NIOSH HEALTH HAZARD EVALUATION REPORT

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Transportation Security Administration:
Palm Beach International Airport
West Palm Beach, Florida

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DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Lisa J. Delaney and Chad H. Dowell of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Dino A. Mattorano and Marilyn Radke, HETAB. Desktop publishing was performed by Shawna Watts and Robin Smith. Editorial assistance was provided by Ellen Galloway.

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For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation (HHE) from the Transportation Security Administration (TSA) at the Palm Beach International Airport in West Palm Beach, Florida. TSA management submitted the HHE request because some screeners had experienced health problems, possibly related to the hot working environment. NIOSH investigators conducted an evaluation in August 2004.

What NIOSH Did

- We monitored work area temperatures.
- We monitored screeners' physiological response to working in their hot work environment.
- We talked with employees about their health concerns and work area.

What NIOSH Found

- Screeners were working in excessive heat during our visit.
- Some employees were affected by working in the hot environment.
- The effects of working in this environment may be worse during warmer weather and when the workload is greater.

What TSA Managers Can Do

- Control screeners' exposure to the excessive heat.
- Assign screeners to either the checked baggage or passenger screening areas.
- Develop a heat-acclimatization program.
- Educate screeners about working in hot environments.
- Develop a heat-related illness surveillance program.
- Monitor environmental heat conditions.
- Establish a heat alert program.
- Allow screeners to take unscheduled breaks when they feel weak, nauseated, excessively fatigued, confused, and/or irritable due to the heat.

What the TSA Screeners Can Do

- Know symptoms of excessive heat exposure.
- Inform your supervisor that you need to take a break if you feel weak, nauseated, excessively fatigued, confused, and/or irritable due to the heat.
- Take breaks inside the terminal.
- Drink plenty of liquids while working.
- Work with a buddy and monitor each other for symptoms of heat illness.
- Report symptoms of excessive heat exposure to supervisors.

CDC Workplace Safety and Health

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2004-0334-3017

NIOSH

Health Hazard Evaluation Report 2004-0334-3017 Transportation Security Administration: Palm Beach International Airport West Palm Beach, Florida October 2006

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SUMMARY

On July 22, 2004, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the Transportation Security Administration (TSA) at the Palm Beach International Airport in West Palm Beach, Florida. The HHE request asked NIOSH to determine the potential for exposure to heat stress conditions for screeners working in the checked baggage screening area. The request indicated that some employees had experienced health problems possibly related to heat stress, including heat cramps and heat exhaustion.

In response to the request, NIOSH investigators conducted heat stress and heat strain monitoring on August 28–31, 2004. Wet bulb globe temperatures (WBGT) were measured to evaluate the heat stress conditions. Individual heat strain was assessed using core body temperature (CBT), heart rate (HR), and pre- and post-shift body weight measurements.

WBGT readings ranged from 77.5ºF to 83.9ºF in the checked baggage screening area. When compared to the NIOSH and American Conference of Governmental Industrial Hygienists (ACGIH®) screening criteria, the results indicate that the screeners were exposed to excessive heat stress conditions during the evaluation.

Twenty-three participants were monitored for physiological signs of heat stress during their work shifts. All employees were considered acclimatized to their work environment during the evaluation. Eight participants (35%) showed signs of heat strain. One of the screener's CBT exceeded the ACGIH criterion of 101.3ºF for acclimatized workers. There were 10 instances of screeners' HRs exceeding the ACGIH criterion of 180 minus their age. In addition, three of the screeners had average HRs that approached or exceeded 115 beats per minute (bpm) during the shifts they were monitored. None of the screeners had a body weight loss of more than the ACGIH criterion of 1.5%.

TSA screeners working in the checked baggage screening area were exposed to heat stress in excess of the occupational screening criteria. Some employees developed signs of heat strain as measured by CBT or sustained HR. In addition, some complained of symptoms of heat strain. Recommendations for identifying and reducing heat stress and strain are provided in this report.

Keywords: NAICS 488119 (Other Airport Operations), heat stress, heat strain, core body temperature, WBGT, heart rate, heat cramps, heat exhaustion

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INTRODUCTION

On July 22, 2004, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the Transportation Security Administration (TSA) management at the Palm Beach International (PBI) Airport in West Palm Beach, Florida. The HHE request asked NIOSH to determine the potential for exposure to excessive heat stress for screeners working in the checked baggage screening area. The request indicated that some employees had experienced health problems possibly related to heat stress, including heat cramps and heat exhaustion. In response to the request, NIOSH investigators conducted heat stress and heat strain monitoring on August 28–31, 2004. Wet bulb globe temperatures (WBGT) were measured to document the heat stress conditions during the site visit. Individual heat strain was assessed using core body temperature (CBT), heart rate (HR), and pre- and post-shift body weight measurements.

BACKGROUND

PBI began operations with one small runway in 1936. The most recent expansion in 1988 created 560,000 square feet of terminal space. The terminal includes 3 concourses, 25 passenger gates (with a potential expansion of 24 more), and a two-story concession mall. This facility serves nearly 6 million passengers each year; 16 commercial and commuter airlines operate out of the airport.

On November 19, 2001, the Aviation and Transportation Security Act [49 CFR 1500], which established TSA within the Department of Transportation, was signed into law.[1] The law required TSA to hire and train federal security employees to inspect all passengers and property for explosives and incendiaries before boarding and loading onto the airplane. This rulemaking transferred the Federal Aviation Administration rules governing civil aviation security to TSA. A deadline of December 31, 2002, was established for airports and TSA to implement this law. TSA employees at PBI began screening passengers and baggage in December 2002.

Approximately 85 full- and part-time screeners are employed by TSA at PBI. Full-time employees work an 8-hour shift, and part-time employees work a 4-hour shift. All checked passenger bags are screened in one large area. Bags checked by passengers at the ticketing counter are brought to the baggage area via conveyor belts. The conveyor belts deposit bags onto carousels where TSA employees manually load them onto a belt-driven conveyor that routes each bag through an Explosive Detection System (EDS) machine. Some bags undergo additional testing using an Explosive Trace Detection (ETD) system. After examination, the bags are loaded onto another carousel where airline personnel transfer the bags to carts attached to tugs for transport to the aircraft.

The baggage area is open to the tarmac on the south side and consists of carousels and EDS and ETD machines. During peak travel periods in the winter months, more than 350,000 bags are screened monthly. The warmer summer months are considered the off-season. However, PBI officials anticipate increased passenger volume and the concomitant increased baggage volume, during the warmer months in the coming years as the number of flights increases. The baggage area was originally designed as a location for airline employees to pick up and drop off checked passenger bags. The area is not provided with conditioned, cool air. Thermal comfort fans are located near each of the EDS machines.

