September 1, 2011

Honorable David Michaels, Ph.D., M.P.H.
Assistant Secretary of Labor for Occupational Safety and Health
Department of Labor
Occupational Safety and Health Administration
200 Constitution Avenue, NW
Washington, DC 20210

Dear Dr. Michaels,

Public Citizen, a consumer and health advocacy group representing more than 225,000 members and supporters nationwide; Farmworker Justice, a nonprofit advocacy group for agricultural workers; United Electrical, Radio and Machine Workers of America, an independent labor union; and Dr. Thomas Bernard, Professor and Chair of Environmental and Occupational Health at the University of South Florida and a leading expert on occupational heat stress, hereby petition the Occupational Safety and Health Administration (OSHA), pursuant to section 6(c) of the Occupational Safety and Health Act, 29 U.S.C. § 655(c), to issue an Emergency Temporary Standard (ETS) for a heat stress threshold that will protect workers from suffering unnecessary and entirely preventable health effects, including death, from excessive indoor and outdoor heat exposure. We are also requesting that OSHA immediately initiate the usual rulemaking process for a permanent heat stress standard, pursuant to 29 U.S.C. § 655(b) that would include the heat threshold above, in addition to multiple other proven protective measures from extreme heat. Although hundreds of workers have died and tens of thousands more have been seriously injured in the U.S. from the effects of excessive heat exposure at work, and the National Institute of Occupational Safety and Health (NIOSH, the research arm of federal activity on this topic) proposed the details of an OSHA heat standard 39 years ago, there is still no federal OSHA standard in place to protect these workers.

This summer has been one of the hottest on record, with large areas of the country placed under "excessive heat warnings."[1] Deaths due to the heat have been reported in cities and towns across the country,[2,3] and if prior years are any indication, the most vulnerable people in our society — including the elderly[4] and certain workers[5] — have likely borne the brunt of the serious and often fatal health effects. Workers across the country, in industries from construction to agriculture, have been working full time in extreme heat, often with no precautions taken to protect them from heat exhaustion — and little in the way of federal protection. In one case this past July, construction workers in Indiana were actually fired for

refusing to work in conditions that resulted in the hospitalization of a coworker for heat exhaustion.[6,7]

The epidemic of worker injury and death due to excessive heat exposure is projected to worsen in the coming years. Global warming is resulting in more frequent days of "extreme" heat, and record-breaking summers are now becoming the norm.[8,9] In addition, with the so-called "graying" of the workforce, an ever-larger number of older workers, most vulnerable to the effects of heat stress, will be exposed to these increasingly dangerous temperatures.[10]

OSHA has no standard in place to hold employers accountable for not ensuring that their workers are adequately protected from the heat. In 1972, two years after the Occupational Safety and Health Act (OSH Act) took effect, the newly created National Institute for Occupational Safety and Health (NIOSH) undertook a comprehensive study on the effects of heat stress on workers. This study culminated in a set of detailed criteria for a recommended occupational heat standard.[11] OSHA responded to the report by appointing a committee, the Standards Advisory Committee on Heat Stress (SACHS), to study the institute's recommendations and advise OSHA on an appropriate heat standard. The committee deliberated, essentially agreed with NIOSH's recommendations, and presented a final recommended standard to OSHA.[12] Although initially responsive, OSHA ignored the committee's advice and did not even initiate a rulemaking process to consider a standard.

Due to OSHA's failure to implement a heat standard based on its 1972 recommendations, NIOSH revised and reissued a set of updated recommendations for a heat standard in 1986.[13] Again, OSHA ignored the institute's recommendations. To this day, almost 40 years after the first detailed criteria for a heat standard were issued by NIOSH, OSHA has failed to even begin considering a heat standard that, according to NIOSH, would "… prevent or greatly reduce the risk of adverse health effects to exposed workers …"[14] As a result, hundreds of workers have lost their lives and tens of thousands more have been seriously injured due to entirely preventable heat-induced illnesses.[15,16]

As this petition documents, OSHA refuses to implement a heat standard, despite:

> 1) ample scientific evidence on the fatal effects of excessive heat exposure and feasible, evidence-based measures to mitigate these effects;
>
> 2) existing standards in three states — California, Washington, and Minnesota — and the military, elements of which are replicable on a federal level;
>
> 3) detailed recommendations from NIOSH (twice) and OSHA's own advisory committee calling for a federal heat standard that have gone unheeded; and
>
> 4) at least 523 deaths and 43,454 serious injuries in workers due to extreme heat exposure reported since 1992, many of which would likely have been prevented had an aggressive enforcement program been in place.

This year, the agency finally addressed the epidemic — but has unfortunately opted for voluntary half-measures instead of a mandatory standard. OSHA and the Department of Labor

have undertaken a nationwide campaign to educate employers and workers on the dangers of heat exposure, with guidance on preventive measures to reduce the risk of injury and death.[17] Years ahead of OSHA, three states — California, Washington, and Minnesota — have taken the lead and enacted enforceable standards that actually hold employers accountable rather than rely on their good faith to protect workers. It is time for OSHA to follow suit to prevent the hundreds of deaths and tens of thousands of injuries that will certainly continue to occur in the absence of a heat standard.

I. Health effects of excessive heat exposure

The human body needs to maintain a core, or internal, temperature of 37 degrees Celsius (98.6 Fahrenheit) and can only tolerate very small deviations from this temperature. There are two sources of heat that can raise the body's temperature: 1) environmental heat, such as that from a hot summer day, and 2) metabolic heat, or the heat that the body generates internally, especially with physical activity. Workers who perform strenuous physical labor while exposed to conditions of extreme heat will rapidly increase their body temperature through both mechanisms simultaneously, leaving them especially vulnerable to the effects of heat stress.

A. THE BODY'S NORMAL RESPONSE TO HIGH HEAT LEVELS: THE IMPORTANCE OF THE SWEAT RESPONSE

Any increase in the body's core temperature induces a series of compensatory responses to emit the excess heat and cool the body. However, in conditions of extreme heat stress, either from the environment or through physical activity, the body can lose its ability to cope with the heat load, and core temperature will rise rapidly, leading to heat stroke and death.

The most important response to an increase in core temperature is sweating. The evaporation of sweat from the skin, either from ambient heat or moving air (e.g., wind) removes heat from the body's surface and serves as the body's best defense against heat stress. Small arteries in the skin also dilate in response to high temperatures in order to expedite the removal of excess heat through the skin. This shunting of blood away from vital organs, such as the brain and kidneys, causes heart rate to increase accordingly, a key indicator of heat strain.

There are three main factors that can impede the critical sweat response: clothing, humidity, and dehydration. Certain types of clothing, such as the personal protective equipment worn by many agricultural or manufacturing workers, serve as a physical barrier to the evaporation of sweat. Humidity in the air causes an increase in vapor pressure, which also inhibits the evaporation of sweat from the skin. Humidity is such a strong influence on the ability of the body to cool itself that only a small increase in vapor pressure can have a profound effect on heat stress experienced by workers.[18] Finally, dehydration (as explained below) depletes the body's supply of water that is required for sweating.

Acclimatization

Acclimatization refers to the body's ability to gradually adapt over a period of time to high heat levels. When a person is exposed to heat levels higher than he or she is accustomed to, the

body gradually adapts, developing a more robust sweat response, among other physiological adjustments, to more optimally emit excess heat. This process is crucial to the ability of a worker to withstand high heat conditions without suffering harmful health effects, and acclimatizing new workers gradually (typically over a period of five to 14 days, with a phased increase in work rate each day[19,20]) is recognized as a key preventive measure against heat stress and strain.[21]

B. DEHYDRATION

The average person requires approximately three liters of water per day just to replace the amount lost through urine and insensible skin losses.[22] Physical exertion and higher temperatures accelerate this water loss greatly. Workers performing physical labor in high temperatures are therefore at high risk of dehydration due to very large water losses through sweating, which may remove from the body several liters of water per shift under certain work conditions.[23]

Drinking coffee or alcohol, or taking certain medications (e.g., diuretics for high blood pressure), may further enhance fluid loss by preventing the kidneys from preserving water so that it can be used for sweating. Older workers are also at greater risk, due to their decreased ability to conserve water in the face of extreme heat, and the elderly tend to suffer the highest death rates during heat waves.[24] This is compounded by the fact that elderly workers are more likely than younger workers to be using prescription drugs such as diuretics.

Dehydration can have a number of serious effects on the body, including dangerously low blood pressure, heart attacks in those with cardiovascular disease, kidney failure, and severe neurological effects, such as fainting or convulsions. Dehydration also affects the body's ability to deal with heat stress. As water stores are depleted, dehydrated workers gradually lose the ability to sweat, resulting in a faster increase in core temperature and further dehydration, in a dangerous cycle.

C. HEAT CRAMPS, HEAT EXHAUSTION, AND HEAT COLLAPSE

The health effects of excessive heat exposure on the body occur in stages, with increasing temperatures or exposure times causing progressively higher body temperatures. At first, the body can respond appropriately with milder health effects, such as heat cramps from electrolyte imbalances and what is called heat fatigue, symptoms of which include mild impairment of sensorimotor or visual skills. However, if preventive measures are not taken, heat exhaustion and heat collapse may result.

Many people have likely experienced heat exhaustion at one point in their lives, with symptoms such as nausea, headache, weakness, and intense thirst. Fainting can result in some cases where the dilation of the blood vessels in the skin and extremities causes decreased blood flow to the brain in a condition known as heat collapse. While heat exhaustion and heat collapse respond rapidly to prompt treatment, if the worker is left alone and not removed immediately from the work site, their condition can further deteriorate to heat stroke and become life-threatening.

D. HEAT STROKE ENSUES WHEN THE BODY LOSES ITS ABILITY TO COPE WITH HEAT STRESS

When no preventive measures are taken, heat exhaustion can rapidly progress to heat stroke, a medical emergency and fatal if not treated promptly. Heat stroke occurs when the body's system of temperature regulation fails, leading to an unrestrained rise in core temperature to critical levels (up to 108 F). Symptoms of heat stroke include confusion; irrational behavior; loss of consciousness; convulsions; a lack of sweating; hot, dry skin; and an abnormally high body temperature, for example, a rectal temperature of at least 41°C (105.8 F).[25] If body temperature remains too high for too long, death will rapidly ensue.

Emergency measures that can be taken at the work site include moving the worker to a shaded area, removing the outer clothing, and initiating a series of aggressive cooling measures, such as immersion cooling in ice water, wetting the skin, or vigorously fanning the worker's body.[26] Crucially, fluids must be replaced as soon as possible, and medical attention sought immediately to avert death.

II. Millions of workers at risk nationwide

In 1986, NIOSH estimated "conservative[ly]" that there were perhaps 5-10 million workers in industries where "heat stress is a potential safety and health hazard."[27] Since then, the nation's workforce has increased considerably, and so, too, have the number of workers exposed to dangerous heat conditions.[28]

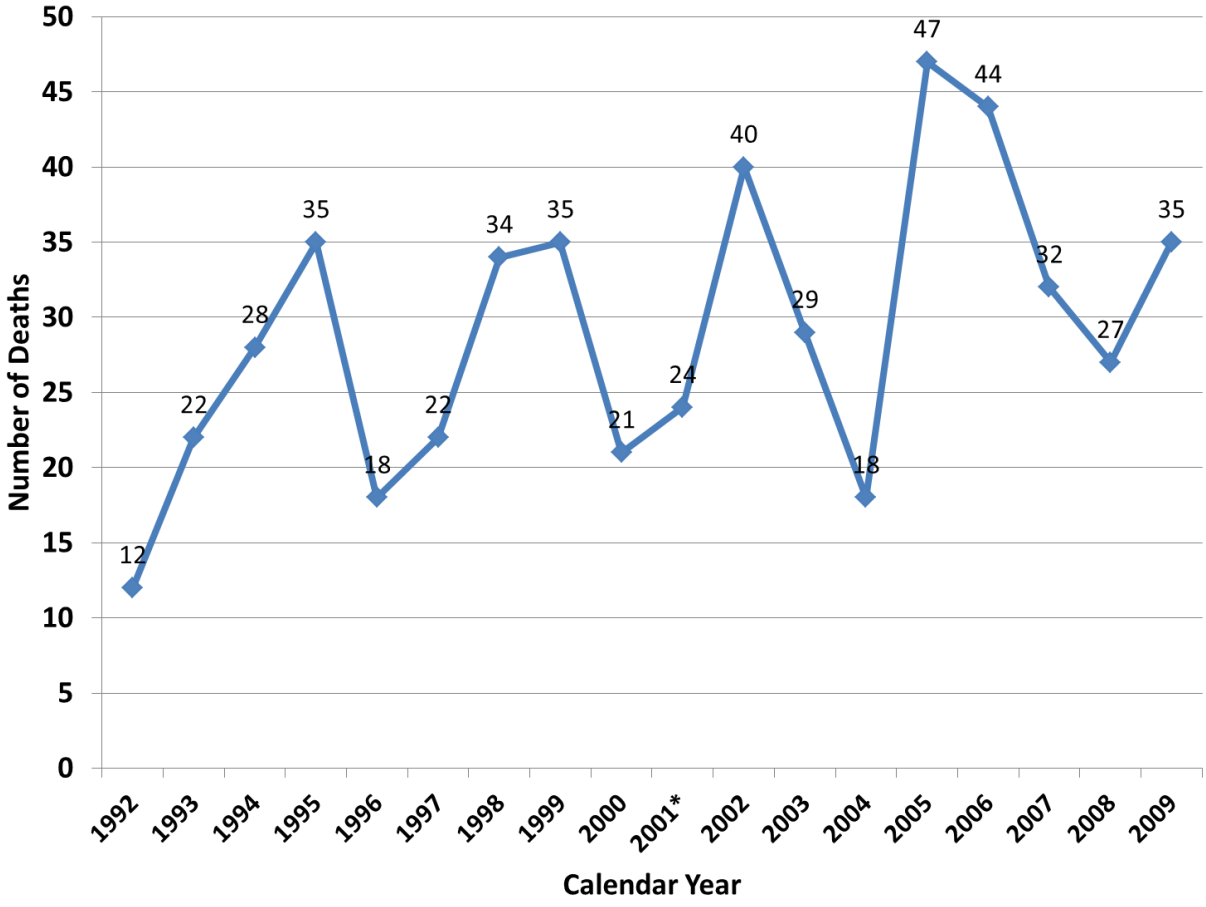
A. TENS OF THOUSANDS OF PREVENTABLE INJURIES AND HUNDREDS OF PREVENTABLE DEATHS FROM EXTREME HEAT EXPOSURE

Figures 1-3 show worker deaths and injuries resulting from overexposure to heat, both outdoor and indoor, since 1992. Not including the past two years, for which data are not yet available, at least 523 workers have died as a result of environmental heat exposure over the past 20 years. The number of heat-related deaths has fluctuated year to year but has increased slightly in recent years. When the increase in the labor force is taken into account, incidence rates have held steady, ranging between 0.16 and 0.4 deaths per 1 million full-time workers and averaging 0.29 per 1 million full-time workers from 1994 to 2009.

Heat exposure has also taken an enormous toll on worker health. A total of 43,454 workers have suffered heat-related injuries serious enough to result in at least one day away from work since 1992, with an average of 2,414 such injuries every year. Considering that this is the total for only a single 18-year period, and that injuries not resulting in workdays missed and unreported cases are not counted, the scale of the problem is even greater.

An additional consequence resulting from these (at least) tens of thousands of missed workdays is the loss of productivity. Businesses reportedly spend $170 billion every year on costs associated with occupational illnesses and injuries,[29] and the effect of lost productivity on the agricultural sector, with one of the smallest labor forces[30] but one of the highest rates of heat-related illness,[31] is likely considerable.

