraphs and show that employees generally do not take rest breaks or other paid time off.

Studies of presenteeism (i.e., working while ill or injured) suggest that employees may be more likely to ignore signs of excessive heat strain than they are to take breaks needed to prevent overheating. Hemp (October 2004, pp. 3-4) stated "[u]nderlying the research of presenteeism is the assumption that employees do not take their jobs lightly, that most of them need and want to continue working if they can." Although financial reasons such as lack of paid leave are often drivers of presenteeism, non-financial considerations also play a major role. One study analyzed presenteeism in many of the industries covered by the proposed standard including in the categories of agriculture, utilities, manufacturing, transportation and storage, and construction (Marklund et al., 2021). Non-financially related reasons for presenteeism reported by Marklund et al. (2021) were not wanting to burden coworkers, perception that no one else can do the work, enjoyment of work, not wanting to be perceived as lazy or unproductive, and pride. Similar reasons were reported in other studies including wanting to spare co-workers from additional work, pressure from coworkers, strong teamwork and good relationships with coworkers, examples set by management, institutional loyalty, or a perception that taking time off is underperformance (Garrow, February 2016; Lohaus et al., 2022).

The proposed requirement to include mandatory rest breaks is consistent with recommendations by authoritative sources. For example, NIOSH recommends mandatory rest breaks (NIOSH, 2016, p. 45; NIOSH, 2017b, p.1). Additionally, ACGIH (2023) lists "appropriate breaks with shade" as an essential element of a heat stress management program. The NACOSH Working Group on Heat also recommended that scheduled, mandatory rest breaks be provided without retaliation (NACOSH Working Group on Heat, 2023, pp. 6- 7).

OSHA examined a number of studies to determine an appropriate frequency and duration of rest breaks. First, a series of laboratory studies by Notley et al. (2021; 2022a, b) provide insight on the appropriate frequency of rest breaks. In those studies, unacclimatized participants wearing a single clothing layer exercised at a moderate intensity level until stay time was reached (i.e., core temperatures reached 38ºC (100.4ºF) or increased by at least 1ºC) at various ambient temperatures and at a relative humidity of 35% (Notley et al., 2021; 2022a, b)[1]. In a study of younger (18–30 years old) and older men (50–70 years old), data from all participants were pooled to calculate initial stay times of 111 minutes at ambient conditions of 34.1ºC (93.4ºF) (heat index = 93.9ºF) and 44 minutes at ambient conditions of 41.4ºC (106.5ºF) (heat index = 119.8ºF) (Notley et al., 2022b). In a study of unacclimatized younger men (mean age 22 years), older men (mean age 58 years), and older men with diabetes (mean age 60 years) or hypertension (mean age 61 years), median stay times were 128 minutes at 36.6ºC (97.9ºF) (heat index = 101.5ºF) and 68 minutes at 41.1ºC (106.5ºF) (heat index = 118.5ºF) (Notley et al., 2021). In a third study, unacclimatized men and women were able to work for a median time of 117 minutes at 36.6ºC (97.9ºF) (heat index = 101.5ºF) and 63 minutes at 41.4ºC (106.5ºF) (heat index = 119.8ºF) (Notley et al., 2022a). Overall, the results of these studies support work times ranging from 111 minutes to 128 minutes at heat indices of 93.9ºF to 101.5ºF and 44 to 68 minutes at heat indices of 118.5ºF to 119.8ºF.

Two laboratory studies support a preliminary conclusion that rest breaks contribute to the protection of workers from the effects of heat (Uchiyama et al., 2022; Smallcombe et al., 2022). These studies were conducted over periods that could represent all or part of a workday, with light exertion exercise conducted under hot conditions (e.g., 37°C (98.6ºF) and 40% relative humidity (heat index = 106ºF)) in Uchiyama et al. (2022), and moderate to heavy exertion exercise conducted under four conditions: 15°C (59°F) and 50% relative humidity (referent group, heat index not relevant), 35°C (95°F) 50% relative humidity (heat index = 105°F); 40°C (104°F) and 50% relative humidity (heat index = 131°F); and 40°C (104°F), and 70% relative humidity (heat index=161°F) in Smallcombe et al. (2022). In both studies, breaks were provided in air-conditioned or cooler areas. The studies show little evidence of excessive heat strain in participants as mean core temperatures remained within 1ºC of 37.5°C (99.5ºC) (ACGIH, 2023, p. 244). Uchiyama et al. (2022) evaluated two work/rest protocols, including one in which participants exercised for 1 hour, rested for 30 minutes, exercised for 1 hour, rested for 15 minutes, and then exercised for another hour; increases in mean core temperatures were less than 1ºC above mean baseline temperature (37.2ºC) in five of the six time points reported and slightly exceeded a 1ºC increase at 180 minutes, the final time point of measurement (38.29ºC). OSHA finds these work/rest cycles to be similar to a late morning period of work, followed by a 30-minute lunch and then an early afternoon work/rest period, although acknowledges that the duration between rest periods is longer in the proposed rule than in this study. Also, in the Uchiyama et al. (2022) study, a lack of heat strain was also observed in a protocol consisting of 1 hour of work and 15 minutes rest, followed by three half hour work periods separated by 10-minute rest periods and, and a final half hour work period.

The Smallcombe et al. (2022) study most closely reflected a typical workday because it was conducted over a 7-hour period with cycles of 50-minute work/10-minute rest and a 1-hour lunch. Participants were tested under one referent conditions and three hot temperature conditions and average rectal temperature remained at or below 38°C (100.4°F) in all groups during each exercise period at heat indices ranging from 105°F to 161°F (Table S2).

Overall, OSHA preliminarily finds that these studies show that 15-minute rest breaks would offer more protection for employees than shorter duration rest breaks, because the frequency of rest breaks in these studies by Uchiyama et al. (2022) and Smallcombe et al. (2022) was greater than what OSHA is proposing and rest breaks were provided in air-conditioned or cooler areas. OSHA expects some employees will not have access to air-conditioned areas during break periods. OSHA acknowledges uncertainties in determining a precise rest break frequency and duration, but preliminarily concludes that a minimum of a 15-minute rest break every two hours would be highly protective in many circumstances at or above the high heat trigger, while offering employers administrative convenience. For example, other approaches such as adjusting rest break frequency and duration based on weather conditions, work intensity, or protective clothing are likely to be difficult for many employers to implement. A 15-minute break every two hours is administratively convenient to implement because, as explained below, a standard meal break could qualify as a rest break, and therefore, assuming an 8-hour workday with a meal break in the middle of the day, paragraph (f)(2) would only require two other breaks, one break in the morning and a second break in the afternoon, assuming the high heat trigger is met or exceeded the entire day.

The frequency and duration of these proposed rest breaks are within the ranges of frequencies and durations required by four U.S. states that have finalized regulations protecting against HRI by requiring rest breaks under high heat conditions. First, the California regulation for outdoor employees requires a minimum ten-minute rest period every two hours for agricultural employees, when temperatures reach or exceed 95ºF (Cal. Code Regs. tit. 8, § 3395 (2024)). Second and similarly, the Colorado regulation for agricultural employees requires a minimum 10-minute rest period every two hours under increased risk conditions that include a temperature at or above 95ºF (7 Colo. Code Regs. § 1103-15:3 (2023)). Third, in Oregon rules applying to agriculture as well as indoor and outdoor workplaces, employers can select from three different options for work-rest periods at high heat, including: (1) an employer-designed program with a minimum of a 10-minute break every two hours at a heat index of 90ºF or greater and a 15-minute break every hour at a heat index of 100ºF or greater, with possible increased frequency and duration of breaks based on PPE use, clothing, relative humidity, and work intensity; (2) development of work/rest schedules based on the approach recommended by NIOSH (see NIOSH, 2016), or (3) a simplified rest break schedule that calls for a 10-minute break every two hours, with durations and frequencies of rest breaks increasing with increases in heat index (Or. Admin. R. 437-002-0156 (2024); Or. Admin. R. 437-004-1131 (2024)). Fourth and finally, for outdoor workplaces, Washington requires a minimum 10-minute rest period every two hours at an air temperature at or above 90ºF and a minimum

15-minute rest period every hour at an air temperature at or above 100ºF (Wash. Admin. Code 296-307-09747 (2023)).

A NIOSH guidance document recommends work/rest cycles for employees wearing "normal clothing" that considers temperature adjusted for humidity levels and cloud cover and work intensity; in that guidance, when the need for rest cycles is triggered, work/rest cycles range from 45 minutes work/15 minutes rest to 15 minutes work/45 minutes rest, with extreme cautioned urged under some conditions (NIOSH, 2017b).

OSHA acknowledges the requirements of some states and recommendations by NIOSH to increase frequency and duration of rest breaks as heat conditions increase, but OSHA has preliminarily decided on a more simplified approach, in part because of implementation concerns raised by stakeholders, such as difficulty in implementing a more complex approach (e.g., longer and more frequent rest breaks with increasing temperature), and interference with certain types of work tasks (e.g., continuous production work and tasks such as pouring concrete that could be disrupted by more frequent breaks). In addition, the requirement to continue providing paid breaks if needed above the high heat trigger, coupled with the requirement to encourage employees to take these breaks, will help ensure that any employee that needs an additional break can take one. However, OSHA acknowledges that, for the reasons discussed above, this encouragement may become more vital as the temperature increases to ensure that employees don't forego the breaks they are entitled to. OSHA welcomes comment and data on the appropriateness of this approach.