METHODS

WBGT measurements were collected using four QUESTemp°36 instruments (Quest Technologies, Inc., Oconomowoc, WI) to document heat stress conditions. These monitors measure temperatures of 23°F–212°F and are accurate to within ± 0.9°F. In addition to temperature, the monitors measure relative humidity of 0%–100% and are accurate to within ± 5%. The WBGT index accounts for air velocity, temperature, humidity, and radiant heat and is a useful index of the environmental contribution to heat stress. It is a function of dry bulb temperature (a standard measure of air temperature taken with a thermometer), natural wet bulb temperature (simulates the effects of evaporative cooling), and black globe temperature (estimates radiant [infrared] heat load). Three of the WBGT monitors were placed in the baggage screening area among the workers while the other was placed in the passenger screening area, to document the environmental conditions where the screeners take their breaks. The monitors collected heat stress data during the times when screener heat strain monitoring was conducted.

Metabolic rates for the screeners were estimated using the NIOSH table, "Estimating metabolic heat production rates by task analysis" (Appendix A).[2] This method allows for specificity in rate estimation because it breaks the job down into categories that account for body position and movement, type of work, and basal metabolism. The NIOSH values are based upon a standard weight of 154 pounds (lbs), so a weight correction factor must be applied when workers weigh other than 154 lbs. Individual results vary depending on age, sex, fitness level, current health status, and body weight, and partly because of observer variability, these errors in estimating metabolic rates may vary by ± 10%–15%.[2]

Heat strain was assessed using the CorTemp™ Wireless Core Body Temperature Monitoring System (HQ, Inc., Palmetto, Florida). The CorTemp Temperature Sensor, a 0.9-inch by 0.4-inch silicon-coated electronic device, is swallowed and provides continuous monitoring of CBT to within ± 0.2ºF. The sensor is passed through the gastrointestinal tract and exits the body in an average time of 72 hours. The sensor, intended for one-time use only, runs on a non-rechargeable silver-oxide battery and utilizes a temperature-sensitive crystal that vibrates in direct proportion to the temperature of the substance surrounding it. This vibration creates an electromagnetic flux (frequency = 262.144 kilohertz) that continuously transmits out of the body. A recorder, the CT2000, receives this signal and translates it into digital temperature information, which is then displayed on the unit and stored to memory. The CT2000 Recorder monitors temperatures of 50ºF–122ºF. The recorder operates on one standard 9-volt alkaline battery, weighs about 7 ounces, and attaches to the user's belt. The participants' CBTs were recorded at 1-minute intervals.

Heat strain was also assessed using a Mini-Mitter Mini-Logger® Series 2000 (Mini-Mitter Company, Inc., Bend, Oregon). Heart rate, which is a function of the body's metabolic rate, was monitored at 1-minute intervals. The participants were asked to wear a Polar® chest band heart rate monitor. The Polar chest band heart rate monitor counts up to 250 beats per minute (bpm) and is accurate to within ± 1 bpm.

Pre- and post-shift body weights were measured on participants to determine their degree of dehydration. Weight loss (or gain) over a few hours is a reflection of change in extracellular fluid volume and occurs when water is lost from sweating and through the respiratory tract. Body weight loss of 1.5% or less is indicative of mild dehydration, whereas a loss of greater than 1.5% indicates a greater risk of heat stress. Participants were weighed in uniform clothing near the beginning and end of the work shift using a self-calibrating electronic digital scale Model 812 (Measurement Specialties, Inc., Fairfield, New Jersey).

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[3] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) [29 CFR 1910.1000].[1] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals or physical agents have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

Heat Stress

NIOSH defines heat stress exposure as the sum of the heat generated in the body (metabolic heat) plus the heat gained from the environment (environmental heat) minus the heat lost from the body to the environment, primarily through evaporation. Many bodily responses to heat stress are desirable and beneficial because they help regulate internal temperature and, in situations of appropriate repeated exposure, help the body adapt (acclimatize) to the work environment. However, at some stage of heat stress, the body's compensatory measures cannot maintain internal body temperature at the level required for normal functioning. As a result, the risk of heat-induced illnesses, disorders, and accidents substantially increases. Increases in unsafe behavior are also seen as the level of physical work of the job increases.[2]

Many heat stress guidelines have been developed to protect people against heat-related illnesses. The objective of any heat stress index is to prevent a person's CBT from rising excessively. The World Health Organization concluded that, "it is inadvisable for CBT to exceed 100.4ºF or for oral temperature to exceed 99.5ºF in prolonged daily exposure to heavy work and/or heat."[5] According to NIOSH, a CBT of 102.2ºF should be considered reason to terminate exposure even when CBT is being monitored. This does not mean that a worker with a CBT exceeding those levels will necessarily experience adverse health effects; however, the number of unsafe acts increases as does the risk of developing heat stress illnesses.[2]

NIOSH recommends controlling total heat exposure so that unprotected healthy workers who are medically and physically fit for their required level of activity are wearing, at most, long-sleeved work shirts and trousers or equivalent, and are not exposed to metabolic and environmental heat combinations exceeding the applicable NIOSH criteria. These criteria state that almost all healthy employees working in hot environments and exposed to combinations of environmental and metabolic heat less than the NIOSH Recommended Action Limits (RALs) for *non-acclimatized* workers (Appendix B, Figure 1) or the NIOSH RELs for *acclimatized* workers (Appendix B, Figure 2), should be able to tolerate total heat stress without substantially increasing their risk of incurring acute adverse health effects. Also, no employee should be exposed to metabolic and environmental heat combinations exceeding the applicable ceiling limits (C) of Figures 1 or 2 without being provided with and properly using appropriate and adequate heat-protective clothing and equipment.[2]

ACGIH guidelines require the use of a decision-making process that provides step-by-step situation-dependent instructions that factor in clothing insulation values and physiological evaluation of heat strain.[6] ACGIH WBGT screening criteria factor in the ability of the body to cool itself (clothing insulation value, humidity, and wind) and, like the NIOSH criteria, can be used to develop work/rest regimens for acclimatized and unacclimatized employees. The ACGIH WBGT-based heat exposure assessment was developed for a traditional work uniform of long-sleeved shirt and pants, and represents conditions under which it is believed that nearly all adequately hydrated, unmedicated, healthy workers, may be repeatedly exposed without adverse health effects. Clothing insulation values and the appropriate WBGT adjustments, as well as descriptors of the other decision-making process components can be found in ACGIH's *Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*.[6] The ACGIH TLV for heat stress attempts to provide a framework for the control of heat-related illnesses only. Although accidents and injuries can increase with increasing levels of heat stress, it is important to note that the TLVs are not directed toward controlling these.[6]