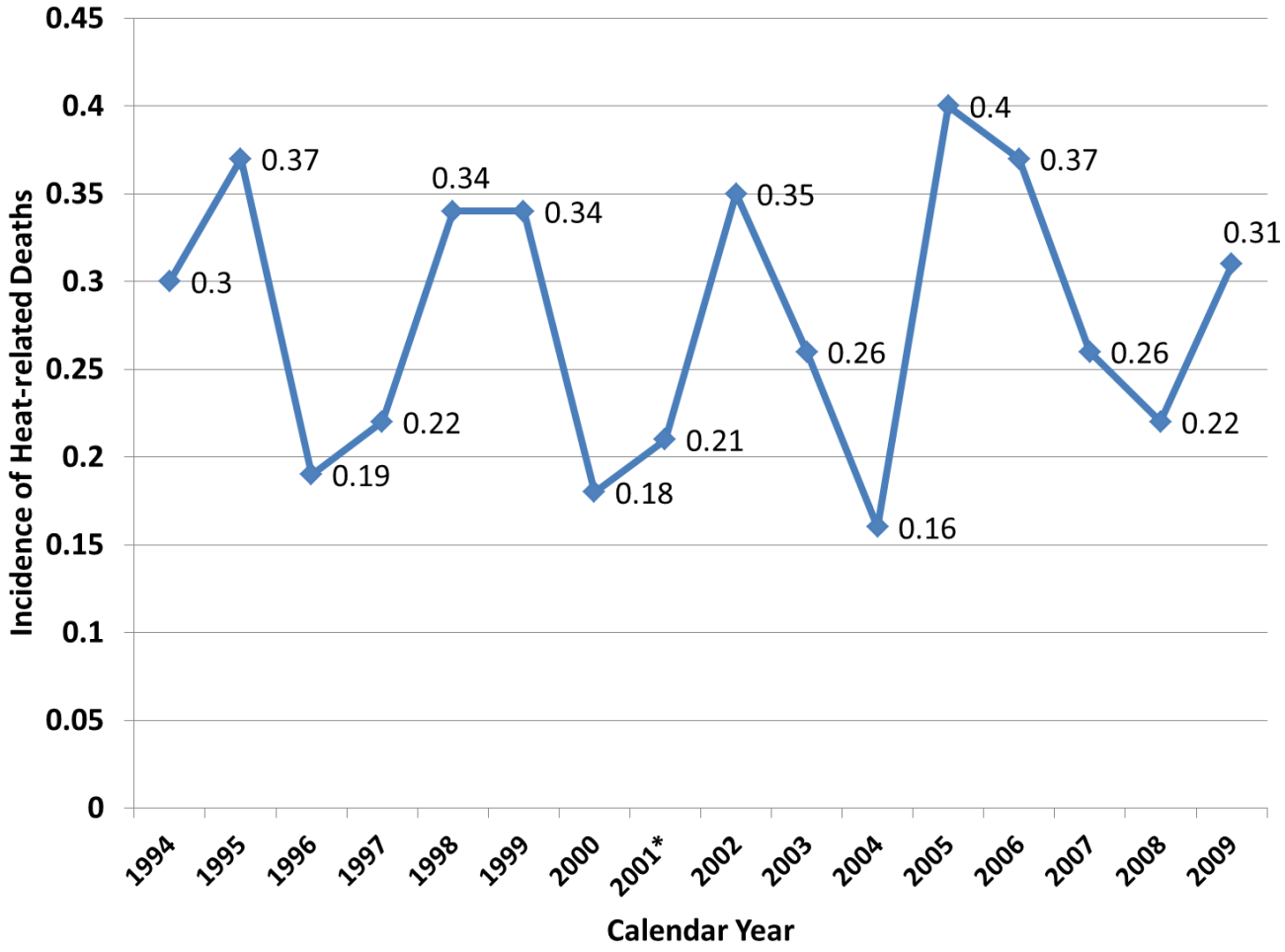
Figure 1.[32] Worker deaths (n=523) resulting from environmental heat exposure,† 1992-2009.



† All ownership categories (private industry and state and local governments). OIICS Exposure Code 321 for environmental heat.

* 2001 total excludes fatalities resulting from the September 11 attacks.

Figure 2.[33] Incidence† of worker deaths (per 1 million full-time workers) resulting from environmental heat exposure,‡ 1994-2009.

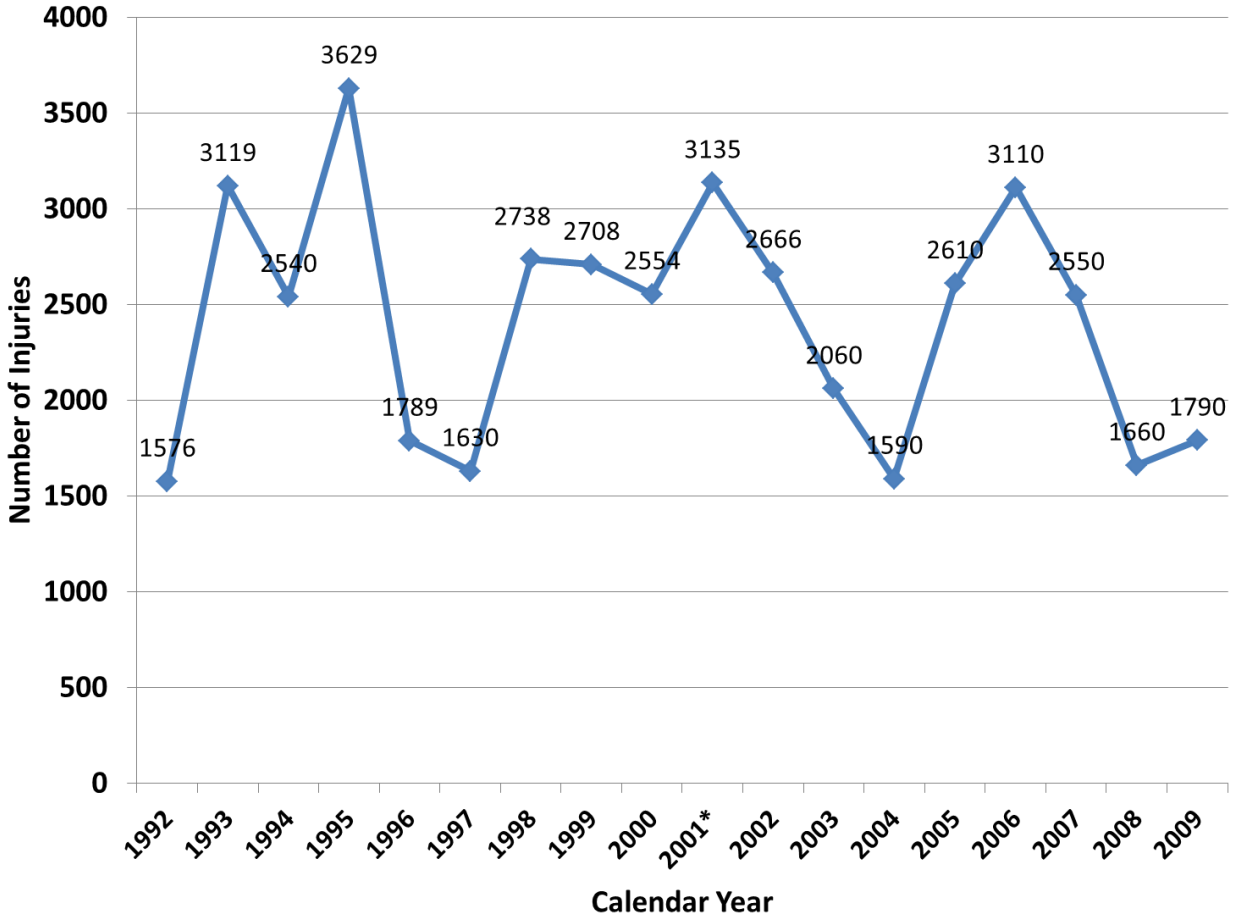


† Incidence rate calculated using 1) Department of Labor statistics on worker deaths (Figure 1) as numerator, and 2) Bureau of Labor Statistics (BLS) number of full-time workers by year as denominator (obtained from BLS via email).

‡ All ownership categories (private industry and state and local governments). OIICS Exposure Code 321 for environmental heat.

* 2001 total excludes fatalities resulting from the September 11 attacks.

Figure 3.[34] Nonfatal worker injuries (n=43,454) from environmental heat exposure that resulted in at least one day away from work,† 1992-2009.



†Only private industry. OIICS Exposure Code 321 for environmental heat.

*2001 total excludes injuries resulting from the Sept. 11th attacks

B. AGRICULTURAL WORKERS AT HIGHEST RISK

Agricultural workers are the most vulnerable to the effects of outdoor heat exposure. In 2008, the Centers for Disease Control and Prevention (CDC) issued a *Morbidity and Mortality Weekly Report* (MMWR) documenting the extent of heat-related deaths in U.S. crop workers over the previous 14 years (1992-2006).[35] Of a total of 423 total deaths in workers from excessive heat exposure, crop workers accounted for 68, or 16%, of all deaths. Crop workers suffered much higher rates of death than did other workers, with 0.39 deaths per 100,000 workers, over 19 times the national rate.[36] Most concerning, the majority of the deaths were in workers aged 20-54, not a population usually at high risk for heat-related deaths.

As **Table 1** shows, workers in farming, fishing, and forestry occupations accounted for more than 1 in 5 deaths resulting from environmental heat exposure, with agricultural workers

comprising the vast majority of these deaths.[37] Consistent with the CDC report, this death rate is over 26 times that of the general worker population. Construction workers have also suffered high rates of heat-related deaths, at 4.5 times the national rate.

Table 1. Heat-related deaths in agricultural and construction workers, 1992-2009.

Occupation	Heat-related Deaths			
	Number (1992-2009)[1]	% of Total (1992-2009)[2]	Incidence (2000-2009)[3]	
			per million workers	relative to national rate
Farming, Fishing, & Forestry	110	21%	7.30	26x
Construction & Extraction	112	21 %	1.22	4.5x
Total for all occupations	523	(100%)	0.27	(1x)

1. Raw totals apply to years 1992-2009. Obtained from the BLS Injury, Illness, and Fatalities data website (http://data.bls.gov/gqt/InitialPage).
2. Raw totals apply to years 1992-2009. Obtained from the BLS Injury, Illness, and Fatalities data website (http://data.bls.gov/gqt/InitialPage).
3. Incidence rates apply to years 2000-2009. Calculated using BLS Current Population Survey (CPS) estimates for number of full-time workers by occupation as denominator, and raw totals from the BLS Injury, Illness, and Fatalities data for 2000-2009 as numerator.

In addition to heat-related deaths, studies of workers' compensation claims suggest a high incidence of heat-related injury in agriculture.[38]

C. UNDERREPORTING BY WORKERS

The existing data, however, are likely to significantly underestimate the prevalence of agricultural heat-related injuries for several reasons. As is the case with all workers (see below), most agricultural workers with heat-related illness short of severe exhaustion are likely to self-treat, do not report illness, and do not (or are not able to) take time off to recuperate.[39] Additionally, in agriculture, signs of heat stress — rash, sweating, headache, and fatigue — can be confused with similar symptoms encountered with exposure to pesticides,[40] thus leading to misclassification of the exposure and further underreporting.

Accurate injury reporting is also hindered by unique features of the agricultural workforce and workplace, including the migrant and seasonal nature of the workforce; poor English skills and educational attainment of workers; and economic and social factors that prevent workers from speaking out about workplace conditions.[41] The majority of farmworkers are poor, can ill afford to stop working to treat or recover from injuries, often fear losing their jobs if they take time off,

lack awareness of employment rights, and may perceive that reporting injuries would be construed by employers as complaints and thus result in reprisal. Most are immigrants, many lacking proper work permits and fearful of deportation if they raise concerns about, or request the most basic protections from, heat stress.

D. EMPLOYER-REPORTED INJURIES ARE LIKELY ONLY THE TIP OF THE ICEBERG

In addition to the particular factors leading to underreporting of heat-related injury in agricultural workers by the workers themselves, there is ample reason to believe that the mortality and injury data presented above for all workers are vast underestimates of the true scale of the problem of extreme occupational heat exposure. The statistics are based on data provided by the Bureau of Labor Statistics (BLS).[42] As explained by the bureau, its annual Survey of Occupational Injuries and Illnesses (SOII) relies on employer logs of worker injuries and deaths obtained from OSHA.[43] The OSH Act of 1970 requires all nonexempt employers to make available to OSHA complete records of injuries and illnesses sustained by their workers on a form known as the Form 300 Log of Injury (or 300 log).[44] However, data based on these employer-recorded logs are limited for several reasons.

First, the OSH Act, and therefore the logs, does not apply to federal government agencies, self-employed persons, and household workers.[45] Most critically, given that agricultural workers have the highest rate of heat-related illness and death, small farms with fewer than 11 workers are also excluded, and so the BLS data does not capture heat-related events in a significant number of agricultural workers. Also exempt from the law are the vast number of injuries that do not lead to death, days away from work, restricted work or transfer to another job, medical treatment beyond first aid, loss of consciousness, or a diagnosis of significant injury by a health care professional.[46] Based on personal communication with two large unions, these nonurgent but nonetheless serious injuries are a major contributor to the burden of heat-related illness in workers.

However, even for those employers covered by the OSH Act and surveyed by the BLS, the data are almost certainly underestimates for several reasons, as outlined in a 2009 Government Accountability Office (GAO) review of OSHA/BLS injury data.[47] First, the 300 logs rely on self-reports by employers, employees, and company doctors. As GAO confirmed, employers are likely to underreport due to, among other obvious reasons, not wanting to increase workers' compensation costs and jeopardize their standing as safe workplaces for future contracts. In addition, employees do not report all injuries out of fear of losing their jobs or company retaliation. Finally, the GAO report noted that occupational medicine physicians and other health practitioners are often pressured to understate the significance of an injury to avoid the need to record it on the 300 log. Over a third of all health practitioners surveyed by the GAO in its 2009 review reported such pressure to avoid recording requirements, leading to insufficient treatment for certain injuries.[48]

Thus, the underreporting inherent in employer self-reported injury logs combined with a lack of verification by OSHA of the accuracy of these logs virtually guarantees that the data presented above showing tens of thousands of worker injuries and hundreds of deaths from 1992 through 2009 greatly underestimate the devastating effects of extreme heat exposure in workers.

III. OSHA's current enforcement policy: reactive and dangerously inadequate in the absence of a standard

As noted above, in 1972, and again in 1986, NIOSH undertook extensive studies of the health effects of excessive heat exposure in order to formulate criteria recommendations to OSHA for a heat standard.[49,50] In response to the 1972 recommendations, a year later, OSHA appointed an advisory committee on the issue, SACHS, which proposed a standard based in part on the NIOSH criteria.[51] OSHA did not act on either this recommendation from its own advisory committee or the revised 1986 NIOSH recommendations and, four decades later, has not even begun the rulemaking process to formulate a standard.