B. Complying with rest break provisions.

The required break periods under paragraph (f)(2) are a minimum. Nothing in the proposed standard would preclude employers from providing longer or more frequent breaks. Additionally, employers would need to comply with paragraph (e)(8) (i.e., providing rest breaks if needed to prevent overheating), which may include situations where employees need more frequent or longer break periods. Paragraph (f)(2) requires employers to ensure that employees have at least one break that lasts a minimum of 15 minutes every two hours when the high heat trigger is met or exceeded. The requirement is in addition to employers' obligation under paragraph (e)(8) to allow and encourage rest breaks if needed to prevent overheating, which continues after the high heat trigger is met. However, if an employee takes a rest break under paragraph (e)(8) that lasts at least 15 consecutive minutes, that would impact when the employer would next need to provide a break under paragraph (f)(2). For example, if the high heat trigger is exceeded for an entire 8-hour work day, and the employee takes a 15-minute break after their first hour of work because they need one to prevent overheating, the employer would not be required to provide another 15-minute break under paragraph (f)(2) for the next two hours. However, the employer's on-going obligation under paragraph (e)(8) would remain. Employers would also need to comply with paragraph (g)(2) (i.e., relieving an employee from duty when they are experiencing signs and symptoms of heat-related illness).

Under proposed paragraph (f)(2), when the high heat trigger is met or exceeded, employers would be required to provide a minimum 15-minute paid rest break at least every two hours in the break area that would be required under paragraph (e)(3) or (e)(4). These rest breaks would be mandatory, and the employer would need to ensure that rest breaks are taken as required.

Proposed paragraphs (f)(2) and (e)(8) would require that employees be paid during rest breaks. As discussed further in the *Explanation of Proposed Requirements* for paragraph (j), *Requirements implemented at no cost to employees*, OSHA finds it important that employees be paid during the time they are taking breaks that are mandatory or needed to prevent overheating so that employees are not financially penalized and thus discouraged from taking advantage of those protections. See *Explanation of Proposed Requirements* for paragraph (j) for *Requirements implemented at no cost to employees* for a discussion of approaches employers can take to ensure that both hourly employees and piece rate employees are compensated for time on rest breaks.

Rest breaks are not the same as slowing down or pacing. In addition, performing a sedentary work activity, even if done in an area that meets the requirements of a break area under proposed paragraphs (e)(3) or (e)(4), would not be considered a rest break under the proposed standard. This ensures that employees can rest (thus modulating increases in heat strain) and hydrate during that rest break.

OSHA recognizes that providing a rest break every two hours might be challenging for some employers. However, employers could consider approaches such as staggering employee break times, within the required two-hour period, to ensure that some employees are always available to continue working. In other cases, employers who have concerns about employee safety, such as having to climb up and down from high locations to take a break, might be able to provide portable shade structures, if safe to use under the conditions (e.g., elevation, wind conditions). In addition, employers could consider scheduling work tasks during cooler parts of the day to avoid required rest breaks.

Proposed paragraphs (f)(2)(i) indicates that a meal break that is not required to be paid under law may count as a rest break. Whether a meal break must be paid is governed by other laws, including state laws. Under the federal Fair Labor Standards Act, bona fide meal periods (typically 30 minutes or more) generally do not need to be compensated as work time (see 29 CFR 785.19). The employee must be completely relieved from duties for the purpose of eating regular meals. Furthermore, an employee is not relieved if they are required to perform any duties, whether active or inactive, while eating.

Proposed paragraphs (f)(2)(ii)-(iii) further clarify that total time of the rest break would not include the time that employees take to put on and remove PPE or the time to walk to and from the break area. OSHA preliminarily finds it important to exclude this time from the 15-minute rest period so employees have the full 15 minutes to cool down.

C. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Stakeholders' experiences with rest breaks required under law or by the employer, including successes and challenges with such approaches;
- Whether there is additional evidence to support a 15-minute rest break every 2 hours as effective in reducing heat strain and preventing HRIs;

- Whether OSHA should consider an alternative scheme for the frequency and/or duration of rest breaks under paragraph (f)(2). If so, what factors (such as weather conditions, intensity of work tasks, or types of clothing/PPE) should it be based on and why;
- Whether varying frequency and duration of rest breaks based on factors such as the heat index would be administratively difficult for employers to implement and how any potential administrative concerns could be addressed;
- Whether employees could perform certain sedentary work activities in areas that meet the proposed requirements for break areas without hindering the effectiveness of rest breaks for preventing HRI, including examples of activities that would or would not be acceptable; and
- Whether OSHA should require removal of PPE that may impair cooling during rest breaks.

III. Observation for signs and symptoms.

Paragraph (f)(3) of the proposed standard would establish requirements for observing employees for signs and symptoms of heat-related illness when the high heat trigger is met or exceeded. As explained in Section IV., Health Effects, heat-related illnesses can progress to life-threatening conditions if not treated properly and promptly. Therefore, it is important to identify the signs and symptoms of heat-related illness early so appropriate action can be taken to prevent the condition from worsening. OSHA preliminarily finds that observation for signs and symptoms of heat-related illness in employees is a critical component of heat injury and illness prevention.

NIOSH recommends observation for signs and symptoms of heat-related illness by a fellow worker or supervisor (NIOSH, 2016). The NACOSH Heat Injury and Illness Prevention Work Group also provided recommendations related to observation for signs and symptoms of heat-related illness in its recommendations to OSHA on potential elements of heat injury and illness prevention standard. The NACOSH Work Group recommended that there be additional requirements for workers who work alone since a buddy system is not possible in those cases, including a communication system with regular check-ins (NACOSH Working Group on Heat, 2023).

Paragraph (f)(3) would require that the employer implement at least one of two methods of observing employees for signs and symptoms of heat-related illness, with a third option for employees who work alone at a work site. As defined under proposed paragraph (b), *Signs and symptoms of heat related illness* means the physiological manifestations of a heat-related illness and includes headache, nausea, weakness, dizziness, elevated body temperature, muscle cramps, and muscle pain or spasms.

The first option, under proposed paragraph (f)(3)(i), that an employer may choose is to implement a mandatory buddy system in which co-workers observe each other. Employers could satisfy this requirement by pairing employees as “buddies” to observe each other for signs and symptoms of heat-related illness. Co-workers assigned as buddies would need to be in the same work area so that it is possible for them to observe each other. Co-workers could also use visual cues or signs and/or verbal communication to communicate signs and symptoms of heat-related illness to each other.

The second option, under proposed paragraph (f)(3)(ii), that the employer may choose is for observation to be carried out by a supervisor or heat safety coordinator. If the employer chooses this option, proposed paragraph (f)(3)(ii) specifies that no more than 20 employees can be observed per supervisor or heat safety coordinator. OSHA preliminarily finds that it is important to limit the number of employees being observed to ensure that each employee is receiving the amount of observation needed to determine if they are experiencing any signs and symptoms of heat-related illness. Supervisors or heat safety coordinators would need to be in a position to observe the employees they are responsible for observing for signs and symptoms (e.g., in close enough proximity to communicate with and see) when observing for signs/symptoms. The supervisor or heat safety coordinator could have other tasks or work responsibilities while implementing the observation role, but they must be able to be within close enough proximity to communicate with and see those they are observing and be able to check in with the employee regularly (e.g., every two hours). When the high heat trigger is met, employers would still be responsible for meeting the proposed requirements of paragraph (e)(9), *Effective Communication*. Employees need to have a means of effective communication with a supervisor (e.g., phone, radio) and employers must regularly communicate with employees at or above both the initial and high heat triggers.

Because symptoms of heat-related illness may not be outwardly visible (e.g., nausea, headache), employers should ensure employees are asked if they are experiencing any signs and symptoms. This is especially true if the employee shows changes in behavior such as working more slowly or dropping things because this could indicate that the employee is experiencing heat-related illness but not recognizing it. It is also important that employees report any signs and symptoms they are experiencing or that they observe in others in order to prevent development of potentially life-threatening forms of heat-related illness (see proposed paragraph (h)(1)(x), *Training*). Additionally, as discussed below, certain signs and symptoms indicate a heat-related emergency.

Employees who work alone at a work site do not have a co-worker, supervisor, or heat safety coordinator present who can observe them to determine if they are experiencing signs and symptoms of heat-related illness. For employees working alone at a work site, the employer would instead need to comply with proposed paragraph (f)(3)(iii) and maintain a means of effective, two-way communication with those employees and make contact with them at least every two hours. This means that employers must not only reach out to lone employees, but also receive a communication back from the employees. Receiving communication back from the employee allows the employee to report any symptoms. If no communication is received, this may be a sign that the employee is having a problem.

Under proposed paragraph (h)(1)(iv), employers would be required to train employees on signs and symptoms of heat-related illness and which ones require immediate emergency action. Proposed paragraph (b) defines *signs and symptoms of a heat emergency* as physiological manifestations of a heat-related illness that requires emergency response and includes loss of consciousness (i.e., fainting, collapse) with excessive body temperature, which may or may not be accompanied by vertigo, nausea, headache, cerebral dysfunction, or bizarre behavior. This could also include staggering, vomiting, acting irrationally or disoriented, having convulsions, and (even after resting) having an elevated heart rate. Employer obligations when an employee is experiencing signs and symptoms of a heat-related illness or heat emergency are addressed under proposed paragraph (g).