NIOSH and ACGIH criteria can only be used when WBGT data for the immediate work area are available and must not be used when workers wear encapsulating suits or garments that are impermeable or highly resistant to water vapor or air movement. Further assumptions regarding work demands include an 8-hour work day, 5-day work week, two 15-minute breaks, and a 30-minute lunch break, with rest area temperatures the same as, or less than, those in work areas, and at least some air movement. It must be stressed that NIOSH and ACGIH guidelines do not establish a fine line between safe and dangerous levels but require professional judgment and a heat stress management program to ensure protection in each situation. The OSHA technical manual's section on heat stress refers back to the ACGIH document for guidelines to evaluate employee heat stress and how to investigate the workplace.[7]

Heat Strain

The body's response to heat stress is called heat strain.[2,6] Operations involving high air temperatures, radiant heat sources, high humidity, direct physical contact with hot objects, and strenuous physical activities have a high potential for inducing heat strain in employees. Heat strain is highly individual and cannot be predicted based upon environmental heat stress measurements. Physiological monitoring for heat strain becomes necessary when impermeable clothing is worn, when heat stress screening criteria are exceeded, or when data from a detailed analysis (such as the International Standards Organization [ISO] required sweat rate [SR_{req}]) shows excess heat stress.[6]

One indicator of physiological strain, sustained peak heart rate, is considered by ACGIH to be the best sign of acute, high-level exposure to heat stress. Sustained peak heart rate, defined by ACGIH as 180 bpm minus an individual's age, is a leading indicator that thermal regulatory control may not be adequate and that increases in CBTs have, or will soon, occur. Sustained peak heart rate represents an equivalent cardiovascular demand of about 75% of maximum aerobic capacity. During an 8-hour work shift, although sustained peak demands may not occur, there may still be excessive demand placed on the cardiovascular system. These 'chronic' demands can be measured by calculating the average heart rate over the shift.[6] A study of Marine Corps recruits revealed that decreases in physical job performance were observed when the average heart rate exceeded 115 bpm over the entire shift. This level is equivalent to working at roughly 35% of maximum aerobic capacity, a level sustainable for 8 hours.[8]

According to ACGIH, an individual's heat stress exposure should be discontinued when *any* of the following excessive heat strain indicators occur:

- Sustained (over several minutes) heart rate is in excess of 180 bpm minus the individual's age in years, (180 bpm – age) for those with normal cardiac performance

- CBT is greater than 100.4ºF for unselected, unacclimatized personnel and greater than 101.3ºF for medically fit, heat-acclimatized personnel
- Recovery heart rate at 1 minute after a peak work effort exceeds 110 bpm
- There are symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness

An individual may be at greater risk of heat strain if:

- Profuse sweating is sustained over several hours
- Weight loss over a shift is greater than 1.5% of body weight
- 24-hour urinary sodium excretion is less than 55 millimoles

Health Effects of Exposure to Hot Environments

Heat disorders and health effects of individuals exposed to hot working environments include (in increasing order of severity) skin disorders (heat rash, hives, etc.), heat syncope (fainting), heat cramps, heat exhaustion, and heat stroke. Heat syncope (fainting) results from blood flow being directed to the skin for cooling, resulting in decreased supply to the brain, and most often strikes workers who stand in place for extended periods in hot environments. Heat cramps, caused by sodium depletion due to sweating, typically occur in the muscles employed in strenuous work. Heat cramps and syncope often accompany heat exhaustion, or weakness, fatigue, confusion, nausea, and other symptoms. The dehydration, sodium loss, and elevated CBT (above 100.4ºF) are usually due to individuals performing strenuous work in hot conditions with inadequate water and electrolyte intake. Heat exhaustion may lead to heat stroke if the patient is not quickly cooled and rehydrated.

While heat exhaustion victims continue to sweat as their bodies struggle to stay cool, heat stroke victims cease to sweat as their bodies fail to maintain an appropriate core temperature. Heat stroke occurs when hard work, hot environment, and dehydration overload the body's capacity to cool itself. This thermal regulatory failure (heat stroke) is a life-threatening emergency requiring immediate medical attention. Signs and symptoms include irritability, confusion, nausea, convulsions or unconsciousness, hot dry skin, and a CBT above 106ºF. Death can result from damage to the brain, heart, liver, or kidneys.[9]

Prolonged increases in CBT and chronic exposures to high levels of heat stress are associated with disorders such as temporary infertility (male and female), elevated heart rate, sleep disturbance, fatigue, and irritability. During the first trimester of pregnancy, a sustained CBT greater than 102.2ºF may endanger the fetus.[6] In addition, one or more occurrences of heat-induced illness in a person predisposes him/her to subsequent injuries and can result in temporary or permanent loss of that person's ability to tolerate heat stress.[2,7]

The level of heat stress at which health effects occur is highly individual and depends upon the heat tolerance capabilities of each individual. Age, weight, degree of physical fitness, degree of acclimatization, metabolism, use of alcohol or illicit drugs, over the counter and prescribed medications, and a variety of medical conditions, such as hypertension and diabetes, all affect a person's sensitivity to heat. At greatest risk are unacclimatized workers, people performing physically strenuous work, those with previous heat illnesses, the elderly, people with cardiovascular or circulatory disorders (diabetes, atherosclerotic vascular disease), those taking medications that impair the body's cooling mechanisms, people who use alcohol or are recovering from recent use, people in poor physical condition, and those recovering from illness. With regard to prescribed medications, β-adrenergic receptor blockers and calcium-channel blockers, used to treat hypertension, limit maximal cardiac output and alter normal vascular distribution of blood flow in response to heat exposure. Diuretics, such as caffeine, can limit cardiac output and affect heat tolerance and sweating; antihistamines, phenothiazines, and cyclic antidepressants can impair sweating.[2] A CBT increase of only 1.8ºF above normal encroaches on the brain's ability to function.[6]

Acclimatization

When workers are first exposed to a hot environment, they show signs of distress and discomfort, experience increased CBTs and heart rates, and may have headaches and/or nausea. On repeated exposure there is marked adaptation to the hot environment known as acclimatization. Acclimatization is the process that allows the body to begin sweating sooner and more efficiently, reduces electrolyte concentrations in the sweat, and allows the circulation to stabilize so that the worker can withstand greater amounts of heat stress while experiencing reduced heat strain signs and symptoms.