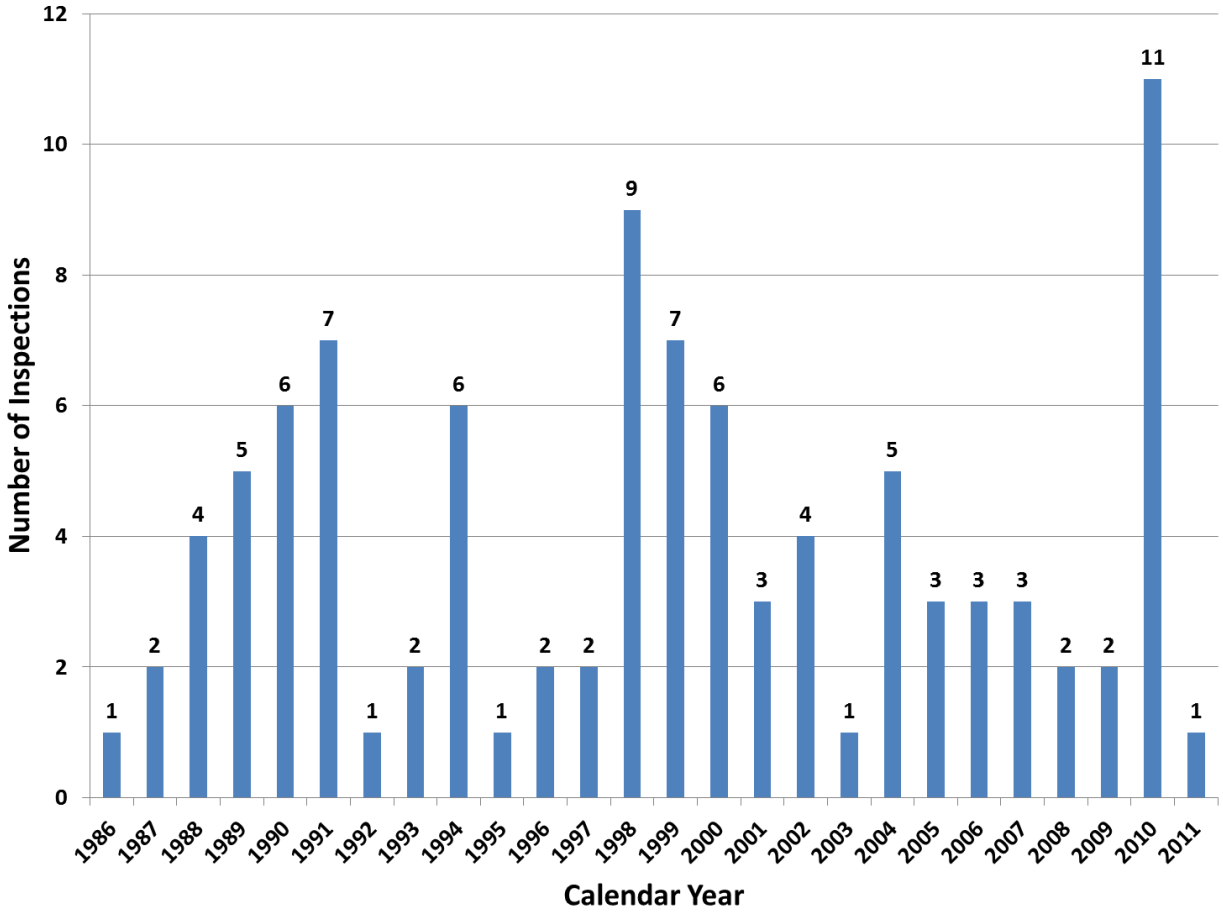
As a consequence, OSHA does not currently have a specific standard setting limits on heat exposure in the workplace and relies primarily on its authority under the General Duty Clause (§ 5[a][1]) to take enforcement action against dangerous workplace heat exposures. However, as seen below, the agency exercises this authority rarely and only in cases of egregious employer negligence. This should not come as a surprise. As David Michaels, now head of OSHA, stated several years ago when testifying before the Senate on OSHA's inadequate enforcement policies, the agency has become "hesitant to use [the clause], even for the most obvious and egregious hazards."[52]

A. GENERAL DUTY CLAUSE: UNSURPRISING UNDERENFORCEMENT

The General Duty Clause gives OSHA broad leeway in holding employers accountable for safety hazards for which there is no specific standard in place.[53] However, as seen below in the case of dangerous workplace heat practices, enforcement is rare and, in many cases, reactive rather than proactive.

Over the past 25 years, OSHA has conducted a total of only 112 inspections in which at least one citation was issued for violations of safe heat exposure practices (no inspections were found prior to 1986). Of these inspections, 13 — including nine that involved the death of a worker — were later dismissed. Therefore, only 99 inspections resulted in a final citation, or less than three inspections per year over the 40-year existence of the agency (**Figure 4**). In addition, 39, or almost 40%, of these inspections were reactive in nature, conducted in response to the death of a worker from heat-related causes.

Figure 4.[54] Total OSHA inspections (n=99)* resulting in at least one citation for violations of safe heat exposure practices under the General Duty Clause or specific standards,† 1986-2011.‡

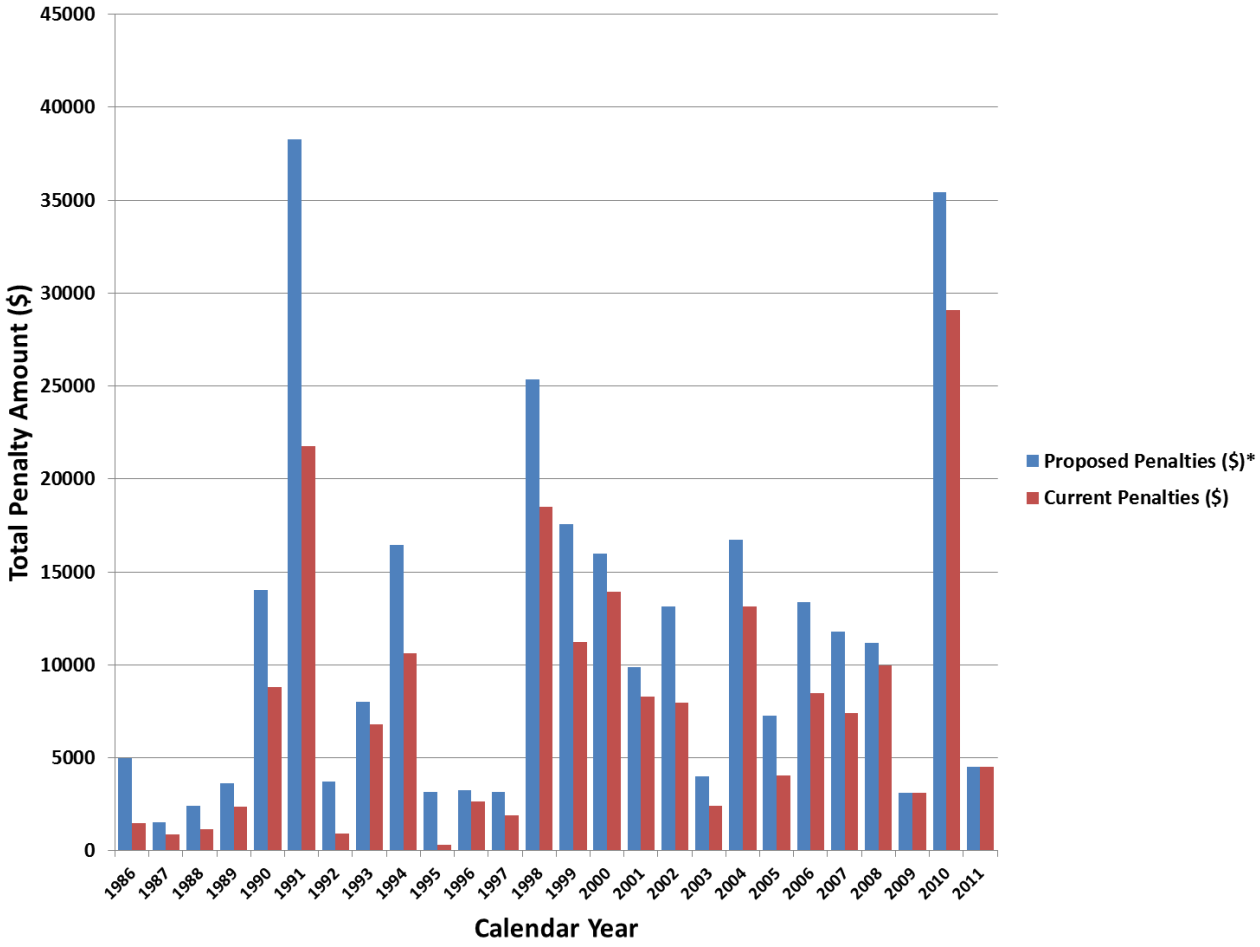


* Thirteen (out of an original 112) inspections involved citations that were later "deleted" by OSHA.

† A total of six inspections (out of 99) cited employers under specific standards and not the General Duty Clause. See "Methods," Appendix I.

‡ Data current through Aug. 5, 2011. No inspections found before 1986.

Figure 5.[55] Total proposed (n=$291,987)* and current (n=$201,954) penalties handed down by OSHA for violations of safe heat exposure practices under the General Duty Clause or specific standards,† 1986-2011.‡**



* Dollar amounts not adjusted for inflation. "Proposed" penalties refer to those initially handed down after an inspection. "Current" penalties reflect the final (almost always reduced) amount after further deliberation by OSHA and based on "… the employer's good faith, history of previous violations, the gravity of the alleged violation, and size of business."[56]

** Thirteen (out of an original 112) inspections, comprising total penalties of $50,455 (proposed) and $34,955 (current), involved citations that were later "deleted" by OSHA.

† A total of six inspections (out of 99) cited employers for specific standards and not the General Duty Clause, with total penalties of $8,900 (proposed) and $6,750 (current). See "Methods," Appendix I.

‡ Data current through Aug. 5, 2011. No inspections found before 1986.

As can be seen from **Figure 5 and Table 2**, penalties handed down under the General Duty Clause are so small that no reasonable person can conclude that the fines serve as a deterrent against further violations. In one case in 1999, seven different workers had to be hospitalized for heat exhaustion in Missouri.[57] For this offense, OSHA proposed a penalty of only $3,500 and later reduced even this inconsequential fine to $2,450. This pattern of reducing financial penalties for heat-related violations extends even to cases involving worker deaths. Of the 39

inspections conducted in response to heat-related fatalities, OSHA fined the companies only $3,279 per violation that lead to the death, only to reduce it further by almost 25% to $2,507. In other words, employers that OSHA deemed negligent, in incidents where "… the employer knew, or should have known, of the hazard …"[58] that led to the heat-related death of a worker, were fined an average of only $2,507. By contrast, the maximum allowable fine for serious offenses such as these[59] is $7,000, or almost three times the average citation amount OSHA chose to hand down for heat-related deaths.

These minimal fines were typical of all violations, not only those involving worker deaths. **Table 2** shows that the average penalty issued for all citations involving heat-related safety violations was $2,040 per offense, or only 29% of the maximum allowable for "serious" offenses.

Table 2.[60] Average proposed and current penalties* issued per violation of safe heat exposure practices under the General Duty Clause or specific standards,† 1986-2011.**

	All heat-related violations	Violations involving heat-related deaths
Proposed Penalty (% maximum)	$2,949 (42%)	$3,279 (47%)
Current Penalty (% maximum)	$2,040 (29%)	$2,507 (36%)
Maximum Penalty‡	$7,000	$7,000

* Dollar amounts not adjusted for inflation. "Proposed" penalties refer to those initially handed down after an inspection. "Current" penalties reflect the final (almost always reduced) amount after further deliberation by OSHA and based on "… the employer's good faith, history of previous violations, the gravity of the alleged violation, and size of business."[61]

** Data current through Aug. 5, 2011. No inspections found before 1986.

† A total of six inspections (out of 99) cited employers for specific standards and not the General Duty Clause, with total penalties of $8,900 (proposed) and $6,750 (current). See "Methods," Appendix I.

‡ Refers to the maximum penalty for "serious" violations, which was the violation category for almost all (88 of 99) heat-related citations.

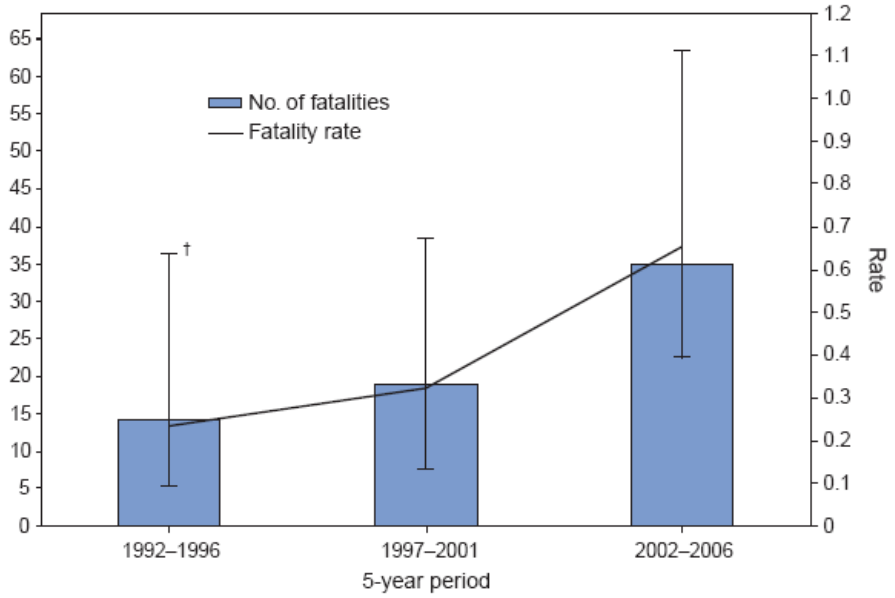
B. FIELD SANITATION STANDARD: IMPORTANT BUT NO SUBSTITUTE FOR A HEAT STANDARD

In 1987, OSHA instituted what is known as the Field Sanitation Standard (29 C.F.R. 1928.110), which required agricultural employers to provide adequate sanitation facilities and potable water for all employees working in the fields. The standard was vague and only required the provision of drinking water that was "readily accessible" and in "sufficient amounts," and only mandated that employers encourage workers to "drink water frequently and especially on hot days."[62] In subsequent interpretations, OSHA cited heat stress and heat exhaustion as "primary hazards

addressed by the standard,"[63] yet the agency did not attempt to expand upon the standard or make it more specific. Ultimately, although the general idea was a good one, the language — like the General Duty Clause — is vague and leaves up to the employer what constitutes "accessible" and "sufficient" quantities of drinking water.

In 1992, OSHA claimed in a fact sheet that the new standard, along with similar state standards, would "… reduce heat-related injuries among those covered by more than 90 percent."[64] Not surprisingly, given that the standard only addresses heat-related illness through a single and vaguely worded provision for drinking water, the prediction that the rate of heat-related injuries would decline by 90% proved a gross overestimate of the standard's impact. **Figure 6** shows that the rate of heat-related deaths in agricultural workers has actually increased since the implementation of the standard over 20 years ago.

Figure 6. Number (left vertical axis) and rate*(right axis) of heat-related deaths among crop workers, by five-year period — U.S., 1992-2006 (graph taken as is from CDC MMWR, 2008).[65]



* Per 100,000 workers. Rates calculated using annual national average estimates of employed civilians aged ≥15 years based on the Current Population Survey.
† 95% confidence interval for fatality rate.

C. OUTREACH AND EDUCATION: INDUSTRY WILL NOT POLICE ITSELF

This past summer (2011), OSHA has embarked on a nationwide outreach and educational campaign in an attempt to tackle the problem of heat-related illness.[66] While commendable, this is not a substitute for a legally enforceable requirement that employers establish adequate heat protections for their workers. As seen in a recent report on OSHA's Voluntary Protection Program (VPP), no industry can be relied upon to police itself.[67] The report outlined how certain companies — deemed "model workplaces" and exempt from any OSHA inspections under the

VPP — predictably failed to live up to their favored designation. At least 80 workers have died at “model workplaces” over the past decade, with serious safety violations found in over half of these cases.

This should come as no surprise, however. A system relying on for-profit companies to go out of their way to protect the most vulnerable workers — especially in the case of migrant or guest workers, who often have no other recourse — is doomed to fail. Only the potential for much more frequent monetary penalties (which will arise from a specific, enforceable heat standard) will ensure that employers take the necessary and often minimal steps required to protect workers from entirely preventable heat injury and death.

IV. Three states and the military well ahead of OSHA in protecting workers from outdoor and indoor heat exposure

Well ahead of OSHA, two states, California and Washington, have already enacted standards to protect workers from excessive outdoor heat exposure, and one, Minnesota, has a similar standard for indoor exposure. The military also has rigorous guidelines protecting soldiers and other employees from extreme outdoor heat conditions. **Table 3** summarizes the key elements of the state and military standards and compares them to expert recommendations from NIOSH and the American Conference of Governmental Industrial Hygienists (ACGIH)

Table 3. Comparison of heat standards of the three states (CA, WA, MN) and the military with NIOSH and ACGIH recommendations.