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Stakeholders' experiences with implementing observational systems such as those that OSHA is proposing and examples of the implementation of other observational systems for signs and symptoms of heat-related illness that OSHA should consider;
- Data of the effectiveness of such observation systems;
- The frequency at which observation as described in this section should occur;
- Whether there are alternative definitions of signs and symptoms of heat-related illness that OSHA should consider;
- Whether employers should be able to select a designee to implement observation in situations where it may not be possible to have a supervisor or heat safety coordinator present;
- Possible logistical concerns regarding proposed requirements for communication at least every two hours for employees who work alone at the work site; whether there are examples of successful implementation of these types of communication systems; examples of the types of technologies or modes of communication that most effectively support this type communication; and whether there are

innovative approaches for keeping employees working alone safe from HRI and allowing for prompt response in an emergency; and

- For employees who work alone at the work site, whether the employer should know the location of the employee at all times.

IV. Hazard alert.

Paragraph (f)(4) of the proposed standard would require employers to issue a hazard alert to employees prior to a work shift or when employees are exposed to heat at or above the high heat trigger.

As explained in Section IV., Health Effects, hazardous heat can lead to sudden and traumatic injuries and heat-related illnesses can quickly progress to life threatening forms if not treated properly and promptly. To protect employees, it is not sufficient to respond to HRIs after they occur. Prevention of HRIs is critical. A hazard alert will help prevent HRIs by notifying employees of heat hazards, providing information on HRI prevention, empowering employees to utilize preventative measures, and providing practical information about how to access prevention resources (e.g., drinking water, break areas to cool down) and seek help in case of emergency.

Heat alert programs have been identified as important prevention strategies (NIOSH, 2016; Khogali, 1997). NIOSH identified heat alert programs as a strategy to prevent excessive heat stress and recommended that heat alert programs be implemented under certain high heat conditions (NIOSH, 2016, p. 10). NIOSH further describes an example of an effective heat alert program, drawing in part on recommendations described by Dukes-Dobos (1981). Effective elements of a hazard alert program include similar elements to the proposed provision (f)(4), such as “Establish[ing] criteria for the declaration of a heat alert” and “Procedures to be followed during the state of [the] [h]eat [a]lert” (e.g., reminding employees to drink water) (NIOSH, 2016, pp. 80-81).

Employees may face pressure or incentives to work through hazardous heat which can increase their risk of heat-related illness; some employees also may not recognize that they are developing signs and symptoms of a heat-related illness (see Section IV., Health Effects). The hazard alert provision would require that employers provide information about prevention measures, including employees’ right to take rest breaks if needed, at the employees’ election, and the rest breaks required by paragraph (f)(2), which will empower employees to utilize the preventative measures available. This requirement would also enable effective response in the event of a heat emergency by requiring employers to remind employees in advance of its heat emergency procedures.

OSHA preliminarily finds that the hazard alert requirement in proposed paragraph (f)(4) is an important strategy for the prevention of HRIs. The provision includes minimum requirements for the hazard alert and provides flexibility for employers in how they implement the provision. Additionally, employers may choose to include additional information in the alert that is appropriate for their work sites.

Paragraph (f)(4) would require that prior to the work shift or upon determining the high heat trigger is met or exceeded, the employer must notify employees of specific information relevant to the prevention of heat hazards. Specifically, the employer would be required to notify employees of the following: the importance of drinking plenty of water; employees’ right to, at employees’ election, take rest breaks if needed and the rest breaks required by paragraph (f)(2); how to seek help and the procedures to take in a heat emergency; and for mobile work sites, information on the location of break area(s) required by paragraph (e)(3) or (e)(4) and drinking water required by paragraph (e)(2). Because the location of break area(s) and drinking water may change frequently for mobile work sites, it is important to make sure employees at those work sites are reminded of their location on high heat days. Mobile work sites include work sites that change as projects progress or when employees relocate to a new project (e.g., landscaping, construction).

Paragraph (f)(4) would require the employer to issue the hazard alert prior to the work shift or upon determining the high heat trigger is met or exceeded. However, issuing the alert prior to the start of the work shift would not be required unless exposures will be at or above the high heat trigger at the start of the work shift. If the start of the work shift is below the high heat trigger and the hazard alert is not issued at the start of the work shift, then the hazard alert must be issued when the high heat trigger is met and ideally before exposure occurs. For example, if a work shift runs from 8 a.m. to 5 p.m. and the high heat trigger is not met until 10 a.m., the employer must either issue the alert at the beginning of the work shift, or issue the alert when the high heat trigger is met at 10 a.m. If an employer regularly communicates with an employee via a particular means of communication and uses that form of communication to issue the alert, then the employer can presume the notification was received. If, however, the employer has reason to believe the hazard alert was not received, they would need to take additional steps to confirm.

Employers could satisfy the requirements of this provision by posting signs with the required information at locations readily accessible and visible to employees. For example, some employers may choose to post signs at the entrance to the work site. Signs are not an option for all employers as they may not be sufficient to ensure employees receive the hazard alert (e.g., employers with mobile employees or employees who work alone on a work site). Additionally, signs may not be an option for employers who choose not to provide the hazard alert at the start of the work shift. For example, posting a sign at the entrance to the work site would not be sufficient to ensure employees are notified after all employees have already entered the work site. Employers may also satisfy the hazard alert notification requirement by issuing the alert electronically (e.g., via email, text message) or through verbal means (e.g., an in-person meeting, radio or voicemail). Employers may be able to use the system they have in place to meet the requirements of paragraph (e)(9) for effective, two-way communication with employees to issue the hazard alert.

For any method the employer chooses to issue the hazard alert notification, the hazard alert must be sufficient to ensure all employees are notified of the information in paragraphs (f)(2)(i)-(iv). To ensure this, the hazard alert must be issued in languages and at a literacy level understood by employees.

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Whether any additional information should be required in the hazard alert;

- The frequency of the hazard alert, particularly in locations that frequently exceed the high heat trigger; and
- Any alternatives to a hazard alert requirement that OSHA should consider.

V. Excessively high heat areas.

Paragraph (f)(5) of the proposed standard would require that employers place warning signs at indoor work areas with ambient temperatures that regularly exceed 120°F. The warning signs must be legible, visible, and understandable to employees entering the work area. Specifying the requirement for warning signs ensures that all employees and contractors at the work site are aware of areas with excessively high heat. Warning signs signal a hazardous situation that, if not avoided, could result in death or serious injury and, if employees need to enter the areas, serve as a reminder to take appropriate precautions.

The warning signs must be legible, visible, and understandable to employees entering the work areas. The sign must be in a location that employees can clearly see before they enter the excessively high heat area. To maintain visibility of the warning signs, employers must ensure that there is adequate lighting in the area to read the signs and that the signs are not blocked by items that would prevent employees from seeing them. The signs would have to be legible (e.g., writing or print that can be read easily). The proposed standard does not specify contents of the sign, but signs could include a signal word such as “Danger”, the hazard (e.g., “High Heat Area”), possible health effects (e.g., May Cause Heat-Related Illness or Death), information pertaining to who is permitted to access the area (e.g., Authorized Personnel Only), and what precautions entrants would have to take to safely enter the area. Employees must be able to understand the signs. Therefore, the signs must be printed in a language or languages that all potentially exposed employees understand. If it is not practical to provide signs in a language or languages spoken by all employees, employers still must ensure all employees understand what the signs mean. Employers could do this by training on what the warning signs mean and providing those employees with information regarding the extent of the hazardous area as indicated on the signs.

Employers would have to place warning signs at indoor work areas with ambient temperatures that regularly exceed 120°F. The term "regularly" means a pattern or frequency of occurrence rather than isolated incidents. This would mean that the indoor work areas experience temperatures exceeding 120°F on a frequent or recurring basis, such as daily during certain seasons or under specific operational conditions. The process of identifying heat hazards pursuant to proposed paragraph (d) may help employers identify excessively high heat areas. Under proposed paragraph (d)(3), employers would be required to identify each work area(s) where employees are reasonably expected to be exposed to heat at or above the initial heat trigger and develop a monitoring plan. If, while monitoring, an employer determines temperatures in an indoor work area regularly exceed the 120°F threshold, then the employer would need to ensure that warning signs are placed at that work area to alert employees to the potential hazards associated with such extreme temperatures.

If an employer's work site contains an excessively high heat area(s), the employer must train employees in the procedures to follow when working in these areas (see proposed provision (h)(1)(xvi)).

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Whether OSHA should further specify the required location of warning signs;
- Whether OSHA should specify the wording/contents of the warning signs; and
- Whether OSHA should consider defining "excessively high heat area" as something other than a work area in which ambient temperatures regularly exceed 120°F; and evidence available to support a different temperature threshold or other defining criteria.

G. Paragraph (g) Heat illness and emergency response and planning.

Paragraph (g) of the proposed standard would establish requirements for heat illness and emergency response and planning. It would require that employers develop and implement a heat emergency response plan as part of their HIIPP, as well as specify what an employer's responsibilities would be if an employee experiences signs and symptoms of heat-related illness or a heat emergency. Effective planning and emergency response measures can minimize the severity of heat-related illnesses when they occur and allow for more efficient access to medical care when needed.