Acclimatization begins with consecutive exposures to working conditions for 2 hours at a time, with a requisite rise in metabolic rate. This will cause the body to reach 33% of optimum acclimatization by the fourth day of exposure. Cardiovascular function will stabilize, and surface and internal body temperatures will be lower by day 8 when the body has reached 44% of optimum acclimatization. A decrease in sweat and urine electrolyte concentrations are seen at 65% of optimum (day 10); 93% of optimum is reached by day 18 and 99% by day 21.[6]

The loss of acclimatization begins when the activity under those heat stress conditions is discontinued, and a noticeable loss occurs after 4 days. This loss is usually rapidly made up so that by Tuesday workers who were off on the weekend are as well acclimatized as they were on the preceding Friday. Chronic illness, an acute episode of mild illness (e.g., gastroenteritis), the use or misuse of pharmacologic agents, a sleep deficit, a suboptimal nutritional state, or a disturbed water and electrolyte balance may reduce the worker's capacity to acclimatize.[6]

Dehydration and Hyponatremia

When working in hot environments it is often difficult to completely replace lost fluids as the day's work proceeds. High sweat rates with excessive loss of body fluids may result in dehydration and electrolyte imbalances.[10] Some studies have shown that even small deficits adversely affect performance.[11] Dehydration also negates the advantage granted by high levels of aerobic fitness and heat acclimatization.[12]

Several studies have shown that dehydration increases CBT during exercise in temperate and hot environments; a deficit of only 1% of body weight increases CBT during exercise. As the magnitude of the water deficit increases, there is an accompanying elevation in CBT when exercising in the heat. The magnitude of this elevation ranges from 0.2ºF–0.4ºF for every 1% body weight loss.[13] A 2% loss of body weight is generally accepted as the threshold for thirst stimulation.[14] A 3% decrease in body weight causes an increase in heart rate, depressed sweating sensitivity, and a substantial decrease in physical work capacity.[15] Some investigators have reported that a 4%–6% water deficit has been associated with anorexia, impatience, and headache, while a 6%–10% deficit is associated with vertigo, shortness of breath, cyanosis, and spasticity. With a 12% water deficit, an individual will be unable to swallow and will need assistance with rehydration. Lethal dehydration levels are estimated to occur at 15%–25% lost body weight.[16]

Because water is the most abundant constituent in the body, comprising approximately 60% of the body weight in men and 50% in women, maintaining enough water improves the body's overall function. Total body water is distributed in two major compartments: 55%–75% is intracellular fluid (ICF) and 25%–45% is extracellular fluid (ECF).[17] The solute, or dissolved particle concentration of a fluid, is known as its osmolality expressed as milliosmoles per liter (mosm/L). The major ECF component is sodium (Na^+); therefore, ECF volume is a reflection of total body sodium content.

Normal plasma osmolality ranges from 275–290 mosm/L and is kept within a narrow range by mechanisms capable of sensing a 1%–2% change in plasma concentration. Most people have an obligate water loss consisting of urine, stool, and evaporation from the skin and respiratory tract. In order to maintain a steady state, water intake must equal water excretion. Disorders of water regulation result in hyponatremia or hypernatremia. Changes in urine and plasma osmolality are better suited for diagnosing hydration status than changes in hematocrit, serum protein, and blood urea nitrogen (BUN), which are more dependent on factors other than hydration.[4,18] The primary stimulus for water ingestion is thirst, which can be triggered by the following physiological mechanisms: an increase in osmolality, a decrease in ECF volume, or a decrease in blood pressure. Osmoreceptors in the hypothalamus are stimulated by a rise in serum concentration. The average osmotic threshold for thirst is approximately 295 mosm/kg and varies among individuals. Under normal circumstances, daily water intake exceeds physiological requirements.[19]

Dehydration is not the only factor in heat stress, there is also the matter of electrolyte depletion. Sodium, a vital electrolyte, is excreted as the body sweats in order to utilize evaporative cooling. Two of the many functions of sodium in the body are to conduct impulses along neurons and maintain concentration gradients in the kidney for proper urine production.

Most individuals with acute exercise-induced heat disorder are dehydrated with normal to mildly increased serum sodium and serum osmolality (hypernatremia). Hyponatremia develops when serum sodium levels drop below 135 milliequivalents per liter (mEq/L) and is a life-threatening condition that has been recognized as a potential health consequence of endurance activities conducted in hot environments. Increased water intake prior to and during activities in hot environments is highly emphasized to prevent dehydration and heat illness. However, drinking too much water can lead to decreased serum sodium concentrations (water toxicity or hyponatremia), and has been recognized as an increasing problem among US military recruits.[20]

Hyponatremia may occur with hypo-, hyper-, or normal hydration status.[21] Symptomatic and potentially life-threating hyponatremia can occur when blood sodium concentrations decrease to less than 130 mEq/L and is generally caused by hypervolemia (water overload) secondary to extensive over-drinking. Many people with hyponatremia have increased their total body water by about 1 gallon to achieve such low serum sodium values.[22]

Most cases of hyponatremia result from the inability of the kidneys to excrete an appropriately dilute urine. The most significant clinical signs of hyponatremia involve the central nervous system, and symptoms vary from subtle changes in one's ability to think, to decreases in energy levels, and to severe alterations, such as coma or seizure. Symptoms generally parallel the rate of development and degree of hyponatremia.[23]

Fluid Replacement

Palatability of any fluid replacement solution is important to ensure adequate rehydration. There is evidence that adding sweeteners to drinks leads to increased consumption. Glucose-electrolyte solutions have been shown to facilitate sodium and water absorption. Also, the glucose in these solutions provides energy for muscular activity in endurance events that require vigorous exercise.[24] However, workers should be cautioned to avoid drinking large amounts of sugar laden beverages in hot climates as this will precipitate an osmotic diuresis that increases fluid loss through urination. Caffeinated beverages and alcohol intake will also increase urinary fluid loss and should be avoided. The temperature of the drink will also influence consumption of fluids. Ideally, fluids should be ingested at 50ºF–60ºF in small quantities (5–7 ounces) and frequent intervals (every 15–20 minutes).

Average Americans consume adequate, if not excessive, amounts of sodium in their usual diet such that for mild dehydration, only water replacement is needed. However, in moderate dehydration or when involved in events resulting in prolonged sweating, electrolyte (i.e., sodium) replacement is indicated. There are many oral electrolyte replacement formulas available such as Gatorade®. Salt tablets are not recommended as they can irritate the stomach, leading to vomiting which can exacerbate fluid losses and do not address water replacement needs. Those with nausea and vomiting from heat stress may require intravenous saline administration to replace their water and sodium.