Key Elements of Standard	California	Washington	Minnesota	Military*	NIOSH**	ACGIH**
Scope	-Year-round -All outdoor worksites	-May 1 – Sept 30 only -All outdoor worksites -Only when temperatures exceed certain thresholds. -Workers with "incidental" (<15 min/hr) exposure exempted.	-Year-round -All indoor worksites	-Year-round -All worksites	-Year-round -All worksites (outdoor and indoor)	-Year-round -All worksites (outdoor and indoor)
Heat Stress Thresholds (Permissible Exposure, or Ceiling Limits)	No. Employers required to monitor employees (especially those unacclimatized) for effects of heat stress when outside temperatures exceed 95F, but no Ceiling Limit.	No. Law only applies when outside temperatures exceed certain thresholds (89F for most workers), but no Ceiling Limit.	Yes. Ceiling Limit (temperature above which heat-protective clothing and equipment must be provided).	Yes. The Navy has a "Physiological Heat Exposure Limit" or PHEL, which represents a "maximum allowable" exposure based on metabolic and environmental heat load.	Yes. Ceiling Limit (temperature above which heat-protective clothing and equipment must be provided). Recommended Alert Limits (metabolic heat, environmental heat, acclimatization, and clothing).	Yes. Threshold Limit Curves (metabolic heat, environmental heat, acclimatization, and clothing).
Drinking Water	Employers required to provide one quart of potable water per employee per hour, and encourage frequent drinking (up to 4 cups per hour).	Employers required to provide the opportunity for one quart of water per employee per hour, but employees explicitly responsible for their own hydration.	No	Yes. Soldiers should be provided cool (50-60F) water at a rate of 0.5 - 1.5 quarts/hr based on work intensity and ambient temperature.	Yes. Employers should provide enough drinking water to permit 1 cup (150-200cc) of cool (50-59F), potable water every 15-20 minutes.	Yes. Employers should encourage workers to drink 1 cup of cool, palatable water every 20 minutes.
Shade requirements	Yes. Upon request when temp <85F. When temp >85F, shade must be provided to all employees and able to cover at least 25% of employees at one time.	No	N/A	No specific guidelines on shade.	No specific guidelines on shade.	No specific guidelines on shade.
Mandatory Rest Breaks	No, only upon employee request.	No	No	Yes. Rigorous work-rest cycles based on WBGT thresholds.	Indirectly. Threshold Limit Curves differ depending on duration of work per hour.	Indirectly. Temperatures at which employer should institute extra precautions differ depending on duration of work per hour.
Employers required to monitor employees for effects of heat stress	Employers required to monitor employees for signs of heat-related illness when temperature >95F.	Employers required to respond to signs of heat-related illness once they occur, but otherwise, employees explicitly given responsibility for monitoring themselves.	No	Yes. Language on monitoring of soldiers interspersed throughout guidance document, but no strict criteria.	Yes. Employers should institute a medical screening and surveillance program.	Yes. Employers should "monitor heat stress [WBGT thresholds] and heat strain [signs and symptoms]".
Employee / Employer Training required	Yes. Upon hiring.	Yes. Upon hiring and at least annually thereafter.	Yes. Upon hiring and at least annually thereafter. In written form.	Yes. Vague guidance on need for leaders to alert troops of dangerous heat conditions.	Yes. Upon hiring and continuously thereafter. Oral and/or written.	No specific guidelines on training.
Recordkeeping Requirements	Employers required to record, in writing: 1) procedures for complying with the standard; 2) an emergency response plan in the event of a heat-related emergency.	Employers required to include their outdoor heat safety program in the written Accident Prevention Program.	Employers required to maintain records of training materials and persons involved in the training, for at least three years.	N/A	Yes. Extensive record-keeping requirements of metabolic and environmental heat measurements, and various surveillance records.	No specific guidelines on record-keeping.

* Military heat standard "provisions" were based on a reading of *Technical Bulletin: Heat Stress Control and Heat Casualty Management,* 2003. It is unclear after this reading whether the guidelines constitute binding requirements or recommendations.

** All NIOSH and ACGIH provisions are recommendations to inform a standard and do not represent requirements. In certain cases, "provisions" were not explicitly stated as such and represent the interpretations of the author based on a careful reading of the NIOSH and ACGIH guidelines.

CALIFORNIA'S OUTDOOR HEAT STANDARD: THE FIRST IN THE COUNTRY

California implemented the regulation for its standard as an emergency measure in 2005 in response to a spike in heat-related worker deaths that year, and made the measure permanent in 2006.[68] The main provisions of the standard are summarized in **Table 3**, and include requirements for employers to: 1) provide one quart of potable drinking water per worker per hour; 2) monitor, and provide shade for, all employees on particularly hot days; 3) provide rest breaks for employees upon request; and 3) train new employees and supervisors on heat-related illness and preventive measures.[69]

Since the enactment of its standard five years ago, thousands of inspections have been conducted, with millions of dollars in penalties assessed for violations of the standard (**Table 4**). California has targeted its inspections at what have traditionally been the highest-risk industries for heat-related injuries, the agriculture and construction sectors – which have also incurred the most violations (**Table 6, Appendix II**). However, the average penalty assessed for such violations is even lower than that issued by federal OSHA under the General Duty Clause. Of a total of 4,342 violations, only $4,913,698 in penalties was issued, for an average initial penalty of only $1,132 per violation. Data were not available on final penalties, but given Cal/OSHA's record of reducing penalties even more than federal OSHA (below), these are likely considerably lower.

Table 4. Cal/OSHA enforcement of its heat illness prevention standard (§ 3395). (Presented as obtained from Cal/OSHA).[70]

CY05	CY06	CY07	CY08	CY09	CY10	CY11*	
39	234	1018	2586	3574	3183	1265	inspections conducted coded S 18 Heat**
9	158	490	899	935	788	195	inspections w/ 3395 violations (some 2011cases still open)
2	136	614	1121	1163	957	349	violations of 3395 cited during specified year (breakdown below)
$7,085	$535,140	$822,990	$1,775,071	$1,041,527	$578,995	$152,890	assessed initial penalties during specified year (to date)
14	96	284	1145	2562	2482	1065	heat outreach activities (enforcement and consultation***)

* Information reflective of the data within the Integrated Management Information System (IMIS) database at time of report (July 26, 2011). Not complete year.
** Inspections "coded S 18 Heat" refer to the total number of inspections. Inspections "w/ 3395 violations" refer to inspections resulting in at least one violation of the heat standard (§ 3395).The number of 3395 (heat) violations cited is generally higher than the number of inspections with 3395 violations, as multiple subsections of 3395 may be cited in one individual inspection (case). However, in some cases (e.g., CY 2006), it may be lower given the lag time between an inspection and when the violation and penalty were finalized.

*** Cal/OSHA Consultation heat illness outreach activities for CY 2008-2011 include workshops, seminars, training related to on-sites, etc.

B. CALIFORNIA CLEARLY DEMONSTRATES THE IMPORTANCE OF A SPECIFIC, ENFORCEABLE STANDARD

In its enforcement, despite its often minimal penalties, California has demonstrated the critical importance of having a specific heat standard. As seen in **Table 5**, in the years since enactment of their outdoor heat standard in 2005, California has conducted **138 times more inspections** resulting in a citation for unsafe heat exposure practices than OSHA. In fact, California conducted more of these inspections (195) in the first half of this year (2011) alone, than OSHA has completed in almost 40 years of enforcement under the General Duty Clause (99). This alarming disparity clearly shows why a specific, enforceable heat standard is urgently needed on a federal level.

Table 5. Total number of inspections resulting in at least one citation for unsafe heat exposure practices since the enactment of Cal/OSHA's outdoor heat standard: Cal/OSHA vs. federal OSHA, 2005-2011.

Calendar Year	Cal/OSHA[1]	Federal OSHA[2]
2005	9	3
2006	158	3
2007	490	3
2008	899	2
2009	935	2
2010	788	11
2011[3]	195	1

1. Cal/OSHA inspections conducted under the authority of their outdoor heat exposure standard (Cal/OSHA Standard 3395) and include only outdoor inspections. Standard 3395 enacted as an emergency measure in 2005 and made permanent in 2006.
2. Federal OSHA inspections conducted under the authority of the General Duty Clause and include both outdoor and indoor inspections. Three inspections resulting in violations that were later "deleted" by OSHA were not included in federal totals.
3. Cal/OSHA data current through July 26, 2011. Federal OSHA data current through August 5, 2011.

Due to enforcement of its mandatory heat standard, Cal/OSHA claims that compliance with the standard has more than doubled, from 35% of the state's employers in 2006 to 76% in 2010.[71] However, in 2010, OSHA identified systematic deficiencies in Cal/OSHA's enforcement program,[72] and found that Cal/OSHA's inspection targeting system was not effectively identifying high-risk establishments, where serious hazards were likely to exist. OSHA also found that Cal/OSHA classified only 19% of its violations as serious (compared to 77% in the

federal program), and that penalties had been reduced in California by a significantly higher percentage than in federal OSHA nationwide.

Despite its deficient enforcement record, California has shown that an outreach and educational program to raise awareness of the heat stress problem with both employers and employees can serve as an effective complement to, but not a substitute for, enforcement. Over the last several years, California has conducted thousands of "consultations," including workshops and seminars for outdoor workplaces (**Table 4**), and in 2010, the state undertook a heat illness prevention campaign, to reduce heat-related illness and deaths among low-wage, non-English speaking outdoor workers.[73] Cal/OSHA points to these campaigns along with its enforcement activities, as the major reason for the (Cal/OSHA-claimed) increase in employer compliance with its heat standard.[74] Similarly, OSHA's outreach campaign can be an effective tool to combat heat illness only when the specter of accountability falls on employers.

Weaknesses of California's standard

In addition to the concerns raised above about California's inadequate enforcement record, the actual standard as written omits a number of areas crucial for adequate worker protection (**Table 3**).[75] First, the standard does not have a heat stress threshold that accounts for the critical effect of humidity (among other factors) on worker heat stress. Instead, the standard only requires increased "monitoring" of employees when the (dry-air) temperature exceeds 95 F, which, especially in the presence of humidity and for unacclimatized workers, can easily be fatal.

Second, the standard does not provide mandatory rest breaks for workers, no matter their workload or ambient temperatures, nor does it require that employers provide shade for employees absent of a specific request, unless temperatures rise above 85 F. Even then, employers are only required to provide shade sufficient enough to cover only 25% of employees at one time. Agricultural workers are often paid by the "piece," that is, for each fruit or vegetable picked, rather than by time worked, and may therefore be reluctant to request a rest break unless already suffering severe heat-related symptoms.

Finally, the standard, while requiring certain training activities to be recorded in writing and provided to Cal/OSHA upon request, does not require this of all training activities, nor does it include a mechanism to ensure that workers understand the training sessions and are appropriately aware of the hazards of, and preventive measures against, heat illness.

C. WASHINGTON'S OUTDOOR HEAT STANDARD

In 2005, a farmworker collapsed and died from heat stroke while working in fields near Yakima, Wash. This incident prompted farmworker advocates to pressure Washington's Department of Labor and Industries to enact a heat standard similar to California's to protect outdoor workers. Over the next two summers in 2006 and 2007, emergency temporary standards were put into place while the department initiated its rulemaking process for a permanent standard.[76] Following a formal petition for a permanent standard, the state enacted the second permanent outdoor occupational heat standard in the country in 2008.[77]

Washington's heat standard is similar to California's in some of its core provisions but differs in several respects (**Table 3**). The standard does address such critical elements as requirements for employers to provide sufficient drinking water and to educate employees and supervisors on heat stress. However, as is the case with California, the law has critical omissions that severely restrict its enforceability and effectiveness.

Weaknesses of Washington's standard

The most important weaknesses of Washington's standard are the same deficiencies seen in California's standard and described above, namely 1) the absence of a heat stress threshold; 2) no mandatory rest breaks or shade requirements in conditions of high heat stress; and 3) no requirement to keep a record of any training activities or a plan of how the business will comply with the standard.

Washington's standard is even weaker than California's on at least two counts. Perhaps most critically, the standard is only applicable from May 1 to September 30 every year, and for many workers, only when the outside temperature exceeds 89 F (accounting for humidity), thus limiting its scope. In addition, the standard, while requiring employers to provide one quart of water per hour to workers, does not specify that the water must be cool or even palatable.

D. MINNESOTA'S INDOOR HEAT STANDARD

Much of the discussion on occupational heat stress has traditionally focused on outdoor workers and the effects of the summer heat. However, these workers are only one group that is at risk for serious health effects from heat stress. Millions of workers suffer the same risks while working indoors, either in jobs that require close-range exposure to extreme heat sources (such as furnaces or smelters) or workplaces without adequate air-conditioning on hot days. A 1999 study of workers in an aluminum smelter found 24-hour average daily temperatures approximately 3C above the normal value of 24C during the four week study period, and significant levels of worker heat strain in response to the heat.[78] In other studies from India, most automotive, glass, and textile factories had heat levels in excess of ACGIH TLV levels,[79] and 13% of steel pipe production workers were found to have heat-related illness.[80]

To our knowledge, Minnesota is currently the only state with an indoor heat standard.[81] The state adopted the standard in 1997,[82] and it incorporates the effects of humidity and air movement, in addition to the ambient temperature and the intensity of work, into a maximum allowable heat limit. Provisions of the standard are presented in **Table 3**.

Weaknesses of Minnesota's standard

Minnesota's standard extends only to indoor workplaces and just includes a threshold limit for heat and mandated training on heat stress for employers and employees. It does not include any other provisions, such as compulsory drinking water, mandatory rest breaks every hour, or even a requirement to monitor employees for signs or symptoms of heat strain.

However, although the standard addresses only allowable heat exposure (and not other key elements), it is unique among the three state standards in two respects: 1) it uses the Wet-Bulb

Globe Temperature (WBGT, see "Heat stress threshold" section under part V for explanation) as the measure of heat burden, in line with the ACGIH and NIOSH recommendations, and 2) it sets a permissible exposure limit (PEL) for heat, not allowing any exposure to temperatures above this limit. Setting a PEL for indoor environments is obviously more feasible, as temperatures can be modified to comply with the standard, whereas for outdoor environments, work would have to be stopped on very hot days. However, the effects of heat are the same whether they come from the sun or a furnace. Therefore, a feasible PEL (modeled on the ACGIH TLV for heat stress) for outdoor environments is necessary, regardless of potential work stoppages. Workers' safety takes precedence over productivity in the presence of serious health risks.

E. THE MILITARY'S HEAT STRESS GUIDELINES

In 2003, the military released a technical bulletin on heat stress and effective measures to prevent heat-related injury in soldiers in both outdoor and indoor workplaces.[83] The main points of the guidelines are outlined in **Table 3**. The military provides detailed instructions on acclimatization, with gradually increasing workload and environmental heat exposure over a two-week period. A rigorous WBGT threshold is calculated for differing work intensities and environmental temperatures, with a recommended work-rest cycle developed based on these values.[84] The military recommendations limit continuous work after temperatures rise above 82 F for "moderate" intensity work and above 78 F for "hard" work (**Table 10, Appendix II**). The military is unique among all known guidelines and regulations in that it also recommends a quantified schedule of electrolyte (sodium and chloride) replacement based, again, on increasing work intensity and temperature. The Navy has a Physiological Heat Exposure Limit (PHEL), based on metabolic and environmental heat load, which represents a "maximum allowable" exposure, apparently unique among the branches of the military.[85]

Weaknesses of the military's standard include no requirements on record-keeping to verify compliance, no shade requirements, and no exposure limit, with the exception of the Navy's PHEL. In addition, it is unclear on reading the technical bulletin whether these guidelines are binding requirements or just recommendations. Nevertheless, the military's work-rest cycle and acclimatization protocols, in addition to the Navy's PHEL, clearly represent rigorous and feasible model provisions on which to base a federal standard.

V. Essential components of a model heat standard

The ultimate goal of any heat standard is to prevent heat-related illness. Biologically, this means preventing the body's core temperature from rising too high. As determined by the World Health Organization (WHO), and accepted by both NIOSH and the ACGIH, no worker (except under certain circumstances) should be exposed to conditions that raise their core temperature above 38.0C (100.4 F).[86,87] The following criteria formulated by NIOSH (revised in 1986) and ACGIH (revised this year) were, therefore, devised around this target (**Table 3**).

As noted above, NIOSH released a set of recommended criteria for a heat standard in 1972 and a revised set in 1986. The 1986 revised criteria are referred to throughout this document. The ACGIH is a member-based organization of occupational and environmental health experts that

issues annual suggested TLVs and biological exposure indices (BEIs) for hundreds of chemical and physical workplace exposures.[88] The ACGIH TLVs for heat stress are heavily relied upon and referenced in both the NIOSH criteria documents and the OSHA *Technical Manual* on heat stress as an acceptable and evidence-based benchmark.[89]

A. HEAT STRESS THRESHOLD

There is a consensus within the occupational health community that there is an upper limit of heat stress that a worker performing physical labor can tolerate before serious health effects ensue. As mentioned previously, the total heat load (heat stress) on a person comes from two sources: 1) environmental heat, such as that from the sun or another external heat source, and 2) metabolic heat, that is, the heat that the body naturally generates at rest, particularly with exertion. The sum of these two sources — after also factoring in clothing worn — is the net heat load, or heat stress, on the worker. Standardized formulas have been developed to estimate the contribution from each source of heat in calculating total heat stress on a worker.