Proposed paragraph (g)(1) specifies that the employer would be required to develop and implement a heat emergency response plan as part of their HIIPP and specifies the elements that would be required in an employer's emergency response plan.

Because the emergency response plan is part of the HIIPP, some of the requirements in paragraph (c) are relevant to the emergency response plan. For example, the employer would need to seek the input and involvement of non-managerial employees and their representatives, if any, in the development and implementation of the emergency response plan (see proposed paragraph (c)(6)). See *Explanation of Proposed Requirements* for paragraph (c), for a detailed explanation of the requirements that apply to the HIIPP. Only one plan would be required for each employer (i.e., for the whole company). However, if the employer has multiple work sites that are distinct from each other, the plan would be tailored to each work site or type of work site. For instance, if an employer has employees engaged in work activities outdoors on a farm, as well as employees loading and unloading product from vehicles at various locations, the employer could have one emergency response plan with the specifications for each of these types of work sites represented. Employers may also choose to include other elements in the plan to account for any work activities unique to their workplace.

Proposed paragraph (g)(1)(i) would require employers to include a list of emergency phone numbers (e.g., 911, emergency services) in their emergency response plan. Indicating the most appropriate phone number(s) to contact in the case of an emergency helps ensure medical support and assistance are provided timely and efficiently during a heat emergency. Examples of other phone numbers for assistance aside from 911 that employers might include in the plan are those for on-site clinicians or nurses to be contacted if an employee is experiencing signs and symptoms of a heat-related illness.

Proposed paragraph (g)(1)(ii) would require employers to include a description of how employees can contact a supervisor and emergency medical services in their emergency response plan. Because time is of the essence in emergency situations, it is important that employees know beforehand how to contact a supervisor and emergency medical services in the event of a heat emergency. For example, if employees do not have phone service or access to a phone to call for medical help, but they do have access to other means of communication such as radios, walkie-talkies, personal locator beacons, and audio signals, the employer’s plan would describe how to use these other means of communication to contact a supervisor and emergency medical services.

Proposed paragraph (g)(1)(iii) would require the emergency response plan to include the individual(s) designated to ensure that heat emergency procedures are invoked when appropriate. Clearly assigning this responsibility to an individual(s) can reduce confusion and allow for swift action in the event of a heat emergency. Employers with multiple work sites or dispersed work areas may not be able to ensure heat emergency procedures are invoked without designating different individuals for each work site/area. For example, an employer with work activities inside two factories in different geographic locations would need to designate an individual(s) to ensure heat emergency procedures are invoked at each factory location.

Proposed paragraph (g)(1)(iv) would require the emergency response plan to have a description of how to transport employees to a place where they can be reached by an emergency medical provider. Planning for where employees can access emergency medical services can ensure aid is provided efficiently. This is especially important for employers with employees engaging in work activities in remote locations, where medical services cannot reach them. For example, an employee working in an area of a farm not easily accessible by vehicle or an employee in a difficult to reach location inside a building being constructed.

Proposed paragraph (g)(1)(v) would require the emergency response plan to include clear and precise directions to the work site, including the address of the work site, which can be provided to emergency dispatchers. For certain work sites that are remote/hard to reach or do not have an address, GPS coordinates may be necessary to share with emergency responders, or a description of how to get to their location from the main road, entrance, building, etc. If an employee's work site changes frequently, the emergency response plan would need to include a clear strategy to account for their changing locations and ensure directions to the work site are readily accessible when needed to provide to emergency dispatchers.

Proposed paragraph (g)(1)(vi) would require the emergency response plan to include procedures for responding to an employee experiencing signs and symptoms of heat-related illness, including heat emergency procedures for responding to an employee with suspected heat stroke. Prior development of emergency response procedures can ensure assistance and medical attention are provided efficiently and quickly. In developing the procedures, OSHA expects that employers would look to resources such as OSHA guidance (e.g., *www.osha.gov/heat-exposure/illness-first-aid*) and NIOSH recommendations (NIOSH, 2016) for more information.

The proposed standard does not require employers to develop a plan for each work site. However, the employer's emergency response plan(s) must contain all the information required by paragraphs (g)(1)(i)-(vi), some of which will vary based on work site. The employer may be able to incorporate the information needed for different work sites into the same emergency response plan. For instance, if an employer has employees engaged in work activities outdoors on a farm, as well as employees loading and unloading product from vehicles at various locations, the employer could have one emergency response plan with the specifications for each of these types of work sites represented. Employers may also choose to include elements beyond those required by paragraphs (g)(1)(i)-(vi) in their plan to account for any work activities unique to their workplace.

Proposed paragraph (g)(2) specifies the actions employers would be required to perform if an employee is experiencing signs and symptoms of heat-related illness. Under proposed paragraph (b) *signs and symptoms of heat-related illness* means the physiological manifestations of a heat-related illness and includes headache, nausea, weakness, dizziness, elevated body temperature, muscle cramps, and muscle pain or spasms.

Proposed paragraph (g)(2)(i) would require employers to relieve from duty employees who are experiencing signs and symptoms of heat-related illness. Relieving the employee from duty would allow the employer to address the heat-related illness according to the procedures outlined in proposed paragraphs (g)(2)(ii)-(v). This relief from duty, including the time it takes to address the heat-related illness according to the procedures outlined in proposed paragraphs (g)(2)(ii)-(v), must be with pay and must continue at least until symptoms have subsided.

Proposed paragraph (g)(2)(ii) would require that employers monitor employees who are experiencing signs and symptoms of heat-related illness, and proposed paragraph (g)(2)(iii) would require employers to ensure that employees who are experiencing signs and symptoms of heat-related illness are not left alone. Continuous monitoring of employees who are experiencing signs and symptoms of a heat-related illness is important to ensure that if the employee's condition progresses to a heat emergency, someone is there to observe it and quickly respond.

Proposed paragraph (g)(2)(iv) would require employers to offer employees who are experiencing signs and symptoms of heat-related illness on-site first aid or medical services before ending any monitoring. This requirement is intended to be consistent with existing first aid standards (e.g. 29 CFR 1910.151, 29 CFR 1915.87, 29 CFR 1926.23 and 29 CFR 1926.50), which require accessibility of medical services and first aid to varying degrees depending on the industry or whether the workplace is near an infirmary, clinic or hospital. Proposed paragraph (g)(2)(iv) would not add new requirements for staff to be fully trained in first aid. Employers would offer the first aid or medical resources they have available to employees on site to the extent already required by first aid standards and follow the procedures developed in (g)(1)(vi) as applicable.

Proposed paragraph (g)(2)(v) would require employers to provide employees who are experiencing signs and symptoms of heat-related illness with means to reduce their body temperature. Examples of means to reduce body temperature are instructing those employees to remove all PPE and heavy outer clothing (e.g., heavy/impermeable protective clothing) and moving them to a cooled or shaded area (e.g., the break areas required under paragraphs (e)(3) and (4)) where they can sit and drink cool water. If the employer has cooling PPE (e.g., cooling bandanas or neck wraps, and vests and cooling systems such as hybrid personal cooling systems (HPCS), and fans) available on site, those could also be used to cool employees as well. (For information related to the requirement to reduce an employee's body temperature in the case of a heat emergency, see discussion below.)

Proposed paragraph (g)(3) specifies the actions employers would have to perform if an employee is experiencing signs and symptoms of a heat emergency. Proposed paragraph (b) defines *signs and symptoms of a heat emergency* as the physiological manifestations of a heat-related illness that requires emergency response and includes loss of consciousness (i.e., fainting, collapse) with excessive body temperature, which may or may not be accompanied by vertigo, nausea, headache, cerebral dysfunction, or bizarre behavior. This could also include staggering, vomiting, acting irrationally or disoriented, having convulsions, and (even after resting) having an elevated heart rate.

Proposed paragraph (g)(3)(i) would require employers to take immediate actions to reduce the employee's body temperature before emergency medical services arrive. Rapid cooling of body temperature during a heat emergency is essential because the potential for organ damage and risk of death increase in a short period of time, often before medical personnel can respond, transport, and treat the affected individual (Belval et al., 2018). Immersion in ice water or cold water has been reported to have the fastest cooling rates (McDermott et al., 2009b; Casa et al., 2007). However, OSHA realizes that immersing an employee in a tub of ice/cold water is not an option that will be available at most work sites. Other, more practical methods of reducing employee body temperature using materials that employers are likely to have, or are similar to materials that an employer is likely to have, on site have been reported to be highly effective in preventing death from exertional heat stroke. DeGroot et al. (2023) reported survival of 362 of 363 military personnel who were suffering from exertional heat stroke and were treated with strategically placed “ice sheets” (i.e., bed sheets soaked in ice water). McDermott et al. (2009a) reported 100% survival in nine marathon runners who were suffering from exertional heat stroke and treated by dousing with cold water and rubbing of ice bags over major muscle groups. Another possible approach is the tarp-assisted cooling oscillation (TACO) method that involves wrapping the affected individual in a tarp with ice (Luhring et al., 2016).