Results

Heat Stress

WBGT readings reached a high of 83.7ºF in the checked baggage screening area with an average dry bulb temperature of 89.2ºF. In the passenger screening area inside the terminal, representative of the checked baggage screener's break area, the WBGT reading reached a high of 68.8ºF, with an average dry bulb temperature of 73.8ºF. According to the National Oceanic and Atmospheric Administration (NOAA), the mean of the daily mean temperatures for July and August, the two hottest months of the year, is 82.5ºF and 82.8ºF, respectively, with mean daily maximum temperatures of 90.1ºF for both months.[25] Daily WBGT range and average dry bulb results are reported in Tables 1–4.

Metabolic heat produced was estimated for screeners using energy expenditure tables and the guidelines provided in the NIOSH document, *Occupational Exposure to Hot Environments, Revised Criteria 1986*.[2] Using this method, the average energy expenditure of a standard male worker (154 pounds with a body surface of 19.4 square feet) can be calculated to produce approximately 246 kilocalories per hour (kcal/hour), corresponding to a moderate workload.

WBGT results and metabolic rate estimates for a standard male were compared to those listed in the NIOSH RELs.[2] A comparison of this metabolic heat value with the highest WBGT temperatures recorded in the checked baggage screening area yields a recommended work/rest regimen of 45 minutes work and 15 minutes rest per hour.

The metabolic rate estimates were also assigned a moderate workload category and compared to the ACGIH screening criteria. Use of the ACGIH screening criteria for heat stress also provides recommendations on work/rest schedules according to WBGT temperatures taken in the work areas. These criteria also suggest a 75% work and 25% rest schedule for acclimatized workers with moderate workloads in environments with a WBGT between 81.5ºF and 83.3ºF, which is similar to temperatures measured in the checked baggage screening area where screeners are handling luggage.

On the days of the NIOSH evaluation, an average of 61.3% of the monitored periods were in the range for the heat stress screening criteria of moderate work with a 75% work and 25% rest regimen. The time period above the heat stress screening criteria for moderate work started between approximately 0830 and 1200 and lasted until approximately 1830, depending on the day's weather conditions.

These metabolic heat rate estimates reflect regimens that would be applicable had the screeners rested in the same temperature as the work environment and were handling luggage for the entire hour. This may not be the case for all screeners; some screeners were observed taking breaks in the cooler terminal and periods of little to no luggage handling were observed. It is important to remember that the NIOSH RELs were calculated for a standard worker, these work/rest regimens will vary from screener to screener, and an hourly estimate of metabolic heat rate and WBGT provides a more accurate recommendation for work/rest regimens.

Heat Strain

Twenty-three participants, including twenty-two screeners and one screener supervisor, volunteered to be monitored for physiologic responses to the conditions of the work environment. These responses provide signals of heat strain. Nine screeners were monitored over one shift, seven screeners over two shifts, and seven screeners over three shifts for a total of 44 individual measurements. CBT, HR, and body weight were measured. Sampling times ranged from 135–490 minutes with an average sampling time of 351 minutes. All employees were considered acclimatized to their work environment during the NIOSH evaluation. Eight of the screeners monitored developed signs of heat strain, as measured by CBT or sustained HR levels that exceeded the ACGIH criteria for acclimatized workers.

One screener exceeded the ACGIH CBT criteria of 101.3ºF for an acclimatized worker for 8 minutes of his work shift. Sixteen screeners exceeded the ACGIH CBT of 100.4ºF for unacclimatized workers. The average CBTs for the screeners ranged from 98.6ºF to 101.4ºF. Individual averages and ranges for CBT measurements are reported in Tables 5–8.

There were 10 instances of screener's HRs exceeding the ACGIH criterion of 180 minus the worker's age. One screener's HR exceeded the criterion during all three shifts monitored (19%, 26%, and 29% of shift) and one screener exceeded the HR criterion during two of the three shifts monitored (19% and 41% of shift). In addition, three of the screeners representing six individual measurements, had average HRs that approached or exceeded 115 bpm during the shifts they were monitored. Individual averages and ranges for HR measurements are reported in Tables 5–8.

Body weight changes over the screeners' shift ranged from a 1.4% loss to a 2.2% gain, with an average of a 0.1% gain. None of the screeners had a body weight loss of more than the ACGIH criterion of 1.5%. Individual body weight changes are reported in Tables 5–8.

Heat Stress Management

TSA at PBI did not have a formal heat stress program in place. Employees received training on factors affecting a body's response to heat stress, and preventive measures were emphasized. Cold bottled water was provided in the baggage screening area and screeners were encouraged to take frequent hydration breaks. Thermal comfort fans were located near each EDS machine. Employees were permitted to take a 15-minute break, one in the first half and one in the second half of the shift, and to eat lunch in the air-conditioned terminal. Management stated employees frequently reported symptoms of heat strain such as cramps and exhaustion. According to TSA management, two employees previously sought medical treatment for a heat-related illness.

DISCUSSION

The study results indicate that TSA screeners working in the baggage screening area were exposed to heat stress conditions in excess of the screening criteria during the NIOSH evaluation. Eight of the screeners monitored (35%) developed signs of heat strain during their activities, as measured by CBT or sustained HR levels that exceeded the ACGIH criteria. When screeners exceed these criteria, ACGIH recommends employees discontinue heat stress exposure.

Some screeners were observed taking their lunch and work breaks in environments similar to those of the checked baggage screening area while other screeners were observed taking their lunch and work breaks in environments similar to those of the passenger screening area (air-conditioned area of the terminal). A time-weighted average (TWA) WBGT value can be calculated if an employee's work and/or break areas are distributed over more than one location. By taking breaks in cool areas, employees' heat stress exposure is lowered thus allowing for longer exposures to the work environment without heat strain signs or symptoms.

All screeners, at the time of the NIOSH evaluation, were considered to be acclimatized. Screeners who typically work in the checked baggage area have opportunities to work in the air-conditioned passenger screening area when the need arises. TSA management was also considering establishing rotations that would require screeners to work in both the checked baggage and passenger screening areas. These practices, if done over a number of days, may interfere with establishing or maintaining heat-acclimatization and change the workers' status to un-acclimatized. If TSA had this rotation in place during the time of the NIOSH evaluation, 18 screeners (78%) would have showed signs of heat strain due to a lack of acclimatization. These screeners and new screeners would need to be re-acclimatized to the work environment each time they returned to the checked baggage screening area.