Environmental heat

A study of workers' compensation claims involving heat-related illness from 2000 to 2009 in Washington revealed that serious health effects can result from exposure to outside temperatures within normal ranges for the summer months and well below those seen during the heat wave observed earlier this summer in many parts of the country.[90] Almost 90% of claims for heat-related illness were filed for worker exposures to outdoor temperatures less than 100 F, and more than half of the injuries occurred at temperatures less than 90 F. Inspection data from California show that prolonged worker exposure to temperatures as low as 80 F can result in serious illness.[91]

However, when quantifying the burden of environmental heat, other factors need to be considered, such as the effects of humidity, air currents, and direct sunlight. The WBGT incorporates all of these factors, along with the ambient (air) temperature, into a single quantity. Originally developed for use in the military for training exercises in 1957,[92] the WBGT was first proposed by NIOSH in its 1972 criteria recommendations as the standard measure of heat stress to be used in all workplaces.[93] The formulas differ for outdoor and indoor environments but essentially attempt to identify the total external heat burden on an individual, accounting for multiple factors (**Appendix II**).[94]

The WBGT does have its limitations as a heat stress measure, perhaps most notably, that it may not adequately account for the variability in the human sweat response that occurs with even slight changes in humidity or wind levels.[95] However, it is the best available formula for estimating the total environmental heat burden on an individual and is the accepted standard by all three major occupational health governmental and nongovernmental groups: NIOSH, OSHA, and the ACGIH.

Metabolic heat

The other major source of heat that puts workers at risk for heat strain is metabolic heat. Workers are at higher risk of heat strain due to the additional heat their bodies generate when

engaged in physical labor as part of their jobs, such as those in agriculture and construction. This additional burden — known as metabolic heat — exacerbates the stress workers incur from environmental heat and can have a significant impact on workers' ability to cope with the stress. The ACGIH combines the effects of metabolic and environmental heat in its proposed TLV for heat stress (**Figure 7**).[96] As a person's work rate increases, the amount of environmental heat he or she can tolerate decreases substantially. Therefore, workers in "light" jobs can likely function in hotter environments without adverse health effects, whereas "heavy" work can only take place at lower temperatures (for calculation of work rate, see **Table 9, Appendix II**).

Importance of acclimatization

Acclimatization is the body's gradual adaptation, over a period of many weeks, to work in high temperature conditions. OSHA advises in its *Technical Manual* that new workers in hot environments should undergo a phased acclimatization program, beginning at low levels of heat exposure in the first days and working their way up gradually to full-intensity work and exposure.[97] Through a similar program targeting new recruits for extra protection during summer training drills in 1956, the Army reduced the incidence of heat-related illness by almost two-thirds.[98] A reasonable period of acclimatization typically involves exposure of the new worker to the desired heat level for two hours per day for five to 14 days, with a progressive increase in work load.[99,100] This gradual acclimatization to high-heat environments is now accepted as a critical measure to prevent heat-related illness and is recognized in occupational heat standards and guidelines.[101,102,103,104]

It should be remembered that acclimatization to one temperature does not adequately protect a worker in the event of sudden increases in temperature from one day to the next. Acclimatized workers are still at risk should a heat wave occur that exposes them to temperatures well in excess of prior experience, particularly in cases of rapid fluctuations in temperature.

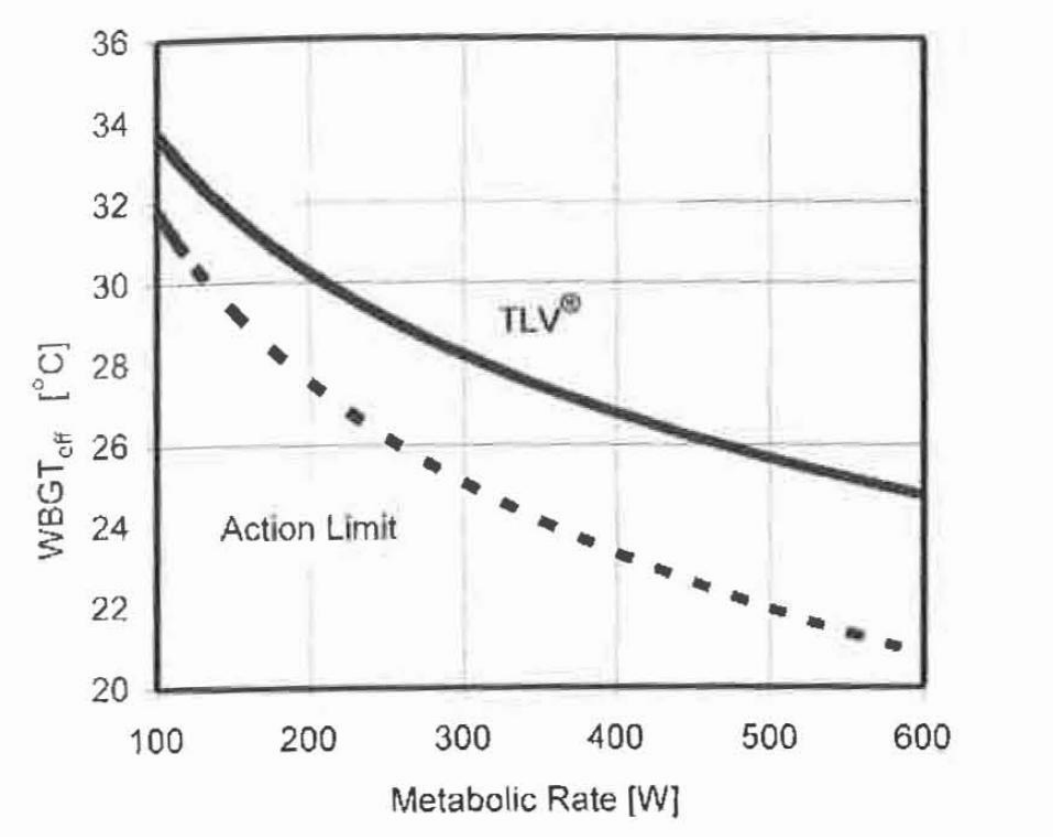
Heat threshold

Combining the two main heat sources — environmental and metabolic — with other factors, such as clothing and acclimatization, the ACGIH has formulated a temperature-work rate curve that can be used in any workplace, outdoor or indoor, to determine the maximum temperature a worker can tolerate given their work intensity before protective measures must be taken. In **Figure 7**, the TLV line corresponds to acclimatized workers while the "Action Limit" applies to new workers who have not yet adapted to the hot conditions and whose tolerance is consequently lower. In addition, certain workers may wear — or be required to wear — certain types of clothing (e.g., personal protective equipment) that are less permeable to heat or restrict evaporative sweating, placing them at higher risk for heat exhaustion. Therefore, the ACGIH corrects for clothing types by incorporating a "clothing factor" (**Table 8, Appendix II**) into its WBGT calculation (**see Appendix II for WBGT formula**), yielding an "effective WBGT or $WBGT_{eff}$" which it uses in its threshold curves.

The importance of a time-weighted average (TWA) must be considered when designing an appropriate heat threshold. A TWA is a method of assessing workplace exposures whereby multiple measurements are made over a period of time and then averaged to obtain an estimate

of the exposure over that period of time. The span of time over which the measurements are averaged is a critical factor. For example, choosing to average measurements over an eight-hour period (as opposed to a two-hour period) will overlook dangerous variations in the temperature over the course of the day. Therefore, NIOSH recommends hourly heat measurements to most accurately estimate the workers' exposure throughout the day.[105]

Figure 7. Heat stress threshold developed by the ACGIH, representing maximum heat burdens for workers under various levels of metabolic and environmental heat (taken as is from ACGIH 2011 TLVs and BEIs booklet).[106]



* WBGT$_{eff}$ is the measured WBGT plus the Clothing Adjustment Factor. See Appendix II.
** "TLV" refers to threshold for acclimatized workers; "Action Limit" refers to unacclimatized workers.

B. DRINKING WATER

Dehydration can easily result from prolonged exposure to heat, especially in workers who can lose several liters of water per shift through sweating in hot conditions.[107] In addition, workers who consume diuretics such as coffee, alcohol, or certain medications (e.g., diuretics for high blood pressure) can lose even greater amounts. Dehydration, in turn, depletes the body of water needed for sweating, removing the body's most effective and important cooling mechanism, causing still further dehydration and placing the individual at a much greater risk for heat exhaustion or heat stroke. Getting ahead of this dangerous cycle through adequate hydration is, therefore, critical.

Sufficient amounts of potable water should be provided by employers, especially in outdoor environments with no access to continuous supplies of water. NIOSH emphasizes the importance of frequent hydration in order to keep up with large fluid losses. It must be remembered that thirst is not a sufficient indicator of the need to hydrate. Relying on thirst alone will invariably result in sub-optimal hydration and could place workers at risk for dehydration. The institute therefore recommends that workers proactively drink a cup (150-200 milliliters [mL]) of cool (10-15C) water three to four times every hour. Following NIOSH's lead, both California and Washington mandate that employers provide workers with at least one quart of water per employee per hour, and that they encourage employees to drink frequently. A federal heat standard should use the NIOSH recommendations as a guide and mandate that employers provide cool water in sufficient amounts. Employers should also be held responsible for ensuring that workers hydrate themselves frequently and adequately.

C. REST BREAKS AND SHADE REQUIREMENTS

The need for periodic rest breaks when working in very hot conditions is recognized by both NIOSH and the ACGIH. The ACGIH compiled a table listing certain "screening" temperatures that should alert employers to monitor workers for heat-related signs and symptoms and take appropriate measures to prevent injury (**Table 7, Appendix II**). The temperatures are dependent on both the intensity of work and the time worked continuously per hour but in all cases fall below 32.5C (90.5 F). In much of the country, this represents a fairly typical summer day's temperature. NIOSH in 1986 undertook a similar approach to ACGIH in outlining different threshold limits based on total duration of work in a given hour (**Figures 8 and 9, Appendix II**). As with the ACGIH guidelines, workers given more rest breaks can tolerate higher temperatures before adverse health effects ensue.

The military has instituted detailed work-rest cycles based on these principles.[108] In its recommendations, workers are limited from working continuously with increasing workload and ambient temperatures, with a maximum duration of 45 minutes of "hard" work when WBGT exceeds 90 F. This conservative approach of frequent and lengthy rest periods in extreme heat conditions has been developed with young, healthy soldiers in mind and should thus be used as a minimal set of criteria when applied to the broader workforce, who are typically not nearly as fit.

California mandates that workers in hot conditions who feel they need a break are entitled to at least five minutes of rest in the shade.[109] However, these rest breaks are reactive and not preventive. As outlined clearly in the NIOSH and ACGIH threshold curves (**Table 7 and Figures 8-9, Appendix II**), on particularly hot days, workers laboring continuously without a break are at high risk for severe heat-related effects. Rest breaks, staggered over the course of an hour, should be mandatory in all such cases and not contingent on whether an employee develops symptoms severe enough to trigger a request for one.

An important side note on this requirement is that, when applied to certain agricultural workers, a problem arises. Many crop workers are paid by the "piece," that is, by the number of fruits or vegetables harvested and not by the amount of time worked. Therefore, these workers may be inclined to skip even required rest breaks or water breaks in order to maximize their earnings. It

is clear that this may prove to be a dangerous dilemma for this group of workers most at risk for heat-related illness. Any standard mandating rest breaks necessary to protect the health and safety of workers should not be implemented at the expense of the worker. Therefore, these rest breaks must be reimbursed in some way so as to prevent these workers from having to choose between their safety and their livelihood. The burden to protect worker safety and health should fall on the employer, and this is no exception.

D. EMPLOYEE AND SUPERVISOR TRAINING

Training is one area where OSHA's current heat stress educational campaign will be a particularly important complement to an overall heat standard. California and Washington require that employers provide adequate training to both employees and their supervisors on the hazards of heat stress and measures to prevent heat-related illness.[110,111] This training is required for all new employees and supervisors and, in Washington's standard, annually thereafter. Only California's standard requires employers to inform workers of their rights under the state's heat standard (although compliance with this provision is difficult to demonstrate in the absence of written records). A federal standard should incorporate the best of both states' mandates, requiring training both for new employees and supervisors upon hiring and annually thereafter, in addition to requiring a detailed explanation of the employee's rights under the heat standard. This training should be documented in writing, and the training records furnished upon request to OSHA to verify compliance. In addition, employee understanding of the training should be demonstrated through a written questionnaire, also made available to OSHA. All training should be administered orally and in writing, and both the training and questionnaires made available both in English and the employee's primary language.

E. HEAT ILLNESS PREVENTION PLAN

Employers are currently required by California's and Washington's heat standards to implement a prevention plan in writing, detailing how they will comply with the standard.[112,113] This should be required of all employers on a federal level for any heat standard and should be furnished upon request to OSHA for review. As OSHA is planning on releasing its Injury and Illness Prevention Program (I2P2) requirement for employers,[114] a required Heat Illness Prevention Plan should eventually be incorporated into this wider initiative.

VI. Summary of Requested Actions

A. OSHA NEEDS TO ACT IMMEDIATELY: Outreach and education are not enough

The Department of Labor's recent outreach campaign urging measures to prevent heat-related illnesses is a good first step in combating what Secretary of Labor Hilda Solis recently acknowledged are "all … preventable" injuries and deaths.[115] The campaign is modeled after California's similar public awareness campaign, launched in 2010.[116] However, California's initiative was meant as a *complement to*, not a *substitute for*, a legally enforceable heat standard. OSHA is relying on employers' good faith to abide by the guidance, with essentially no mechanism for accountability. Without the critical leverage a heat standard would provide, the

campaign — though laudable — will be ineffective, and hundreds of workers will needlessly die in the years to come.

This need for aggressive OSHA monitoring was illustrated last year during the BP Gulf oil spill. After the spill, tens of thousands of workers descended upon the area for cleanup and rescue efforts. Heat stress from the notoriously hot and humid Gulf summers was recognized at the time as "one of the most serious health hazards facing [these workers]" by OSHA head David Michaels.[117] With no standard to follow, but under pressure from OSHA, BP implemented a voluntary heat stress prevention plan. OSHA placed 35-40 monitors throughout the spill area, but without a specific standard in place to ensure that BP complied with its plan, 1,000 of an estimated 60,000 workers still suffered some type of heat-related event.[118] That year (2010), OSHA issued only 11 citations for violations of safe heat practices nationwide (**Figure 4**), and none to BP or other companies involved in the cleanup efforts. This episode serves as a poster-child example of why a specific heat standard is necessary that would actually hold employers accountable for such negligence.

B. ECONOMIC CONSIDERATIONS

In 2006, Washington conducted an economic impact analysis to estimate the cost of employers' compliance with the state's planned heat exposure standard.[119] The analysis took into consideration the costs to employers of such items as drinking water, informational sessions for employees, and time spent monitoring and implementing the new regulation, as well as the benefits of increased worker productivity and averted medical expenses. The state concluded that businesses would actually benefit monetarily from the new standard by avoiding both the loss of worker productivity and indirect medical costs that result from excessive worker heat exposure, such as dehydration and heat exhaustion.[120]

Regardless of Washington's analysis, OSHA would conduct its own economic impact analysis, and business owners from around the country will, as is typical, be given ample opportunity to provide input and express their concerns. However, OSHA will need to ensure that worker safety and health — and not company profits — come first in any such analysis.

C. A PERMANENT STANDARD: SUMMARY OF PETITION REQUEST

The federal heat standard asked for in this petition must apply to both indoor and outdoor environments and consist, at a minimum, of the following elements:

- **Scope.** The standard must:
    - Apply year-round, given the variation in climate in different regions of the country;
    - Apply to all outdoor and indoor workplaces, regardless of ambient temperature, as other critical factors (e.g., humidity, clothing, and hydration levels) may cause heat-related illness at lower temperatures;
    - Apply to all employees, without exemptions for duration of time worked per hour, as this will already be considered in the heat stress thresholds outlined below.