Proposed paragraph (g)(3)(ii) would require employers to contact emergency medical services immediately for employees experiencing signs and symptoms of a heat emergency, and proposed paragraph (g)(3)(iii) would require employers to also perform the activities described in paragraphs (g)(2)(i) through (g)(2)(iv) to aid an employee during a heat emergency until emergency medical services arrives. Some heat-related illnesses can quickly progress and become fatal (see Section IV., Health Effects). The severity and survival of heat stroke is highly dependent on how quickly effective cooling and emergency medical services are provided (Vicario et al., 1986; Demartini et al., 2015; Belval et al., 2018).

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Whether OSHA should require a minimum duration of time an employee who has experienced signs and symptoms of heat-related illness must be relieved from duty, and what an appropriate duration of time would be before returning employees to work;
- Whether OSHA should add or remove any signs or symptoms in the definitions of *signs and symptoms of heat-related illness* and *signs and symptoms of a heat emergency* in proposed paragraph (b). If so, provide clear and specific evidence for inclusion or exclusion;
- Whether paragraph (g)(3)(i) should require specific actions that the employer must take to reduce an employee's body temperature before emergency medical services arrive, rather than merely requiring unspecified "immediate actions". If so, describe those specific actions; and
- Whether paragraph (g)(3)(i) should prohibit certain actions to reduce an employee's body temperature before emergency medical services arrive. If so, indicate if there is evidence or observations that certain actions are not helpful or are counterproductive.

H. Paragraph (h) Training.

Paragraph (h) of the proposed standard establishes requirements for training on HRI prevention. It addresses the topics to be addressed in training, the types of employees who are to be trained, the frequency of training, triggers for supplemental training, and how training is to be conducted. OSHA regularly includes training requirements in its standards to ensure employees understand the hazards addressed by the standard, the protections they are entitled to under the standard, and the measures to take to protect themselves. Here, OSHA believes that it is essential that employees are trained on heat-related hazards and how to identify signs and symptoms of HRIs as well as on the requirements of the proposed standard and the employer's heat-related policies and procedures. This training ensures that employees understand heat hazards and the workplace specific control measures that would be implemented to address the hazard. The effectiveness of the proposed standard would be undermined if employees did not have sufficient knowledge and understanding to identify heat hazards and their health effects or sufficient knowledge and understanding of their employer's policies and procedures for addressing those hazards.

Surveys and interviews with diverse working populations highlight the need for additional education and training on HRIs and prevention strategies amongst employees (Luque et al., 2020; Smith et al., 2021; Fleischer at al., 2013; Stoecklin-Marois et al., 2013; Langer et al., 2021; Jacklitsch et al., 2018). The NACOSH Heat Injury and Illness Prevention Work Group recommended that both workers and supervisors are trained in heat illness and injury prevention strategies. Additionally, the Work Group recommended that the training program includes the following elements: identification of hazards; mitigation of hazards through prevention; reporting of signs and symptoms; and emergency response. OSHA preliminarily finds that effective training is an essential element of any heat injury and illness prevention program and that the requirements in proposed paragraph (h) are necessary and appropriate to ensure the effectiveness of the standard as a whole.

Proposed paragraph (h)(1) establishes the initial training requirements for all exposed employees. It would require employers to ensure that each employee receives, and understands, training on the topics outlined in proposed paragraphs (h)(1)(i)-(xvi) prior to the employee performing any work at or above the initial heat trigger. Requiring that initial training occur before employees perform any work at or above the initial heat trigger ensures that the employees have all the knowledge necessary to protect themselves prior to their exposure to the hazard.

This provision, like paragraphs (h)(2), (h)(3), and (h)(4), would require employers to ensure that employees, including supervisors and heat safety coordinators, understand the training topics. While OSHA does not mandate testing or specific modes of ascertaining employee understanding of the training materials, OSHA expects that all required training will include some measure of comprehension. Different ways that employers could ensure comprehension of the training materials include a knowledge check (e.g., written or oral assessment) or discussions after the training. Post training assessments may be particularly useful for ensuring employee participation and comprehension when employers offer online training. Proposed paragraph (h)(5), discussed below, includes additional requirements for presentation of the training.

Proposed paragraph (h)(1)(i) would require employers to provide training on heat stress hazards. Heat stress is the total heat load on the body. There are three major types of hazards which contribute to heat stress: (1) environmental factors such as high humidity, high temperature, solar radiation, lack of air movement, and process heat (i.e., radiant heat produced by machinery or equipment, such as ovens and furnaces), (2) use of personal protective equipment or clothing that can inhibit the body's ability to cool itself, and (3) the body's metabolic heat (i.e., heat produced by the body during work involving physical activity and exertion). Employers should make employees aware of all the sources of heat at the workplace that contribute to heat stress.

Proposed paragraph (h)(1)(ii) would require employers to provide training on heat-related injuries and illnesses. See Section IV., Health Effects, for a discussion of HRIs. Examples of heat-related illnesses include heat stroke, heat exhaustion, heat cramps, heat syncope, and rhabdomyolysis. Heat-related injuries that could result from heat illness include slips, trips, falls, and other injuries that could result from the mishandling of equipment due to the effects of heat stress.

Proposed paragraph (h)(1)(iii) would require employers to provide training on risk factors for heat-related injury or illness, including the contributions of physical exertion, clothing, personal protective equipment, a lack of acclimatization, and personal risk factors (e.g., age, health, alcohol consumption, and use of certain medications). As noted above, physical exertion, clothing, and personal protective equipment all increase an employee's heat load. More information on acclimatization and how it affects risk is included in Section V.C., Risk Reduction, and more information about personal risk factors is included in Section IV.O., Factors that Affect Risk for Heat-Related Health Effects.

Proposed paragraph (h)(1)(iv) would require employers to provide training on signs and symptoms of heat-related illness and which ones require immediate emergency action. As defined in proposed paragraph (b), *signs and symptoms of heat-related illness* means the physiological manifestations of a heat-related illness and includes headache, nausea, weakness, dizziness, elevated body temperature, muscle cramps, and muscle pain or spasms. Also defined in proposed paragraph (b), *signs and symptoms of a heat emergency* means the physiological manifestations of a heat-related illness that requires emergency response and includes loss of consciousness (i.e., fainting, collapse) with excessive body temperature, which may or may not be accompanied by vertigo, nausea, headache, cerebral dysfunction, or bizarre behavior. This could also include staggering, vomiting, acting irrationally or disoriented, having convulsions, and (even after resting) having an elevated heart rate. Employers must train employees on how to identify these signs and symptoms of heat-related illness in themselves and their coworkers and when to employ the employer's emergency response procedures, as required under proposed paragraph (g). That provision specifies the actions that an employer must take both when an employee experiences signs and symptoms of a heat-related illness and when an employee experiences signs and symptoms of a heat emergency. For further discussion see the *Explanation of Proposed Requirements* for Paragraph (g).

Proposed paragraphs (h)(1)(v) through (h)(1)(vii) would require employers to train employees on the importance of removing PPE that may impair cooling during rest breaks, taking rest breaks to prevent heat-related illness or injury, and that rest breaks are paid, and drinking water to prevent heat-related illness or injury. Removing PPE when possible, allows employees to cool down faster during rest breaks. As discussed in Section V.C., Risk Reduction, drinking adequate amounts of water and taking rest breaks are important for reducing heat strain that could lead to HRI. Training on these topics could give the employer an opportunity to address common misperceptions regarding heat, such as that drinking cold water in the heat is harmful. In addition, proposed paragraph (h)(1)(viii) and (h)(1)(ix) would require that employers train employees on where break areas and employer provided water are located. This would ensure employees are aware of the locations of break areas and water and encourage their effective utilization.

Proposed paragraph (h)(1)(x) would require employers to train employees on the importance of reporting signs and symptoms of heat-related illnesses that they experience personally or those they observe in co-workers. Training employees to be observant of and to report early any signs and symptoms of heat-related illnesses they see at the workplace is a key factor to identifying and addressing potential heat-related incidents before they result in a serious illness or injury. In addition, employers should ensure that employees are familiar with the employer’s own procedures for reporting signs and symptoms of a heat emergency or heat-related illness pursuant to its heat emergency response plan as required in proposed paragraph (g).

Proposed paragraph (h)(1)(xi) would require employers to train employees on all the policies and procedures applicable to the employee’s duties, as indicated in the work site’s HIIPP. Employees play an important role in effective implementation of the employer’s work site-specific policies and procedures to prevent heat-related illnesses and injury, and training on these policies and procedures is necessary to ensure that they are implemented effectively. OSHA recognizes that employees perform various duties and therefore likely need different types of training, and the proposed requirement allows employers flexibility to account for these differences in their training programs. Thus, certain components of the training may need to be tailored to an employee's assigned duties. For example, while all employees would require training on recognizing signs and symptoms of heat-related illness, employees observing a co-worker as part of buddy system under proposed paragraph (f)(3)(i) may require additional training on how to report signs and symptoms according to the policies and procedures established and implemented by the employer. In another example, the individual designated by the employer to ensure that emergency procedures are invoked when appropriate under proposed paragraph (g)(1)(iii) might require more detailed training on the employer's heat emergency response procedures. Another example could be training employees who wear vapor-impermeable clothing on the policies and procedures the employer has implemented to protect them under proposed paragraph (c)(3).