Environmental temperatures can be warmer than on the days of the NIOSH evaluation, according to NOAA.[25] In addition, baggage volume and therefore workload was reported to be higher earlier in the summer months during peak tourist travel. Management reported that the airport is growing, and it is expected that more flights and larger planes will be flying into the airport in the future. With this increase in passenger volume, it is expected that the workload and metabolic rate estimates for TSA screeners will also increase. In this case, NIOSH and ACGIH screening criteria are more likely to be exceeded, thereby raising the potential for heat stress and disorders among screeners.

Heat strain is highly individual and can be hard to predict based upon environmental heat stress measurements alone. Some of the first symptoms of heat strain are hampered judgment and inability to think critically, symptoms that usually go unnoticed by the affected person. Screeners reported feeling hot and sweaty but did not report feelings of fatigue, nausea, weakness, or confusion, which may indicate a lack of awareness of their heat strain.

CONCLUSIONS

Environmental temperature measurements and work load assessments showed that during the NIOSH evaluation, screeners working in the checked baggage screening area were exposed to heat stress in excess of the occupational screening criteria. Some employees developed heat strain signs and/or complained of heat strain symptoms. The potential for heat stress and strain increases as temperatures rise and as work activities increase. Employees were not aware of having developed heat strain, indicating the need for further education and training, and for a physiological self-monitoring program.

RECOMMENDATIONS

Heat stress exposures in the occupational setting can be addressed with a variety of techniques, including engineering controls, work practices, personal protective equipment, and preventive medical practices. Engineering controls are always the preferred method to reduce or eliminate the hazards associated with working in hot environments. Situations exist in occupational settings where the complete control of heat stress by the application of engineering controls may be technologically impossible or impractical. Where engineering controls of the heat stress are not practical or complete, other solutions must be sought to keep the level of heat stress on the worker within limits that are not accompanied by an increased risk of heat disorders. The application of preventive practices frequently can be an alternative or complementary approach to engineering techniques for controlling heat stress.

The following recommendations are provided to TSA management to control heat stress in the baggage screening area at PBI.

1. Implement engineering controls to reduce convective, radiant, and evaporative heat in the checked baggage screening area and thus lower heat stress conditions. This can be accomplished by reducing the dry bulb air temperature, shielding the screeners from the sun, and decreasing ambient water vapor pressure (relative humidity).

2. Implement engineering controls to reduce the screeners' job metabolic heat production rate. This would include eliminating the need for the screeners to manually handle the baggage. Metabolic heat is not a major contributor to the total heat load. However, it does represent an extra load on the circulatory system and can be a critical component in high heat exposures.

3. Management should allow employees to take unscheduled breaks if they report feeling weak, nauseated, excessively fatigued, confused, and/or irritable. These heat strain symptoms and any other signs of heat overexposure, described in Appendix C, should be reported by screeners to their supervisor for investigation and follow-up.

4. Assign screeners to either the checked baggage or passenger screening areas and limit the frequency of rotation between the areas without allowing adequate time to acclimate. Rotating screeners between the outdoor checked baggage screening area and the indoor passenger screening area will decrease the screeners' ability to tolerate heat stress.

5. Develop a heat-acclimatization program to decrease the risk of heat-related disorders. Such a program involves exposing screeners to work in hot environments for progressively longer periods. NIOSH recommends that workers who have had previous experience in jobs where heat levels are high enough to produce heat stress (CBT and HR increase, but do not exceed recommended levels) should work in the environment 50% of the shift on day one, 60% on day two, 80% on day three and 100% on day four. New screeners who will be similarly exposed should start with 20% on day one, with a 20% increase in exposure each additional day.[2] The duration of exposure required for full acclimatization is highly variable between individuals and screeners may be able to work a full shift before this process is completed. The body's acclimatization will continue to improve each day in that environment for up to 3 weeks.

6. Ensure screeners stay hydrated and do not lose any body weight during their shift. Always provide cool (50°F–60°F) water or any cool liquid (except alcohol and caffeinated beverages) and encourage them to drink small amounts frequently, e.g., one cup every 20 minutes. Drinking from individual containers improves water intake over the use of drinking fountains. Although some commercial drinks contain salt, this is not necessary because most people add enough salt to their diets to accommodate working in this environment.

7. Develop continuing education programs to ensure that all screeners potentially exposed to hot environments and physically demanding job activities stay current on heat stress and heat stress prevention information. Screeners working the checked baggage screening area should have continuing education at least yearly. A good heat stress training program should include at least the following components:
   - knowledge of the hazards of heat stress
   - recognition of predisposing factors, danger signs, and symptoms
   - awareness of signs and symptoms of heat-related illness and first-aid procedures for treatment
   - employee responsibilities in avoiding heat stress
   - medical conditions that may increase the risk of heat-related illnesses
   - dangers in using drugs, including therapeutic ones, and alcohol in hot and physically demanding work environments
   - preventive measures that can be taken to reduce heat stress
   - instructing screeners to monitor themselves and others for heat strain signs and symptoms following guidelines in Appendix C
   - encouraging screeners to take their breaks in a cool location such as the airport terminal

8. Create a buddy system so that screeners can monitor each other for symptoms of heat disorders. A buddy system will help to ensure that each has had enough water and food and is feeling well enough to continue. If a coworker appears to be disoriented or confused, or suffers inexplicable irritability, malaise, or flu-like symptoms, the screener should be removed for rest in a cool location with rapidly circulating air and kept under skilled observation. Immediate emergency care is necessary if sweating stops and the skin becomes hot and dry.

9. Develop a heat-related illness surveillance program, which includes establishing and

maintaining accurate records of any heat-related disorder events and noting the environmental and work conditions at the time of disorder. Such events may include repeated accidents, episodes of heat-related disorders, or frequent health-related absences. Job-specific clustering of specific events or illnesses should be followed up by environmental and personal monitoring and medical evaluations.

10. Monitor environmental heat exposures during the hottest months using a WBGT at or as close as possible to the area where the screeners are exposed. Break areas and other areas in which the screeners may be working that differ in temperature should also be measured and used to calculate hourly TWA WBGTs. Make at least hourly WBGT measurements during the hottest part of each shift, during the hottest months of the year and when heat waves occur or are predicted to occur. If two sequential measurements exceed the applicable criteria (NIOSH RAL or REL, or ACGIH TLV), then work conditions should be modified until two more sequential WBGT measurements are within the exposure limits. On these days, administrative controls such as increasing the number of breaks, use of cooling methods, and additional awareness training can be implemented to help reduce heat stress.