- **Heat stress threshold:** The heat stress threshold must be consistent with the ACGIH TLV and Action Limit curves to require employers to take specific engineering and work practice controls necessary to keep core temperature below 38.0C (100.4 F) for most workers (below 38.5C for acclimatized, healthy workers with no risk factors for heat illness), factoring in the effects of environmental heat, metabolic heat, acclimatization, and clothing. If employers fail to show that these controls protect workers from heat-related illness, the heat stress threshold will be interpreted as a PEL, prohibiting worker exposure to levels above the threshold.

    - Acclimatization: OSHA must develop strict criteria to distinguish between acclimatized and unacclimatized workers, in a manner consistent with current NIOSH, ACGIH, or military guidelines, for the purposes of determining differential heat stress thresholds applied to each type of worker. During heat waves, defined as days when the National Weather Service has declared heat advisories or warnings; days with maximum temperatures above 95 F; or when the daily maximum temperature exceeds 90 F and is 9 F higher than the previous day,[121] previously acclimatized workers will be reclassified as unacclimatized and an appropriate heat stress threshold recalculated accordingly.

    - Unacclimatized workers will be gradually introduced to conditions of high heat stress through a rigorous acclimatization protocol consistent with the NIOSH,[122] ACGIH,[123] or the military's[124] guidelines.

- **Drinking water:** Workers must be given access — at no cost to themselves — to quantities of cool, potable water sufficient to maintain adequate levels of hydration. At least one quart of water per worker per hour must be provided, and workers must be given the opportunity and encouraged to drink at least 150-200 mL of potable water every 15-20 minutes. The water must be cool (10-15C), palatable, and provided in individual (not communal) serving cups. Employers will be held responsible should workers fail to adequately hydrate themselves.

- **Rest requirements:** Workers must be given periodic rest breaks every hour (in the shade for outdoor environments) at certain WBGT threshold levels, consistent with ACGIH and NIOSH recommendations (**Table 7 and Figures 8 and 9, Appendix II**). The requirements must apply to all workers exposed to heat stress levels outlined in the ACGIH and NIOSH threshold curves and not be limited to those workers already experiencing symptoms of heat illness.

- **Shade:** Employers must provide access for outdoor workers to sufficient areas of shade, both during the rest breaks and upon request, with enough cover to be able to accommodate all employees comfortably at one time.

- **Employee and supervisor training:** All employers must be required to provide initial training to new employees and supervisors and at least annually thereafter on 1) employee rights under the new heat standard, 2) the hazards of heat stress, 3) warning signs and symptoms of heat-related illness, and 4) available measures to treat heat

illness. For workers not fluent in English, all training sessions should be administered in the worker's first language.

  - All employees and supervisors will then be formally assessed for understanding of these training sessions, through an oral *and* written evaluation (in the worker's first language) that will be kept by the employer and furnished to OSHA upon request. In addition to the above schedule, these trainings will also be required before any major change in ambient temperature or humidity conditions, such as before a heat wave.

- **Emergency response:** In the case of a heat-related illness, the employer must take immediate action to remove an employee showing or reporting signs of heat illness from exposure to hazard and immediately obtain necessary assistance and consultation from a certified first-aid responder or medical professional. Employers should have a plan (included as part of the Heat Illness Prevention Plan) for providing on-site first aid to workers with possible symptoms of heat-related illness.

- **Record-keeping and reporting.** All businesses must keep adequate records and furnish upon request to OSHA:

  - A written Heat Illness Prevention Plan. This will be a detailed plan outlining how the employer will comply with all requirements of the new heat standard, with specific measures taken to prevent heat-related illness, including policies regarding use of protective clothing and equipment, scheduling work times, adjusting work pace during heat waves to reduce risk of heat illness, and an "Emergency Response" plan as outlined in the provision above. The Heat Illness Prevention Plan will also include a detailed listing of all training sessions and evaluations given to employees and supervisors as required in the "Employee and Supervisor Training" provision above;

  - A record of all worker injuries due to heat, consistent with OSHA reporting requirements for serious injuries.[125] OSHA must mandate a separate line on the Form 300 Log of Injury for the recording of all such heat-related injuries; and

  - Any heat-related death or the hospitalization of three or more employees due to excessive heat exposure will be reported, consistent with OSHA reporting requirements, within eight hours.[126]

D. NEED FOR AN EMERGENCY TEMPORARY STANDARD

In releasing its 1986 criteria and recommendations for a federal heat standard, NIOSH stated that such a standard would "… prevent or greatly reduce the risk of adverse health effects to exposed workers …"[127] We agree. Such a standard has prompted a level of enforcement in a single state — California — that dwarfs OSHA' minimal enforcement record under the General Duty Clause. As is true with this and many other occupational hazards, the clause has proven time and again to be an insufficient and rarely used enforcement tool to hold employers accountable. Therefore, a specific, enforceable standard is needed as soon as possible to

reduce the hundreds of deaths and tens of thousands of injuries that are almost entirely preventable with minimal interventions.

However, given that a new standard could potentially take many years before it's finalized and implemented, OSHA must act immediately to protect workers from environmental heat exposure through the enactment of an ETS. Both Washington and California initially implemented emergency temporary standards prior to the completion of their rulemaking processes.[128,129] In both cases, the emergency standards were put into place in response to the deaths of one or more workers from heat-related causes.

Therefore, given that:

> 1) based on BLS data, more workers will almost certainly die within the next six months due to preventable heat-related injury;
>
> 2) two states (California and Washington) implemented an ETS prior to their rulemaking processes (which resulted in permanent heat standards), as they recognized that occupational heat exposure represented an emergent crisis of worker safety; and
>
> 3) there is an existing threshold recommended by the ACGIH, and referenced in OSHA's own *Technical Manual,*[130] that is specific, enforceable, and known to protect against a physical agent (heat) that is a known hazard

we formally request that OSHA immediately issue an ETS for the heat stress threshold outlined on page 29.

As seen in the federal data above, at least 523 workers have died from excessive heat exposure between 1992 and 2009 alone. If this trend continues, hundreds more will die before OSHA issues its own standard. Therefore, as a formal rulemaking process could potentially take years before a permanent standard is eventually adopted, an ETS is essential to help avert the tens of thousands of worker injuries and deaths that are certain to occur in the coming years.

VII. Environmental impact statement

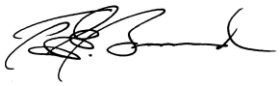
Nothing requested in this petition will have an impact on the environment.

VIII. Certification

We certify that, to the best of our knowledge and belief, this petition includes all information and views on which this petition relies, and that it includes representative data and information known to the petitioners which are unfavorable to the petition.

Sincerely,

Sammy Almashat, M.D., M.P.H.
Staff Researcher
Public Citizen's Health Research Group



Thomas Bernard, Ph.D.
Professor and Chair of Environmental and Occupational Health
University of South Florida

Virginia Ruiz
Senior Attorney
Farmworker Justice

John Hovis
General President
United Electrical, Radio and Machine Workers of America

Sidney Wolfe, M.D.
Director
Public Citizen's Health Research Group

Appendix I: Methods

INJURY AND ILLNESS DATA (Figures 1-3)

On Aug. 10, 2011, injury and illness data from the Bureau of Labor Statistics' (BLS) Injury, Illness, and Fatalities data website (http://data.bls.gov/gqt/InitialPage) were accessed. From here, each of three different categories of data was downloaded ("Case and demographic numbers," "Case and demographic incidence rates," and "Fatal injuries numbers") with the following search terms:

- 1992-2009
- Characteristic type: Event or exposure
- Sub-characteristic: "Exposure to environmental heat 321XXX"
- Ownership: "Private Industry" (for nonfatal injuries) and "All Ownerships" (for fatal injuries)

All files were downloaded as Excel 2010 files, with annual totals used for the tables and graphs.

INCIDENCE RATE OF HEAT-RELATED DEATHS BY INDUSTRY (Figure 2 and Table 1)

For **Figure 2**, raw totals (and percentages) for heat-related deaths were obtained solely from the BLS Injury, Illness, and Fatalities website (http://data.bls.gov/gqt/InitialPage).

For **Table 1**, the incidence data was calculated (for years 2000-2009) by dividing these totals by the number of full-time workers employed in those occupations. The data on full-time workers came from the BLS Current Population Survey (CPS) estimates for those years and were emailed to us by the bureau on Aug. 10, 2011.

GENERAL DUTY CLAUSE SEARCH (Figures 4 and 5)

On Aug. 5, 2011, the OSHA General Duty Clause search website was accessed: http://www.osha.gov/pls/imis/generalsearch.html. The following search terms were utilized:

- Query: "heat"
- January 1, 1972-August 5, 2011
- Category: Heat
- Inspection Nr: not specified
- SIC - not specified
- Office: All offices

A total of 294 inspections that resulted in at least one citation for violation of safe heat exposure practices were retrieved in the initial search. From these, 140 were excluded as unrelated to environmental heat exposure (mostly including fire or explosive hazards), leaving a total of 154 inspections resulting in at least one citation for violation of safe heat exposure practices. Inspections conducted by state and Puerto Rico OSHA plans (n=42) were also excluded, leaving 112 federal inspections. Thirteen of the 112 were later "deleted" by OSHA, leaving a final total of 99 federal OSHA inspections resulting in at least one citation for environmental heat exposure violations.

Of this final total, almost all inspections (n=93) cited employers under the OSH Act of 1970 General Duty Clause (Section 5[a][1]).[131] Six were officially cited under other standards,[132] but all 99 citations included a reference within the citation text to "Section 5(a)(1) of the Occupational Safety and Health Act of 1970" or similar, general Department of Defense clauses. The earliest federal inspection was dated Dec. 22, 1986, and the most recent April 5, 2011.

Appendix II: Additional figures and formulas

Table 6. Cal/OSHA enforcement of outdoor heat standard: inspections and violations by industry[133] (calendar years 2005-2011).*

Industry	Inspections		Inspections Resulting in a Violation**	
	Number	% of total	Number	% of total
Construction	5,674	48%	1,574	45%
Agricultural	3,771	32%	1,105	32%
Other	2,454	20%	795	23%
Total	11,899	100%	3,474	100%

*Obtained from Cal/OSHA and based on data from IMIS database through July 26, 2011.
**Inspections that resulted in at least one violation. Total number of violations is higher (4,342) as some inspections resulted in multiple violations.

CALCULATING THE WET-BULB GLOBE TEMPERATURE (WBGT)

For outdoor workplaces (with direct sun exposure): $WBGT_{out} = 0.7\ T_{nwb} + 0.2\ T_g + 0.1\ T_{db}$

For indoor workplaces (without sun exposure): $WBGT_{in} = 0.7\ T_{nwb} + 0.3\ T_g$

[T_{nwb} = natural wet-bulb temperature; T_g = globe temperature; T_{db} = dry-bulb (air) temperature]

The natural wet-bulb temperature (T_{nwb}) accounts for humidity, which at high levels inhibits a person's ability to sweat, thus weakening this most critical cooling mechanism. The globe temperature (T_g) represents the ambient air temperature, but considers the effects of direct sunlight and air movement, while the dry-bulb temperature (T_{db}) is used in outdoor situations only and represents the outside air temperature shielded from direct sunlight.

Table 7. Screening criteria for TLV and Action Limit for heat stress exposure (taken from ACGIH, 2011).[134]

This table from ACGIH incorporates all four factors (environmental heat, metabolic heat, work duration per hour, and acclimatization) into an easy-to-read table that sets certain temperature threshold limits to alert employers to an increased risk of heat-related health effects.

Allocation of Work in a Cycle of Work and Recovery	TLV® (WBGT values in °C)				Action Limit (WBGT values in °C)			
	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
75 to 100%	31.0	28.0	–	–	28.0	25.0	–	–
50 to75%	31.0	29.0	27.5	–	28.5	26.0	24.0	–
25 to 50%	32.0	30.0	29.0	28.0	29.5	27.0	25.5	24.5
0 to 25%	32.5	31.5	30.5	30.0	30.0	29.0	28.0	27.0

Table 8. Clothing-adjustment factors for some clothing ensembles* (taken from ACGIH 2011 TLVs and BEIs).[135]

Clothing Type	Addition to WBGT [°C]
Work clothes (long sleeve shirt and pants)	0
Cloth (woven material) coveralls	0
Double-layer woven clothing	3
SMS polypropylene coveralls	0.5
Polyolefin coveralls	1
Limited-use vapor-barrier coveralls	11

*These values must not be used for completely encapsulating suits, often called Level A. Clothing Adjustment Factors cannot be added for multiple layers. The coveralls assume that only modesty clothing is worn underneath, not a second layer of clothing.

Table 9. Estimating energy cost of work [work-rate] by task analysis (obtained from NIOSH).[136]

Although inexact, a standard measurement tool was proposed in 1986 by NIOSH, incorporating body position, type of work, and basal metabolism to determine the person's total energy expenditure, or work rate, in a given hour:

A. Body position and movement	kcal/min*
Sitting	0.3
Standing	0.6
Walking	2.0–3.0
Walking uphill	add 0.8 per meter rise

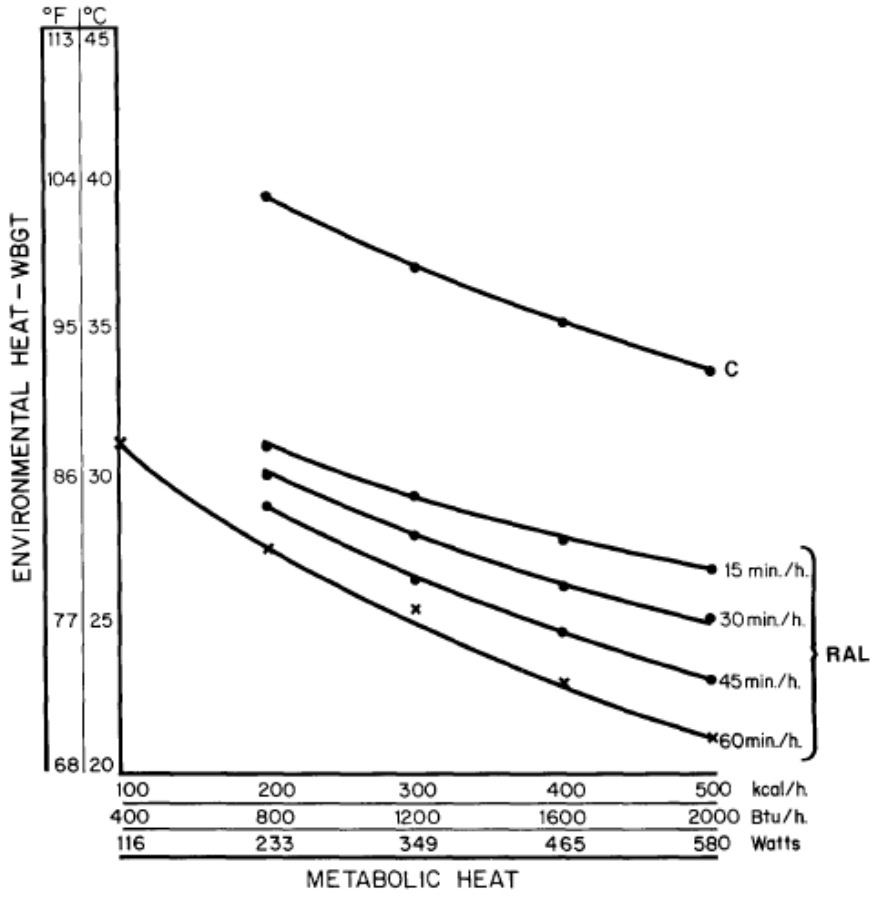
B. Type of work	Average kcal/min	Range kcal/min
Hand work		
light	0.4	0.2–1.2
heavy	0.9	
Work one arm		
light	1.0	0.7–2.5
heavy	1.8	
Work both arms		
light	1.5	1.0–3.5
heavy	2.5	
Work whole body		
light	3.5	2.5–9.0
moderate	5.0	
heavy	7.0	
very heavy	9.0	

C. Basal metabolism	1.0

D. Sample calculation**	Average kcal/min
Assembling work with heavy hand tools	
1. Standing	0.6
2. Two-arm work	3.5
3. Basal metabolism	1.0
Total	5.1 kcal/min