Proposed paragraph (h)(1)(xii) would require employers to train employees on the identity of the heat safety coordinator. Under proposed paragraph (c)(5), the heat safety coordinator would be designated to implement and monitor the HIIPP and would be given authority to ensure compliance with the HIIPP. Therefore, employees could contact the heat safety coordinator to ask questions about the HIIPP, to provide feedback on the policies and procedures, or report possible deficiencies with implementation of the HIIPP. Employers should encourage employees to contact the heat safety coordinator for these reasons. To ensure that employees are able to contact the heat safety coordinator, employers could provide the name of the individual and other information needed to contact them as part of the training required under this paragraph.

Proposed paragraph (h)(1)(xiii) would require employers to train employees on the requirements of this standard. While proposed paragraph (h)(1)(xi) would require training on all policies and procedures applicable to an employee's duties as noted in the employer's HIIPP, training under (h)(1)(xiii) would ensure that employees are familiar with all requirements of this proposed standard. For example, employees would have to be informed of the requirements related to employee participation, including in the development, implementation, review and update of the HIIPP under proposed paragraph (c), and identifying work areas with reasonable expectations of exposures at or above the initial heat trigger, and in developing and updating the monitoring plan under proposed paragraph (d). Employees would also need to be informed that requirements of the proposed standard would be implemented at no cost to employees under proposed paragraph (j). The proposed provision would also ensure that employees are made familiar with the employer's heat-related policies and procedures.

Proposed paragraph (h)(1)(xiv) would require employers to train employees on how to access the work site's HIIPP. If relevant this would include training on how to access both digital or physical copies.

Proposed paragraph (h)(1)(xv) would require employers to train employees on their right to protections under this standard (e.g., rest breaks, water), and that employers are prohibited from discharging or in any manner discriminating against any employee for exercising those rights. Employees' right to be free from retaliation for availing themselves of the protections of the standard or for raising safety concerns comes from section 11(c) of the OSH Act, 29 U.S.C. 660(c), and requiring employers to train on these protections is consistent with the purpose of that provision. Proposed paragraph (h)(1)(xv) is also consistent with section 8(c)(1) of the Act, 29 U.S.C. 657(c)(1), which directs the Secretary to issue regulations requiring employers to keep their employees informed of their protections under the Act and any applicable standards, through posting of notices or "other appropriate means." This training ensures that employees know that they have a right to the protections required by the standard. Having employers acknowledge and train their employees about their rights under this standard provides assurance that employees are aware of the protections afforded them and encourages them to exercise their rights without fear of reprisal. They may otherwise fear retaliation for utilizing the protections afforded them under the standard or for speaking up about workplace heat hazard concerns. This fear would undermine the effectiveness of the standard because employee participation plays a central role in effectuating the standard's purpose.

Proposed paragraph (h)(1)(xvi) would require that if the employer is required under paragraph (f)(5) to place warning signs for excessively high heat areas, they would be required to train employees on procedures to follow when working in these areas. These procedures could include, but are not limited to, any PPE that might be required when working in those areas, if relevant, and reminders to remove PPE when taking rest breaks in break areas and should reinforce employees' access to rest breaks in break areas, required under paragraph (f)(2), and drinking water, required under paragraph (e)(2), as appropriate.

Proposed paragraph (h)(2) would require the employer to ensure that each supervisor responsible for supervising employees performing any work at or above the initial heat trigger and each heat safety coordinator receives training on, and understands, both the topics outlined in paragraph (h)(1) and the topics outlined in paragraphs (h)(2)(i) and (ii). Proposed paragraph (h)(2)(i) would require the employer to train supervisors and heat safety coordinators on the policies and procedures developed to comply with the applicable requirements of this standard, including the policies and procedures for monitoring heat conditions developed to comply with paragraphs (d)(1) and (d)(3)(ii). Proposed paragraph (h)(2)(ii) would require the employer to train supervisors and heat safety coordinators on procedures they would have to follow if an employee exhibits signs and symptoms of heat related illness, which an employer is required to develop for its HIIPP pursuant to proposed paragraph (g)(1)(vi). This would ensure effective and rapid treatment and care for employees experiencing signs and symptoms of heat-related illness. OSHA included these proposed provisions to ensure that supervisors and heat safety coordinators receive additional training needed to perform their duties as specified in the proposed standard.

Proposed paragraph (h)(3) would require the employer to ensure that each employee receives annual refresher training on, and understands, the subjects addressed in paragraph (h)(1) of the proposed standard. This paragraph would also require that each supervisor and heat safety coordinator additionally receive annual refresher training on, and understands, the topics addressed in paragraph (h)(2). OSHA preliminarily finds that annual training is needed to refresh and reinforce an employee's recollection and knowledge about the topics addressed in this paragraph. This proposed provision also indicates that for employees who perform work outdoors, the employer must conduct the annual refresher training before or at the start of the heat season. This can vary depending on the weather conditions in the geographic region where the employer is located. Accordingly, OSHA intends this requirement to be flexible and to allow employers leeway to determine the start of the heat season, so long as those determinations are reasonable. For example, in northern states such as Michigan, employers might find it best to do annual training before the time when temperatures commonly reach the initial heat trigger or above. In those cases, temperatures are likely to be below the initial heat trigger for a substantial portion of the year and employees are likely to need reminders of all policies and procedures related to heat, both for the initial and high heat triggers. Employers can determine when heat season is for them based on normal weather patterns and would be required to conduct training prior to or at the start of the heat season. In most instances, OSHA expects that employers would do this no sooner than 30 days before the start of their heat season, so that employees can recall training materials easily, rather than for example, 6-months before the start of heat season. For new employees at outdoor work sites, this may result in some employees receiving the annual refresher training less than a year after the initial training.

Proposed paragraph (h)(4) specifies when supplemental training would be required. Proposed paragraph (h)(4)(i) would require the employer to ensure that employees promptly receive and understand additional training whenever changes occur that affect the employee's exposure to heat at work (e.g., new job tasks, relocation to a different facility or area of a facility). For example, if an employee is assigned to a new task or workstation that exposes them to high process heat or to outdoor work where the employee is exposed to hazardous heat, and such employee was not previously trained on the necessary topics required under this paragraph, then the employer would have to provide that employee with the requisite training. Similarly, if an employee is assigned to a new work area to which different heat-related policies and procedures apply, they would need to be trained on these area-specific policies and procedures. Additional examples could include when an employer's work site experiences heat waves, when new heat sources are added to the workplace, or when employees are assigned to a new task where they need to wear vapor-impermeable PPE (i.e., non-breathable). In these instances, the training required under this provision would have to comport with the requirements of the rest of this paragraph.

Proposed paragraph (h)(4)(ii) would require that each employee promptly receives, and understands, additional training whenever changes occur in policies and procedures addressed in paragraphs (h)(1)(xi) of this proposed standard. Proposed paragraph (c) would require employers to monitor their HIIPP to ensure ongoing effectiveness. When doing so, the employer may find that the policies and procedures are inadequate to protect employees from heat hazards. If so, the employer would have to update those policies and procedures. When this happens, employers would be required to train all employees on the new or altered policies and procedures so that the employees are aware of the new policies and procedures and how to follow them to reduce their risk of developing heat-related illnesses and injuries.

Proposed paragraph (h)(4)(iii) would require that each employee promptly receives, and understands, additional training whenever there is an indication that an employee(s) has not retained the necessary understanding. Examples of this would include employees who appear to have forgotten signs and symptoms of heat-related illnesses or how to respond when an employee is experiencing those signs and symptoms. It is essential that employees remain familiar with training they have received so they continue to have the knowledge and skills needed to protect themselves and possibly co-workers from heat hazards. Supplemental training under paragraph (h)(4)(iii) must be provided to those employees who have demonstrated a lack of understanding or failure to follow the employer's heat policies and procedures or comply with the requirements of this proposed standard.

Proposed paragraph (h)(4)(iv) would require that each employee promptly receives, and understands, additional training whenever a heat-related injury or illness occurs at the work site that results in death, days away from work, medical treatment beyond first aid, or loss of consciousness. Occurrences of these types of heat-related injuries and illnesses could indicate that one or more employees are not following policies and procedures for preventing or responding to heat-related illnesses and injuries. After a heat-related illness or injury in the workplace occurs that meets the requirements of proposed paragraph (h)(4)(iv), OSHA expects that each employee would receive supplemental training. This training could be a "lessons learned" or "alert" type training.

Both initial and supplemental training are important components of an effective heat injury and illness prevention program. Initial training provides employees with the knowledge and skills they need to protect themselves against heat hazards, and also emphasizes the importance of following workplace policies and procedures in the HIIPP. Supplemental training ensures employees continue to have the knowledge and skills they need to protect themselves from heat hazards. It provides an opportunity to present new information that was not available during the initial training or that becomes relevant when an employee's duties change. Additionally, supplemental training is necessary when an employee demonstrates that they have not retained information from the initial training (e.g., by failing to follow appropriate policies and procedures). Supplemental training does not necessarily need to include all information covered in the initial training, as only some policies or procedures may need to be reviewed, and employees will receive a full refresher training annually.