11. Establish criteria for the declaration of a heat alert; for example, a heat alert may be declared if the area weather forecast for the next day predicts a maximum air temperature of 95°F or above or 90°F if this is 9°F above the maximum reached in any of the preceding 3 days. Procedures to follow during the state of heat alert include:
    - Increase the number of screeners in each team to reduce each screener's metabolic rate.
    - Increase rest allowances.
    - Remind workers to drink small amounts of water frequently to prevent dehydration, to weigh themselves before and after the shift, and to be sure to drink enough water to maintain body weight.
    - Check screeners' oral temperature and pulse during their most severe heat-exposure period.
    - Exercise additional caution on the first day of a shift change to make sure workers are not overexposed to heat, because they may have lost some of their acclimatization over the weekend and during days off.
    - Restrict overtime work.

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Table 1: Heat Stress Measurements, August 28, 2004
Transportation Security Administration, West Palm International Airport
West Palm Beach, Florida
HETA 2004-0334-3017

Monitoring Location	*Sampling Times*	*WBGT Temperature Range (ºF)*	*Average Dry Bulb Temperature (ºF)*	*Maximum Dry Bulb Temperature (ºF)*	*% of time at a recommended 75% work and 25% rest regimen*
Passenger Screening, Checkpoint C	1116–1843	66.1–68.8‡	73.7	74.8	0
Between L3 #2 and 3	1121–1822	78.7–83.7	89.3	91.6	70
Between L3 #5 and 6	945–1823	77.5–83.9	89.2	92.2	47

‡ Indoor WBGT value, representative of where some screeners take their breaks.

Table 2: Heat Stress Measurements, August 29, 2004
Transportation Security Administration, West Palm International Airport
West Palm Beach, Florida
HETA 2004-0334-3017

Monitoring Location	*Sampling Times*	*WBGT Temperature Range (ºF)*	*Average Dry Bulb Temperature (ºF)*	*Maximum Dry Bulb Temperature (ºF)*	*% of time at a recommended 75% work and 25% rest regimen*
Passenger Screening, Checkpoint C	0737–1903	62.7–66.4‡	73.9	75.1	0
Between L3 #1 and 2	0653–1906	78.1–83.5	87.8	90.9	67
Between L3 #5 and 6	0653–1853	78.1–83.3	87.7	91.4	54

‡ Indoor WBGT value, representative of where some screeners take their breaks.

Table 3: Heat Stress Measurements, August 30, 2004
Transportation Security Administration, West Palm International Airport
West Palm Beach, Florida
HETA 2004-0334-3017

Monitoring Location	***Sampling Times***	***WBGT Temperature Range (ºF)***	***Average Dry Bulb Temperature (ºF)***	***Maximum Dry Bulb Temperature (ºF)***	***% of time at a recommended 75% work and 25% rest regimen***
Passenger Screening, Checkpoint C	0945–1915	65.6–68.3[‡]	73.9	74.9	0
Between L3 #1 and 2	0657–1951	79.3–83.5	89.0	91.6	61
Between L3 #5 and 6	0656–1953	79.0–83.6	89.3	92.5	65
Near L3 #9	0700–1941	78.7–83.3	88.0	91.5	56

[‡] Indoor WBGT value, representative of where some screeners take their breaks.

Table 4: Heat Stress Measurements, August 31, 2004
Transportation Security Administration, West Palm International Airport
West Palm Beach, Florida
HETA 2004-0334-3017

Monitoring Location	***Sampling Times***	***WBGT Temperature Range (ºF)***	***Average Dry Bulb Temperature (ºF)***	***Maximum Dry Bulb Temperature (ºF)***	***% of time at a recommended 75% work and 25% rest regimen***
Between L3 #1 and 2	0634–1255	79.1–83.3	88.9	91.0	76
Between L3 #5 and 6	0635–1248	78.9–83.7	88.0	91.3	56
Near L3 #9	0635–1258	78.9–83.4	87.8	91.1	61

Table 5: Heat Strain Physiological Measurements, August 28, 2004
Transportation Security Administration, West Palm International Airport
West Palm Beach, Florida
HETA 2004-0334-3017

Subject	*Sampling period*	*CBT Average (range) [ºF]*	*CBT exceeded unacclimatized criterion*	*CBT exceeded acclimatized criterion*	*Heart rate average (range) [bpm]*	*Heart rate exceeded criterion*	*Body weight change [%]*
Second Shift							
A	1045–1800	99.9 (97.1–100.6)	Yes	No	114 (63–174)	Yes	-0.5
B	1245–1800	100.2 (98.1–101.0)	Yes	No	98 (71–139)	No	0.7
C	1245–1800	99.3 (98.0–100.2)	No	No	115 (76–173)	Yes	-0.8

ACGIH core body temperature (CBT) criterion is 100.4ºF for unacclimatized and 101.3ºF for acclimatized workers.
ACGIH heart rate criterion is 180 minus the worker's age, as beats per minute (bpm), for both unacclimatized and acclimatized workers.
ACGIH body weight criterion is a loss of 1.5% for unacclimatized and acclimatized workers.

Table 6: Heat Strain Physiological Measurements, August 29, 2004
Transportation Security Administration, West Palm International Airport
West Palm Beach, Florida
HETA 2004-0334-3017

Subject	*Sampling period*	*CBT Average (range) [ºF]*	*CBT exceeded unacclimatized criterion*	*CBT exceeded acclimatized criterion*	*Heart rate average (range) [bpm]*	*Heart rate exceeded criterion*	*Body weight change [%]*
First Shift							
D	0750–1220	100.4 (99.0–101.0)	Yes	No	114 (79–142)	Yes	1.6
E	0550–1157	99.6 (99.0–100.1)	No	No	109 (70–154)	No	0.7
F	0550–1149	100.0 (99.0–100.5)	Yes	No	102 (64–138)	No	-1.3
G	*	*	*	*	*	*	†
H	0555–1200	99.1 (98.1–99.9)	No	No	84.5 (37–111)	No	0.3
I	0636–1204	99.1 (98.1–99.8)	No	No	112 (33–219)	Yes	0
J	1200–1415	99.2 (98.4–99.9)	No	No	97.8 (43–131)	No	-0.3
K	0613–1146	99.2 (98.0–100.0)	No	No	75.5 (34–108)	No	0.6
L	0618–1140	99.3 (98.7–100.0)	No	No	75.0 (63–101)	No	-0.6
M	0619–1144	100.2 (98.0–101.2)	Yes	No	83.8 (33–214)	Yes	-0.7
N	0635–1415	99.0 (98.0–100.0)	No	No	89.5 (66–112)	No	-0.2
O	0610–1420	100.2 (99.6–100.7)	Yes	No	105 (86–114)	No	-1.2
Second Shift							
B	1235–1814	100.5 (99.8–101.4)	Yes	Yes	99 (46–147)	No	-0.5
C	1245–1808	99.5 (98.8–100.3)	No	No	115 (66–186)	Yes	-0.8
P	1315–1805	99.8 (99.5–100.1)	No	No	77 (67–120)	No	†
Q	*	*	*	*	*	*	†

ACGIH core body temperature (CBT) criterion is 100.4ºF for unacclimatized and 101.3ºF for acclimatized workers.
ACGIH heart rate criterion is 180 minus the worker's age, as beats per minute (bpm), for both unacclimatized and acclimatized workers.
ACGIH body weight criterion is a loss of 1.5% for unacclimatized and acclimatized workers.
* Data not logged due to monitor failure.
† Data not collected.