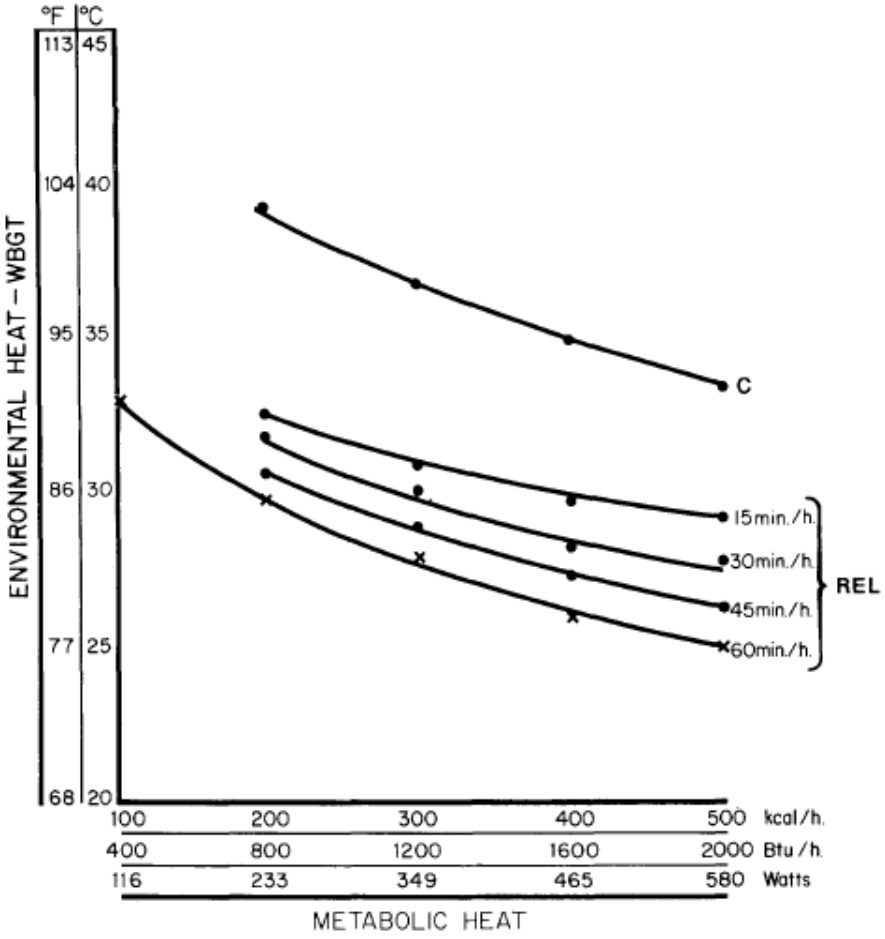
* For standard worker of 70 kg body weight (154 lbs.) and 1.8 m^2 body surface (19.4 ft^2).
**Example of measuring metabolic heat production of a worker when performing initial screening.
Adapted from References 2,108,111,112.

Figure 8. Recommended heat stress Alert Limits (RALs) – unacclimatized workers (taken from NIOSH).[137]



C = Ceiling Limit. According to the 1986 NIOSH recommendations, "No worker shall be exposed to combinations of metabolic and environmental heat exceeding the applicable Ceiling Limits (C) of Figures [8 or 9] without being provided with and properly using appropriate and adequate heat-protective clothing and equipment."[138]

Figure 9. Recommended heat stress Exposure Limits (RELs) – Acclimatized Workers (taken from NIOSH).[139]



C = Ceiling Limit. According to the 1986 NIOSH recommendations, "No worker shall be exposed to combinations of metabolic and environmental heat exceeding the applicable Ceiling Limits (C) of Figures [8 or 9 without being provided with and properly using appropriate and adequate heat-protective clothing and equipment."[140]

Table 10.[141] Recommendations for continuous work duration and fluid replacement during warm weather training conditions

Table 3-3. Recommendations for continuous work duration and fluid replacement during warm weather training conditions (Applies to average size and heat acclimated soldier wearing BDU, hot weather.)

		Easy Work		Moderate Work		Hard Work	
Heat Category	WBGT Index (° F)	Work (min)	Water[2] Intake (qt/hr)	Work (min)	Water Intake (qt/hr)	Work (min)	Water Intake (qt/hr)
1	78 – 81.9	NL[1]	½	NL	¾	70	1
2 (green)	82 – 84.9	NL	½	150	1	65	1 ¼
3 (yellow)	85 – 87.9	NL	¾	100	1	55	1 ¼
4 (red)	88 – 89.9	NL	¾	80	1 ¼	50	1 ¼
5 (black)	>90	180	1	70	1 ½	45	1 ½

Notes:
1. NL can sustain work for at least 4 hours of work in the specified heat category.
2. Fluid needs can vary based on individual differences (± ¼ qt/hr) and exposure to full sun or full shade (± ¼ qt/hr).

[1] Morello L. Big, Record-Setting Heat Wave Settles In as a 'Silent Killer'. New York Times. July 22, 2011. Accessed on August 2, 2011. http://www.nytimes.com/cwire/2011/07/22/22climatewire-big-record-setting-heat-wave-settles-in-as-a-7705.html

[2] Wood A. Summer heat death toll heat climbs to at least 29. Philadelphia Inquirer. July 29, 2011. Accessed on August 2, 2011. http://articles.philly.com/2011-07-29/news/29829742_1_heat-related-death-death-toll-national-weather-service

[3] Marsh W. U.S. heat wave claims as many as 64 lives. Reuters. July 27, 2011. Accessed on August 2, 2011. http://www.reuters.com/article/2011/07/27/us-weather-idUSTRE76Q50M20110727

[4] Flynn A, McGreevy C, Mulkerrin EC. Why do older patients die in a heatwave? QJM. 2005 Mar;98(3):227-9.

[5] Mirabelli MC, Richardson DB. Heat-related fatalities in North Carolina. Am J Public Health. 2005 Apr;95(4):635-7.

[6] 12 workers fired for not braving heat. WLFI NewsChannel 18. July 21, 2011. Accessed on August 2, 2011. http://www.wlfi.com/dpp/news/local/12-workers-fired-for-not-braving-heat

[7] Worker hospitalized for heat exhaustion. WLFI NewsChannel 18. July 22, 2011. Accessed on August 2, 2011. http://www.wlfi.com/dpp/news/local/worker-hospitalized-for-heat-exhaustion

[8] U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems: Final Report, Synthesis and Assessment Product 4.6.

[9] Biello D. The New Normal? Average Global Temperatures Continue to Rise. Scientific American. July 22, 2010. Accessed on August 28, 2011. http://www.scientificamerican.com/article.cfm?id=average-global-temperature-rise-creates-new-normal

[10] United States Department of Labor. Bureau of Labor Statistics. Older workers. July 2008. Accessed on August 28, 2011. http://www.bls.gov/spotlight/2008/older_workers/

[11] DHHS (NIOSH) Publication No. 72-10269. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments. 1972. Accessed on August 3, 2011. http://www.cdc.gov/niosh/72-10269.html

[12] NIOSH Publication No. 86-113. Basis for the Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986), p. 89-90. Accessed on August 19, 2011. http://www.cdc.gov/niosh/pdfs/86-113e.pdf

[13] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[14] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Page 1. Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[15] Fatality data were obtained from the Bureau of Labor Statistics (BLS) Injury, Illness, and Fatalities website. Accessed on August 10, 2011. http://data.bls.gov/gqt/InitialPage

[16] Injury and illness data were obtained from the Bureau of Labor Statistics (BLS) Injury, Illness, and Fatalities website. Accessed on August 10, 2011. http://data.bls.gov/gqt/InitialPage

[17] United States Department of Labor, OSHA. Welcome to OSHA's Campaign to Prevent Heat Illness in Outdoor Workers. Accessed on August 18, 2011. http://www.osha.gov/SLTC/heatillness/index.html

[18] Budd GM. Wet-bulb globe temperature (WBGT)--its history and its limitations. J Sci Med Sport. 2008 Jan;11(1):20-32. Epub 2007 Aug 31.

[19] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). VI. Control of Heat Stress, p. 69. Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[20] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, p. 211. ISBN: 978-1-607260-28-8.

[21] Occupational Safety and Health Administration (OSHA) Technical Manual. Section III: Chapter 4 Heat Stress. Directive Number: TED 01-00-015. Effective date 1/20/1999. Accessed on August 14, 2011. http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html#iii:4_3

[22] Institute of Medicine of the National Academies. Dietary Reference Intakes: Water, Potassium, Sodium, Chloride, and Sulfate. Consensus Report. 2005. Figure C-1, p. 488. 3L value was obtained at 25 degrees Celsius (room temperature) and 1900Kcal/day (the lowest value on the graph) of energy expenditure. Accessed on August 14, 2011. http://books.nap.edu/openbook.php?record_id=10925&page=488

[23] Institute of Medicine of the National Academies. Dietary Reference Intakes: Water, Potassium, Sodium, Chloride, and Sulfate. Consensus Report. 2005. Figure C-1, p. 488. Accessed on August 14, 2011. http://books.nap.edu/openbook.php?record_id=10925&page=488

[24] Flynn A, McGreevy C, Mulkerrin EC. Why do older patients die in a heatwave? QJM. 2005 Mar;98(3):227-9.

[25] Occupational Safety and Health Administration (OSHA) Technical Manual. Section III: Chapter 4 Heat Stress. Directive Number: TED 01-00-015. Effective date 1/20/1999. Accessed on August 14, 2011. http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html#iii:4_3

[26] Bouchama A, Dehbi M, Chaves-Carballo E. Cooling and hemodynamic management in heatstroke: practical recommendations. Crit Care. 2007;11(3):R54.

[27] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Page 16. Accessed on August 3, 2011. http://www.cdc.gov/niosh/pdfs/86-113a.pdf

[28] Employment data, including number of full-time workers (total and by occupation) from 1994-2009 obtained via email from the Bureau of Labor Statistics (BLS) Division of Labor Force Statistics on August 10, 2011.

[29] Department of Labor, OSHA. Safety and Health Add Value. Accessed on August 17, 2011. http://www.osha.gov/Publications/safety-health-addvalue.html

[30] Employment data, including number of full-time workers (total and by occupation) from 1994-2009 obtained via email from the Bureau of Labor Statistics (BLS) Division of Labor Force Statistics on August 10, 2011.

[31] See EPA, A Guide to Heat Stress in Agriculture (1993) at 1-3 (studies have shown that workers compensation claims for heat exposure among farmworkers are among the highest of any occupation).

[32] Fatality data were obtained from the Bureau of Labor Statistics (BLS) Injury, Illness, and Fatalities website. Accessed on August 10, 2011. http://data.bls.gov/gqt/InitialPage

[33] Employment data, including number of full-time workers (total and by occupation) from 1994-2009 obtained via email from the Bureau of Labor Statistics (BLS) Division of Labor Force Statistics on August 10, 2011, and combined with BLS Injury, Illness, and Fatalities statistics.

[34] Injury and illness data were obtained from the Bureau of Labor Statistics (BLS) Injury, Illness, and Fatalities website. Accessed on August 10, 2011. http://data.bls.gov/gqt/InitialPage

[35] Centers for Disease Control and Prevention (CDC). Heat-related deaths among crop workers--United States, 1992--2006. MMWR Morb Mortal Wkly Rep. 2008 Jun 20;57(24):649-53. Accessed on August 2, 2011. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5724a1.htm

[36] Centers for Disease Control and Prevention (CDC). Heat-related deaths among crop workers--United States, 1992--2006. MMWR Morb Mortal Wkly Rep. 2008 Jun 20;57(24):649-53. Accessed on August 2, 2011. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5724a1.htm

[37] Data on "Fatal occupational injuries to workers exposed to environmental heat due to the effects of heat and light, by industry and occupation", containing a breakdown of worker deaths by individual occupation was obtained via email from the Bureau of Labor Statistics (BLS) Office of Safety, Health, and Working Conditions on August 17, 2011. Between 2003-2009, of 45 deaths in the Farming, Fishing, and Forestry occupations, agricultural workers accounted for 40 deaths.

[38] Environmental Protection Agency (EPA). A Guide to Heat Stress in Agriculture (1993). Pages 1-3 (studies have shown that workers compensation claims for heat exposure among farmworkers are among the highest of any occupation). Accessed on August 24, 2011. http://nepis.epa.gov/EPA/html/Pubs/pubalpha_A.html

[39] Jackson L., Rosenburg R., Preventing Heat-Related Illness Among Agricultural Workers, Journal of Agromedicine, 2010, 15:200-215, 201.

[40] Environmental Protection Agency (EPA). A Guide to Heat Stress in Agriculture (1993). Page 7. Accessed on August 24, 2011. http://nepis.epa.gov/EPA/html/Pubs/pubalpha_A.html

[41] Mines R, An Evaluation of the Gathering of Occupational Injury Data by the National Agricultural Workers Survey (NAWS), submitted to the Office of the Assistant Secretary for Policy, U.S. Department of Labor, July 13, 2004, at p. 30; Jackson L., Rosenburg R., Preventing Heat-Related Illness Among Agricultural Workers, Journal of Agromedicine, 2010, 15:200-215; Hofmann J, Snyder K, Keifer M, A Descriptive Study of Workers' Compensation Claims in Washington State Orchards, Occupational Medicine (2006), at 56: 251-257; and Hansen E., Donahoe M., Health Issues of Migrant and Seasonal Farmworkers, Journal of Health Care for the Poor and Underserved, May 2003 14:2, 153-164, 154.

[42] Bureau of Labor Statistics (BLS) Injury, Illness, and Fatalities website. Accessed on August 10, 2011. http://data.bls.gov/gqt/InitialPage

[43] Bureau of Labor Statistics (BLS) Injury, Illness, and Fatalities. Frequently Asked Questions. Accessed on August 28, 2011. http://www.bls.gov/iif/oshfaq1.htm

[44] OSHA Regulations. CFR 1904.7. General Recording Criteria. Accessed on August 28, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9638

[45] Bureau of Labor Statistics (BLS) Injury, Illness, and Fatalities. Frequently Asked Questions. Accessed on August 28, 2011. http://www.bls.gov/iif/oshfaq1.htm

[46] OSHA Regulations. CFR 1904.7. General Recording Criteria. Accessed on August 28, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9638

[47] Government Accountability Office (GAO). Workplace Safety and Health: Enhancing OSHA's Records Audit Process Could Improve the Accuracy of Worker Injury and Illness Data. October 2009. Accessed on August 28, 2011. http://www.gao.gov/new.items/d1010.pdf

[48] Government Accountability Office (GAO). Workplace Safety and Health: Enhancing OSHA's Records Audit Process Could Improve the Accuracy of Worker Injury and Illness Data. Page 24 on PDF. October 2009. Accessed on August 28, 2011. http://www.gao.gov/new.items/d1010.pdf

[49] DHHS (NIOSH) Publication No. 72-10269. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments. 1972. Accessed on August 3, 2011. http://www.cdc.gov/niosh/72-10269.html

[50] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[51] NIOSH Publication No. 86-113. Basis for the Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986), p. 89-90. Accessed on August 19, 2011. http://www.cdc.gov/niosh/pdfs/86-113e.pdf

[52] Is OSHA Working for Working People? Statement of David Michaels, PhD, MPH before the Subcommittee on Employment & Workplace Safety, U.S. Senate Committee on Health, Education, Labor & Pensions. p. 10. April 26, 2007. Accessed on August 28, 2011. http://help.senate.gov/imo/media/doc/Michaels.pdf

[53] OSHA. OSH Act of 1970 – Table of Contents. Sec. 5. Duties (a) (1). Accessed on August 18, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=3359&p_table=OSHACT

[54] General Duty Standard search. OSHA. Accessed on August 5, 2011. See Methods. http://www.osha.gov/pls/imis/generalsearch.html

[55] General Duty Standard search. OSHA. Accessed on August 5, 2011. See Methods. http://www.osha.gov/pls/imis/generalsearch.html

[56] U.S. Department of Labor, OSHA Office of Training and Education. OSH Act, OSHA Standards, Inspections, Citations and Penalties, May 1996. Accessed on August 19, 2011. http://www.osha.gov/doc/outreachtraining/htmlfiles/introsha.html

[57] OSHA Inspection Data. Inspection# 302248398. Citation issued 9/15/1999. Accessed on August 9, 2011. http://www.osha.gov/pls/imis/establishment.inspection_detail?id=302248398

[58] U.S. Department of Labor, OSHA Office of Training and Education. OSH Act, OSHA Standards, Inspections, Citations and Penalties, May 1996. "Citations and Penalties: Serious violation." Accessed on August 19, 2011. http://www.osha.gov/doc/outreachtraining/htmlfiles/introsha.html

[59] Thirty-six of the 39 citations were "Serious", while three were non-Serious, Willful, or Repeat.