Proposed paragraph (h)(5) would require that all training provided under paragraphs (h)(1) through (h)(4) is provided in a language and at a literacy level each employee, supervisor, and heat safety coordinator understands. In addition, the provision would require that the employer provide employees with an opportunity for questions and answers about the training materials. For the training to be effective, the employer must ensure that it is provided in a manner that the employee is able to understand. Employees have varying educational levels, literacy, and language skills, and the training must be presented in a language, or languages, and at a level of understanding that accounts for these differences. This may mean, for example, providing materials, instruction, or assistance in Spanish rather than English if the employees being trained are Spanish-speaking and do not understand English. The employer is not required to provide training in the employee's preferred language if the employee understands both languages; as long as the employee is able to understand the material in the language used, the intent of the proposed standard would be met. As explained above with respect to paragraph (h)(1), OSHA does not mandate testing or specific modes of ascertaining employee understanding of the training materials, but expects that all required training will include some measure of comprehension.

The proposed provision does not specify the manner in which training would be delivered. Employers may conduct training in various ways, such as in-person (e.g., classroom instruction or informal discussions during safety meetings/toolbox talks), virtually (e.g., videoconference, recorded video, online training), using written materials, or any combination of those methods. However, this paragraph would require the employer to provide an opportunity for employees to ask questions regardless of the medium of training. It is critical that trainees have the opportunity to ask questions and receive answers if they do not fully understand the material that is presented to them. If it is not possible to have someone present or available during the training, employers could provide the contact information of the individual that employees can contact to answer their questions (e.g., an e-mail or telephone contact). OSHA expects employers to make an effort to respond to questions promptly.

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Whether the agency should require other training topics in the standard;
- Whether the inclusion of separate training requirements for supervisors and heat safety coordinators is appropriate, or whether the duty-specific training requirements in proposed paragraph (h)(1) are sufficient;
- Whether the agency has identified appropriate triggers for supplemental training;
- Whether the agency should require annual refresher training or whether the more performance-based supplemental training requirements are sufficient; and
- Whether the agency should specify certain criteria that define the start of heat season.

I. Paragraph (i) Recordkeeping.

Paragraph (i) of the proposed standard would require certain employers to create written or electronic records of on-site temperature measurements and establishes the duration of time that employers must retain those records. Specifically, it applies to employers that have indoor work areas where there is a reasonable expectation that employees are or may be exposed to heat at or above the initial heat trigger, and that are therefore required to conduct on-site temperature measurements under paragraph (d)(3)(ii). These employers must have and maintain written or electronic records of these measurements. Under paragraph (i), employers must retain these records for a minimum of six months.

Maintaining these records, whether written or electronic, serves several purposes. It will assist OSHA in determining conditions at the work site, which will facilitate OSHA's ability to verify employers' compliance with the standard's provisions.

Additionally, these records may facilitate employers identifying trends in indoor temperatures and their effect on employee health and safety. In the event of a heat-related injury or illness, these records can help employers assess the conditions at the time of the injury or illness in order to prevent such an event from recurring.

Paragraph (i) applies to indoor work areas only. This is because employers cannot accurately rely on weather forecasting to predict and monitor temperatures in these areas like they can for outdoor work areas. It is therefore not possible for OSHA or the employer to recreate historic temperature records for indoor work areas in the absence of on-site temperature measurement records. OSHA has preliminarily determined that six months is an appropriate timeframe for records retention because this is the maximum time permitted for an OSHA investigation (see 29 U.S.C. 658(c)). There are several commercially available heat monitoring devices that are capable of maintaining electronic logs of recorded measurements for six months (ERG, 2024b). Therefore, employers can comply with the recordkeeping requirement by using monitoring devices with sufficient storage capability. Alternatively, employers could comply by creating and maintaining written records based on monitoring devices that do not have digital recording capabilities.

A. Requests for Comments.

OSHA requests comments and evidence regarding the following:

- Whether six months is an appropriate and feasible duration of time to maintain records of monitoring data;

- Whether permitting employers to maintain records on devices that store data locally is appropriate; and
- Whether the standard should require retention of any other records, and if so, for what duration.

J. Paragraph (j) Requirements implemented at no cost to employees.

Proposed paragraph (j) provides that implementation of all requirements of the standard must be at no cost to employees, including paying employees their normal rate of pay when compliance requires employee time. This provision is included to make it clear that the employer is responsible for all costs associated with implementing the standard, including not only direct monetary expenses to the employee, but also reasonable time to perform required tasks and training.

This proposed requirement is consistent with the OSH Act, which requires employers to ensure a safe and healthful workplace. The OSH Act reflects Congress's determination that the costs of compliance with the Act and OSHA standards are part of the cost of doing business and OSHA may foreclose employers from shifting those costs to employees (see *Am. Textile Mfrs. Inst., Inc. v. Donovan*, 452 U.S. 490, 514 (1981); *Phelps Dodge Corp. v. OSHRC*, 725 F.2d 1237, 1239-40 (9th Cir. 1984); see also *Sec'y of Labor v. Beverly Healthcare-Hillview*, 541 F.3d 193, 198-201 (3d Cir. 2008)). The proposed requirement is also consistent with OSHA's longstanding practice in prior rulemakings. See, e.g., Employer Payment for Personal Protective Equipment; 72 FR 64342, 64344 (Nov. 15, 2007); Occupational Exposure to Bloodborne Pathogens, 56 FR 64004, 64125 (Dec. 1991). The intent of proposed paragraph (j) is that the standard be implemented at no cost to employees because employer payment for items, such as access to water and shade, is necessary to ensure employees are provided safe working conditions and are protected from the hazard of heat stress. Employees are more likely to take advantage of various workplace protections if such protections are provided at no cost to them. Moreover, as explained in Section VIII., Distributional Analysis, workers from underserved populations are disproportionately exposed to occupational heat hazards. For all workers, but particularly more vulnerable workers, protection from occupational hazards must not depend on workers' ability to pay for those protections. In indicating that the implementation of all requirements of this standard must be at no cost to the employee, OSHA considers costs to include not only direct monetary expenses to the employee, but also the time and other expenses necessary to perform required tasks.

The following discussion highlights specific proposed requirements in paragraphs (c) *Heat Injury and Illness Prevention Plan,* (d) *Identifying heat hazards,* (e) *Requirements at or above the initial heat trigger*, (f) *Requirements at or above the high heat trigger,* (g) *Heat illness and emergency response and planning*, and (h) *Training*. This discussion is illustrative of the requirement that employees are not to bear the costs of implementing the standard. However, the requirement in proposed paragraph (j) applies to all provisions of the proposed standard, including employee time spent to implement or comply with those provisions.

Proposed paragraphs (c)(6) and (c)(7) would require employers to seek the input and involvement of non-managerial employees and their representatives, if any, in the development and implementation of the Heat Injury and Illness Prevention Plan (HIIPP) and during any reviews or updates of the HIIPP. Similarly, proposed paragraph (d)(3)(iv) would require the employer to seek the input and involvement of non-managerial employees and their representatives, if any, when evaluating the work site to identify work areas with a reasonable expectation of exposures at or above the initial heat trigger and in developing and updating monitoring plans. Under these paragraphs, the employer would be required to cover the expenses of non-managerial employees such as any travel costs that may be necessary, and to pay employees their normal rate of pay for the time necessary to engage in the development, implementation, and the required reviews and updates of the employer's HIIPP and monitoring plan.

Proposed paragraph (e)(2) would require the employer to provide access to potable water for drinking that is placed in locations readily accessible to the employee, suitably cool, and of sufficient quantity to provide access to 1 quart of drinking water per employee per hour. To ensure this is provided at no cost to employees, the employer would not only need to pay for the water, its container, and the means to utilize the water (cups, bottles, etc.) but would be required to pay employees their normal rate of pay for time necessary to consume water and any time that may be necessary to travel to and from the location where water is provided. For example, if an employee works in an area where water cannot be made available due to safety considerations (e.g., certain areas in foundries) or because of the presence of toxic materials, and must walk to a water fountain in a break room to obtain water, the employer would be required to pay the employee for the time required to walk to the water fountain, consume water, and return to the work area.

Proposed paragraph (e)(7) would require employers to implement an acclimatization protocol for new and returning employees when they would be exposed to heat at or above the initial heat trigger except when the employer can demonstrate the employee consistently worked under the same or similar conditions as the employer's working conditions within the prior 14 days. An acclimatization protocol sets forth the process whereby employees gradually adapt to work in the heat. Proposed paragraph (e)(7)(i) specifies the acclimatization protocol for new employees exposed to heat at or above the initial heat trigger during their first week on the job. The employer would have a choice to either: (A) implement an acclimatization plan that, at minimum, would include the measures in proposed paragraph (f) (i.e., rest breaks, observation for signs and symptoms of heat-related illness, a hazard alert, and warning signs at excessively high heat areas); or (B) provide for gradual acclimatization to heat in which employee exposure to heat is restricted to no more than 20% of a normal work shift exposure duration on the first day of work, 40% on the second day of work, 60% of the third day of work, and 80% on the fourth day of work. Proposed paragraph (e)(7)(ii) specifies the acclimatization protocol for returning employees (i.e., employees who have been away (e.g., on vacation or sick leave) for more than 14 days) exposed to heat at or above the initial heat trigger during their first week back on the job. The employer would have a choice to either: (A) implement an acclimatization plan that, at minimum, would incorporate the measures in proposed paragraph (f) whenever the heat index is at or above the initial heat trigger during the employee’s first week upon returning to work; or (B) provide for gradual acclimatization to heat in which employee exposure to heat is restricted to no more than 50% of a normal work shift exposure during the first day of work, 60% on the second day of work, and 80% on the third day of work.