[60] General Duty Standard search. OSHA. Accessed on August 5, 2011. See Methods. http://www.osha.gov/pls/imis/generalsearch.html

[61] U.S. Department of Labor, OSHA Office of Training and Education. OSH Act, OSHA Standards, Inspections, Citations and Penalties, May 1996. Accessed on August 19, 2011. http://www.osha.gov/doc/outreachtraining/htmlfiles/introsha.html

[62] Regulations (Standards - 29 CFR). Field Sanitation CFR 1928.110. OSHA. Accessed on August 5, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10959

[63] OSHA Standards Interpretation. CFR 1928.110. October 31, 1991. Accessed on August 5, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=INTERPRETATIONS&p_id=20442

[64] U.S. Department of Labor. Program Highlights. Fact Sheet No. OSHA 92-25. OSHA's Field Sanitation Standard. Accessed on August 5, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FACT_SHEETS&p_id=137

[65] Centers for Disease Control and Prevention (CDC). Heat-related deaths among crop workers--United States, 1992--2006. MMWR Morb Mortal Wkly Rep. 2008 Jun 20;57(24):649-53. Accessed on August 2, 2011. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5724a1.htm

[66] U.S. Department of Labor News Release. US Labor Department launches national outreach campaign to protect workers from heat-related illnesses. April 26, 2011. Accessed on August 2, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=19701

[67] Hamby C. 'Model workplaces' not always so safe. Center for Public Integrity, iWatch news. July 7, 2011. Accessed on August 2, 2011. http://www.iwatchnews.org/2011/07/07/5130/model-workplaces-not-always-so-safe

[68] Wilson E. Heat Stress Prevention Heats Up in California. EHS Today. June 1, 2008. Accessed on August 2, 2011. http://ehstoday.com/mag/heat_stress_prevention/

[69] California Code of Regulations. Title 8, section 3395, Heat Illness Prevention. http://www.dir.ca.gov/title8/3395.html

[70] Obtained from Cal/OSHA on August 2, 2011. Data compiled from federal IMIS database.

[71] OH&S Online. Cal/OSHA Launches Heat Illness Prevention Training Program. April 1, 2011. Accessed on August 2, 2011. http://ohsonline.com/articles/2011/04/01/calosha-launches-heat-illness-prevention-training-program.aspx

[72] OSHA, Region IX, San Francisco. FY 2009 California Occupational Safety and Health Program. Federal Annual Monitoring and Evaluation (FAME) Report (23g). p. 15-19 and p. 91. Accessed on August 28, 2011. http://www.osha.gov/dcsp/osp/efame/ca_efame_with_appendices.pdf

[73] Heat Illness Prevention Campaign, Final Performance and Evaluation Report. Labor Occupational Health Program, UC Berkeley. December 2010. Accessed on August 15, 2011. http://www.dir.ca.gov/dosh/HeatIllnessCampaign/HeatIllnessPreventionCampaignReport.pdf

[74] OH&S Online. Cal/OSHA Launches Heat Illness Prevention Training Program. April 1, 2011. Accessed on August 15, 2011. http://ohsonline.com/articles/2011/04/01/calosha-launches-heat-illness-prevention-training-program.aspx

[75] California Code of Regulations. Title 8, section 3395, Heat Illness Prevention. http://www.dir.ca.gov/title8/3395.html

[76] Washington State. Outdoor Heat Exposure. Concise Explanatory Statement. Pages 2-10 (Purpose of Rulemaking). Accessed on August 15, 2011. http://www.lni.wa.gov/rules/AO06/40/0640CES.pdf

[77] Washington State Department of Labor and Industries. General Occupational Health Standards. WAC 296-62-095 Outdoor heat exposure. Accessed on August 2, 2011. http://www.lni.wa.gov/WISHA/Rules/generaloccupationalhealth/HTML/62j-1.htm#wac296-62-095

[78] Logan PW, Bernard TE. Heat stress and strain in an aluminum smelter. Am Ind Hyg Assoc J. 1999 Sep-Oct;60(5):659-65.

[79] Ayyappan R, Sankar S, Rajkumar P, Balakrishnan K. Work-related heat stress concerns in automotive industries: a case study from Chennai, India. Glob Health Action. 2009 Nov 11;2. doi: 10.3402/gha.v2i0.2060.

[80] Pandit K, Tiwari RR. Morbidity profile of steel pipe production workers. Indian J Occup Environ Med. 2008 Aug;12(2):88-90.

[81] Minnesota Administrative Rules. 5205.0110 Indoor Workroom Ventilation and Temperature. Accessed on August 15, 2011. https://www.revisor.mn.gov/rules/?id=5205.0110

[82] Minnesota Department of Labor and Industry, Occupational Safety and Health Division. Heat Stress Guide. p 1. April 2009. Accessed on August 28, 2011. http://www.doli.state.mn.us/OSHA/PDF/heat_stress_guide.pdf

[83] Technical Bulletin: Heat Stress Control and Heat Casualty Management. Headquarters, Department of the Army and Air Force. March 7th, 2003. Accessed on August 28, 2011. http://armypubs.army.mil/med/dr_pubs/dr_a/pdf/tbmed507.pdf

[84] Technical Bulletin: Heat Stress Control and Heat Casualty Management. Headquarters, Department of the Army and Air Force. Pages 16-18. March 7th, 2003. Accessed on August 28, 2011. http://armypubs.army.mil/med/dr_pubs/dr_a/pdf/tbmed507.pdf

[85] Technical Bulletin: Heat Stress Control and Heat Casualty Management. Headquarters, Department of the Army and Air Force. Page 24. March 7th, 2003. Accessed on August 28, 2011. http://armypubs.army.mil/med/dr_pubs/dr_a/pdf/tbmed507.pdf

[86] NIOSH Publication No. 86-113. Basis for the Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986), p. 86. Accessed on August 19, 2011. http://www.cdc.gov/niosh/pdfs/86-113e.pdf

[87] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, p. 211. ISBN: 978-1-607260-28-8.

[88] American Conference of Governmental Industrial Hygienists (ACGIH). Accessed on August 12, 2011. http://www.acgih.org/about/history.htm

[89] Occupational Safety and Health Administration (OSHA) Technical Manual. Section III: Chapter 4 Heat Stress. Directive Number: TED 01-00-015. Effective date 1/20/1999. Accessed on August 14, 2011. http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html

[90] Bonauto D, Rauser E, Lim L. Safety & Health Assessment & Research for Prevention (SHARP) program, Washington State Department of Labor and Industries. Technical Report Number 59-2-2010. Occupational Heat Illness in Washington State, 2000-2009. p 15. April 2010.

[91] California Department of Industrial Relations, Division of Occupational Safety and Health. Cal/OSHA investigations of Heat-Related Illness 2006. Page 18. October 18, 2007. Accessed on August 2, 2011. http://www.dir.ca.gov/dosh/heatillnessinvestigations-2006.pdf

[92] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). IX. Indices for Assessing Heat Stress and Strain, p. 105. Accessed on August 20, 2011. http://www.cdc.gov/niosh/pdfs/86-113f.pdf

[93] DHHS (NIOSH) Publication No. 72-10269. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments. 1972. Page V-16. Accessed on August 3, 2011. http://www.cdc.gov/niosh/72-10269.html

[94] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, p. 211-220. ISBN: 978-1-607260-28-8.

[95] Budd GM. Wet-bulb globe temperature (WBGT)--its history and its limitations. J Sci Med Sport. 2008 Jan;11(1):20-32. Epub 2007 Aug 31.

[96] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, p. 211-220. ISBN: 978-1-607260-28-8.

[97] Occupational Safety and Health Administration (OSHA) Technical Manual. Section III: Chapter 4 Heat Stress. Directive Number: TED 01-00-015. Effective date 1/20/1999. Accessed on August 14, 2011. http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html

[98] Minard D, Belding HS, Kingston JR. Prevention of heat casualties. J Am Med Assoc. 1957 Dec 7;165(14):1813-8.

[99] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). VI. Control of Heat Stress, p. 69. Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[100] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, p. 211. ISBN: 978-1-607260-28-8.

[101] California Code of Regulations. Title 8, section 3395, Heat Illness Prevention. http://www.dir.ca.gov/title8/3395.html

[102] Technical Bulletin: Heat Stress Control and Heat Casualty Management. Headquarters, Department of the Army and Air Force. Page 15. March 7th, 2003. Accessed on August 28, 2011. http://armypubs.army.mil/med/dr_pubs/dr_a/pdf/tbmed507.pdf

[103] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, p. 211-220. ISBN: 978-1-607260-28-8.

[104] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). VI. Control of Heat Stress, p. 69. Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[105] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Page 3. Accessed on August 3, 2011. http://www.cdc.gov/niosh/pdfs/86-113a.pdf

[106] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, p. 211-220. ISBN: 978-1-607260-28-8.

[107] Institute of Medicine of the National Academies. Dietary Reference Intakes: Water, Potassium, Sodium, Chloride, and Sulfate. Consensus Report. Figure C-1, p. 488. Released: February 11, 2004. Accessed on August 14, 2011. http://books.nap.edu/openbook.php?record_id=10925&page=488

[108] Technical Bulletin: Heat Stress Control and Heat Casualty Management. Headquarters, Department of the Army and Air Force. Pages 16-18. March 7th, 2003. Accessed on August 28, 2011. http://armypubs.army.mil/med/dr_pubs/dr_a/pdf/tbmed507.pdf

[109] California Code of Regulations. Title 8, section 3395, Heat Illness Prevention. http://www.dir.ca.gov/title8/3395.html

[110] California Code of Regulations. Title 8, section 3395, Heat Illness Prevention. http://www.dir.ca.gov/title8/3395.html

[111] Washington State Department of Labor and Industries. General Occupational Health Standards. WAC 296-62-095 Outdoor heat exposure. Accessed on August 2, 2011. http://www.lni.wa.gov/WISHA/Rules/generaloccupationalhealth/HTML/62j-1.htm#wac296-62-095

[112] California Code of Regulations. Title 8, section 3395, Heat Illness Prevention. http://www.dir.ca.gov/title8/3395.html

[113] Washington State Department of Labor and Industries. General Occupational Health Standards. WAC 296-62-095 Outdoor heat exposure. Accessed on August 2, 2011. http://www.lni.wa.gov/WISHA/Rules/generaloccupationalhealth/HTML/62j-1.htm#wac296-62-095

[114] Office of Information and Regulatory Affairs, Office of Management and Budget, Executive Office of the President. DOL/OSHA, RIN: 1218-AC48, Publication ID: Spring 2010. Injury and Illness Prevention Program. Accessed on August 15, 2011. http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201004&RIN=1218-AC48

[115] Gorrell M. U.S. Labor Secretary urges 'Be Cool at Work'. The Salt Lake Tribune. August 11, 2011. Accessed on August 12, 2011. http://www.sltrib.com/sltrib/money/52371444-79/workers-heat-solis-labor.html.csp

[116] Water. Rest. Shade. The California Campaign to Protect Outdoor Workers from Heat Illness. Accessed on August 12, 2011. http://www.99calor.org/campaign/

[117] OSHA. Testimony of David Michaels, PhD, MPH, before the Committee on Education and Labor, U.S. House of Representatives. June 23, 2010. Accessed on August 28, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=TESTIMONIES&p_id=1242

[118] Smith S. Michaels on Gulf cleanup workers: We were trying not to kill them. EHS Today. May 25, 2011. A version of this article posted on a related blog, "EHS & Safety News America", was accessed on

August 28, 2011. https://ehssafetynews.wordpress.com/2011/05/30/michaels-on-gulf-cleanup-workers-we-were-trying-not-to-kill-them/

[119] Outdoor Heat Exposure. Concise Explanatory Statement. Economic Analyses, page 90. Accessed on August 4, 2011. http://www.lni.wa.gov/rules/AO06/40/0640CES.pdf

[120] Outdoor Heat Exposure. Concise Explanatory Statement. Economic Analyses, pages 180-181. The net benefit (taking into account only the benefit to employers; range $17.2-39.1 million) was compared with the net cost (range $10.8-28.2 million). Accessed on August 4, 2011. http://www.lni.wa.gov/rules/AO06/40/0640CES.pdf

[121] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Page 11. Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[122] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). VI. Control of Heat Stress, p. 69. Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[123] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, p. 211. ISBN: 978-1-607260-28-8.

[124] Technical Bulletin: Heat Stress Control and Heat Casualty Management. Headquarters, Department of the Army and Air Force. Page 15. March 7th, 2003. Accessed on August 28, 2011. http://armypubs.army.mil/med/dr_pubs/dr_a/pdf/tbmed507.pdf

[125] OSHA Regulations. CFR 1904.7. General Recording Criteria. Accessed on August 28, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9638

[126] OSHA Regulations. CFR 1904.39. Reporting fatalities and multiple hospitalization incidents to OSHA. Accessed on August 28, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12783

[127] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Page 1. Accessed on August 3, 2011. http://www.cdc.gov/niosh/86-113.html

[128] Washington State. Outdoor Heat Exposure. Concise Explanatory Statement. Page 124 (History of the Proposed Rule). Accessed on August 4, 2011. http://www.lni.wa.gov/rules/AO06/40/0640CES.pdf

[129] State of California. Department of Industrial Relations. Finding of Emergency. Government Code Section 11346.1. Occupational Safety and Health Standards Board. Readoption of Emergency Amendments to Title 8. California Code of Regulations, Section 3395 of the General Industry Safety Orders. Accessed on August 4, 2011. http://www.dir.ca.gov/oshsb/heatillnesemergreadoptnotice3.pdf

[130] Occupational Safety and Health Administration (OSHA) Technical Manual. Section III: Chapter 4 Heat Stress. Directive Number: TED 01-00-015. Effective date 1/20/1999. Accessed on August 14, 2011. http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html#iii:4_3

[131] OSH Act of 1970. Table of Contents. SEC. 5. Duties. "(a) Each employer -- (1) shall furnish to each of his 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 his employees." Accessed on August 10, 2011. http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=OSHACT&p_id=3359

[132] Of 112 total federal OSHA cases involving unsafe environmental heat exposure practices, 6 involved citations under standards other than the General Duty Clause (5A0001). Two were cited under CFR 1960.0008 A, one under 1926.0021 B02, one under 1926.0020 B01, one under 1910.0151 A, and one under 1904.0039 A.

[133] Obtained from Cal/OSHA on August 2, 2011. Data compiled from federal IMIS database.

[134] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, Table 2, p. 215. ISBN: 978-1-607260-28-8.

[135] American Conference of Governmental Industrial Hygienists (ACGIH). 2011 Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Heat Stress and Heat Strain, Table 1, p. 214. ISBN: 978-1-607260-28-8.

[136] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). VI. Control of Heat Stress. Table V-3, p. 62. Accessed on August 3, 2011. http://www.cdc.gov/niosh/pdfs/86-113d.pdf

[137] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Pages 14-15. Accessed on August 3, 2011. http://www.cdc.gov/niosh/pdfs/86-113a.pdf

[138] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Page 3. Accessed on August 3, 2011. http://www.cdc.gov/niosh/pdfs/86-113a.pdf

[139] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Pages 14-15. Accessed on August 3, 2011. http://www.cdc.gov/niosh/pdfs/86-113a.pdf

[140] NIOSH Publication No. 86-113. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments (Revised Criteria 1986). Page 3. Accessed on August 3, 2011. http://www.cdc.gov/niosh/pdfs/86-113a.pdf

[141] Technical Bulletin: Heat Stress Control and Heat Casualty Management. Headquarters, Department of the Army and Air Force. Page 17. March 7th, 2003. Accessed on August 28, 2011. http://armypubs.army.mil/med/dr_pubs/dr_a/pdf/tbmed507.pdf