An employer who chooses to provide a plan for gradual acclimatization to heat in which employee exposure to heat is restricted would be required to compensate the employee for the hours they would typically be expected to work, i.e., the employee's normal full shift, after acclimatization. For example, if a new employee would be expected to work 8 hours on a normal shift after acclimatization and the new employee would be restricted to 50% exposure during the normal work shift or 4 hours on the first day, the employer would be required to compensate the employee at their normal rate of pay for the full 8 hours even if the employee worked for only 4 hours.

OSHA anticipates that many employers would provide employees with other work (e.g., work activities performed in indoor work areas or vehicles where air-conditioning consistently keeps the ambient temperature below 80°F, sedentary work activities at indoor work sites) during the acclimatization period when they are restricted from duties that involve exposure to heat at or above the initial heat trigger. Employees would still be able to work a full 8-hour shift as long as their duration of exposure to heat at or above the initial heat trigger is limited to the specified duration.

Proposed paragraphs (e)(8) and (f)(2) would require that employees be paid during the rest breaks required by those provisions. OSHA finds it important that employees be paid during the breaks to which they are entitled under the standard so that employees are not financially penalized and thus discouraged from taking advantage of those protections. For employees compensated on an hourly basis, this means employees would need to receive the same hourly rate of pay during rest breaks required by paragraphs (e)(8) and (f)(2) as they would receive while working.

Some employees are paid on a piece-rate basis, meaning they are compensated based on factors such as jobs completed, quantity of produce picked, or products produced. Examples of employees compensated on a piece-rate basis include agricultural employees paid by the pound of produce picked, mechanics paid for each type of job completed (e.g., oil change or tune-up), warehouse employees paid by the number and size of orders filled, manufacturing employees paid by the number of products manufactured, or construction employees paid by the size and type of job completed. Employees paid on a piece-rate basis may be especially reluctant to take breaks. In a study by Wadsworth et al., 2019, focus group discussions with piece-rate farm employees revealed that many expressed concerns about possible losses in earnings and that they might be replaced by another employee if they took breaks, and many such employees brought their own water to work to reduce the time they are not picking produce.

To ensure piece rate employees are not discouraged from taking rest breaks, the proposed standard would require employers to compensate them at their normal rate of pay for time necessary for rest breaks. In the context of piece rate employees and for purposes of this proposed standard, OSHA intends the phrase “normal rate of pay” to mean the rate that results from the following approach, which has also been adopted by the State of California (Cal. Lab. Code § 226.2 (eff. Jan 1, 2021)): employers would determine the normal rate of pay for piece-rate employees by dividing the total weekly pay by the total hours worked during the work week, not including heat-related rest breaks. That value would be multiplied by the total time of heat-related rest breaks to determine how much employees need to be paid for those breaks. For example, if a piece-rate employee works a 5-day work week, 8 am to 4:30 pm with a 30-minute unpaid lunch break from 12-12:30 each day, and earns $600 in piece rate pay for the week, and under proposed paragraph (f)(2) the employer would be obligated to provide two 15-minute heat-related rest breaks per day (i.e., the employee is exposed at or above the high heat trigger from 8 am to 4:30 pm each day), that employee would receive a normal rate of pay of $16/hour for heat-related rest breaks based on the following formula:

Formula for Heat-Related Rest Break Compensation of Piece-rate Employees
Total heat-related rest break time/week = 0.5 hours/day x 5 days/week = 2.5 hours/week
Hours worked, excluding non-meal heat-related breaks = 40 hours – 2.5 hours = 37.5 hours
Heat-related rest break compensation per hour = $600 ÷ 37.5 hours = $16/hour

For an employee who also took rest breaks needed to prevent overheating under proposed paragraph (e)(8), the time of those rest break(s) would be added to the total heat-related rest break time per week to calculate the employee's normal rate of pay. OSHA has preliminarily determined that this approach accurately represents the normal rate of pay for piece-rate workers and thereby ensures that these workers would not lose pay when taking advantage of the standard's protection.

Proposed paragraph (g)(2)(i) would require that an employee experiencing signs and symptoms of heat-related illness must be relieved from duty. The proposed standard would require the employer to pay employees their normal pay while they are relieved from duty until the signs and symptoms subside.

Proposed paragraph (h) would establish requirements for training on heat hazards and associated protective measures. All training provided by the employer to meet the requirements of the standard would be required to be provided at no cost to the employee. The employer would be required to pay employees for time spent in training, including any time needed to travel to and from training.

A. Requests for Comments.

OSHA requests comments and information on the following:

- Whether OSHA should consider an alternative approach to calculating normal rate of pay for piece-rate employees, and what those alternative approaches are;
- Whether OSHA should make the calculation for piece rate workers' normal rate of pay explicit in paragraph (j); and
- Whether proposed paragraph (j) mandating that requirements be implemented at no cost to employees is adequate, or whether there are other potential costs to employees that OSHA should take into consideration.

K. Paragraph (k) Dates.

Paragraph (k) of the proposed standard would establish the effective date for the final standard and the date for compliance with the requirements specified in the standard. In paragraph (k)(1), OSHA proposes an effective date 60 days after the date of publication of the final standard in the *Federal Register*. This period is intended to allow affected employers the opportunity to familiarize themselves with the standard.

Paragraph (k)(2) of the proposed standard would require employers to comply with all requirements of the standard 90 days after the effective date (150 days after the date of publication of the final standard in the *Federal Register*). The proposed compliance date is intended to allow adequate time for employers to undertake the necessary planning and preparation steps to comply with the standard. OSHA has preliminarily concluded that 90 days is sufficient time for employers to develop a Heat Injury and Illness Prevention Plan (HIIPP), identify heat hazards in their workplace(s), implement the protective measures required under the standard, and provide required training to employees.

A. Requests for Comments.

OSHA solicits comment on the adequacy of the proposed effective and compliance dates. OSHA aims to ensure that protective measures are implemented as quickly as possible, while also ensuring that employers have sufficient time to implement these measures. In addition, the agency is interested in whether there are any circumstances that would warrant an alternative timeframe for compliance, including a shorter timeframe, and seeks comment on approaches that would phase in requirements of the standard.

L. Paragraph (l) Severability.

The severability provision, paragraph (l) of the proposed standard, serves two purposes. First, it expresses OSHA's intent that the general presumption of severability should be applied to this standard; i.e., if any section or provision of the proposed standard is held invalid or unenforceable or is stayed or enjoined by any court of competent jurisdiction, the remaining sections or provisions should remain effective and operative. Second, the severability provision also serves to express OSHA's judgment, based on its technical expertise, that each individual section and provision of the proposed standard remains workable in the event that one or more sections or provisions are invalidated, stayed, or enjoined; thus, the severance of any provisions, sections, or applications of the standard will not render the standard ineffective or unlawful as a whole. Consequently, the remainder of the standard should be allowed to take effect.

With respect to this rulemaking, it is OSHA's intent that all provisions and sections be considered severable. In this regard, the agency intends that: (1) in the event that any provision within a section of the standard is stayed, enjoined, or invalidated, all remaining provisions within remain workable and shall remain effective and operative; (2) in the event that any whole section of the standard is stayed, enjoined, or invalidated, all remaining sections remain workable and shall remain effective and operative; and (3) in the event that any application of a provision is stayed, enjoined, or invalidated, the provision shall be construed so as to continue to give the maximum effect to the provision permitted by law.

Although OSHA always intends for a presumption of severability to be applied to its standards, the agency has opted to include an explicit severability clause in this standard to remove any potential for doubt as to its intent. OSHA believes that this clarity is useful because of the multilayered programmatic approach to risk reduction it proposes here. The agency has preliminarily determined that the suite of programmatic requirements described in Section VII., Explanation of Proposed Requirements, is reasonably necessary and appropriate to protect employees from the significant risks posed by exposure to heat in the workplace. While OSHA preliminarily finds that these requirements substantially reduce the risk of occupational injury and illness from exposure to heat when implemented together, the agency also believes that each individual requirement will independently reduce this risk to some extent, and that each requirement added to the first will result in a progressively greater reduction of risk. For example, should a reviewing court find the requirement of paragraph (f)(2), requiring 15 minute rest breaks every two hours in high heat conditions invalid for some reason, the remainder of controls required by the standard in those conditions would still provide necessary protections to employees, and OSHA would intend that the rest of the standard should stand. Therefore, OSHA intends to have as many of the protective measures in this standard implemented as possible to reduce employees' risk of occupational injury, illness, and death from exposure to heat. Should a court of competent jurisdiction determine that any provision or section of this standard is invalid on its face or as applied, the court should presume that OSHA would have issued the remainder of the standard without the invalidated provision(s) or application(s). Similarly, should a court of competent jurisdiction determine that any provision, section, or application of this standard is required to be stayed or enjoined, the court should presume that OSHA intends for the remainder of the standard to take effect. See, e.g., *Am. Dental Ass'n v. Martin,* 984 F.2d 823, 830–31 (7th Cir. 1993) (affirming and allowing most of OSHA's bloodborne pathogens standard to take effect while vacating application of the standard to certain employers).