Table 7: Heat Strain Physiological Measurements, August 30, 2004
Transportation Security Administration, West Palm International Airport
West Palm Beach, Florida
HETA 2004-0334-3017

Subject	*Sampling period*	*CBT Average (range) [ºF]*	*CBT exceeded unacclimatized criterion*	*CBT exceeded acclimatized criterion*	*Heart rate average (range) [bpm]*	*Heart rate exceeded criterion*	*Body weight change [%]*
First Shift							
D	0750–1220	*	*	*	96 (33–130)	No	1.6
E	0647–1150	99.7 (99.0–100.4)	No	No	101 (55–133)	No	1.3
F	0558-1150	100.5 (99.7–101.1)	Yes	No	100 (34–126)	No	0
G	0628–1203	100.1 (98.2–100.5)	Yes	No	107 (72–167)	No	-0.2
H	0711–1215	98.6 (98.0–99.4)	No	No	85 (63–177)	Yes	0.8
I	0552–1200	99.3 (98.0–100.3)	No	No	79.1 (33–157)	No	0.3
J	0610–1411	99.31 (98.0–99.8)	No	No	*	*	-1.4
K	0642–1218	100.0 (99.3–100.5)	Yes	No	88 (67–134)	No	0.7
L	0606–1149	99.7 (95.7–100.6)	Yes	No	74 (45–90)	No	-0.3
N	0625–1406	99.1 (98.0–100.5)	Yes	No	88 (42–199)	Yes	-1.0
R	0615–1350	99.5 (98.2–100.5)	Yes	No	87 (47–136)	No	†
Second Shift							
C	1200–1814	99.6 (98.7–100.7)	Yes	No	119 (72–199)	Yes	0.4
Q	1332–1807	99.0 (98.2–101.4)	Yes	No	89 (43–110)	No	1.5
P	1352–1914	99.4 (99.0–99.6)	No	No	75 (68–90)	No	-0.5
T	1251–1941	99.7 (98.7–100.9)	Yes	No	92 (60–146)	No	0.3
U	1307–1821	99.3 (98.1–99.9)	No	No	90 (41–122)	No	0.9
V	1307–1915	99.3 (98.0–100.3)	No	No	88 (33–161)	No	1.2
W	1320–1822	100.3 (99.9–100.9)	Yes	No	103 (76–112)	No	0.2

ACGIH core body temperature (CBT) criterion is 100.4ºF for unacclimatized and 101.3ºF for acclimatized workers.
ACGIH heart rate criterion is 180 minus the worker's age, as beats per minute (bpm), for both unacclimatized and acclimatized workers.
ACGIH body weight criterion is a loss of 1.5% for unacclimatized and acclimatized workers.
* Data not logged due to monitor failure.
† Data not collected.

Table 8: Heat Strain Physiological Measurements, August 31, 2004
Transportation Security Administration, West Palm International Airport
West Palm Beach, Florida
HETA 2004-0334-3017

Subject	*Sampling period*	*CBT Average (range) [ºF]*	*CBT exceeded unacclimatized criterion*	*CBT exceeded acclimatized criterion*	*Heart rate average (range) [bpm]*	*Heart rate exceeded criterion*	*Body weight change [%]*
First Shift							
D	0600–1204	100.5 (99.6–101.2)	Yes	No	119 (47–147)	Yes	2.2
F	0607–1204	99.8 (98.5–101.0)	Yes	No	91 (38–119)	No	0.4
G	0554–1159	99.3 (98.0–99.8)	No	No	81 (33–121)	No	-0.5
K	0613–1155	99.5 (98.0–99.9)	No	No	76 (39–167)	No	0.7
L	0607–1204	99.5 (98.2–100.0)	No	No	75 (56–151)	No	†
Q	0655–1219	99.0 (98.7–100.0)	No	No	89 (76–104)	No	1.1
S	0612–1216	99.5 (98.7–100.7)	Yes	No	88 (47–115)	No	-1.0

ACGIH core body temperature (CBT) criterion is 100.4ºF for unacclimatized and 101.3ºF for acclimatized workers.
ACGIH heart rate criterion is 180 minus the worker's age, as beats per minute (bpm), for both unacclimatized and acclimatized workers.
ACGIH body weight criterion is a loss of 1.5% for unacclimatized and acclimatized workers.
† Data not collected.

APPENDIX A

Estimating Metabolic Heat Production Rates by Task Analysis[1]

A. Body Position and Movement	**kcal/min**	
Sitting	0.3	
Standing	0.6	
Walking (uphill)	2.0–3.0 (add 0.8 kcal/meter rise in elevation)	
B. Type of Work	**Average (kcal/min)**	**Range (kcal/min)**
Hand work:		*0.2–1.2*
Light	0.4	
Heavy	0.9	
Work, one arm:		*0.7–2.5*
Light	1.0	
Heavy	1.8	
Work, both arms:		*1.0–3.5*
Light	1.5	
Heavy	2.5	
Work, whole body:		*2.5–9.0*
Light	3.5	
Moderate	5.0	
Heavy	7.0	
Very heavy	9.0	
C. Basal Metabolism	1.0	

The sum of A, B, and C is equal to the estimated metabolic production per task. Estimates are for a standard male worker of 154 pounds (lbs) body weight and 19.4 square feet (ft^2) body surface.

Sample calculation for the job of Screener:

Task	**kcal/min**
A. Standing	0.6
B. Heavy, work with both arms	2.5
C. Basal metabolism	1.0
Metabolic rate total per minute	4.1 kcal/min
Metabolic rate total per hour	246 kcal/hour

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[1] NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, rev. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113.

APPENDIX B

NIOSH Recommended Heat-Stress Alert and Heat-Stress Exposure Limits[1]

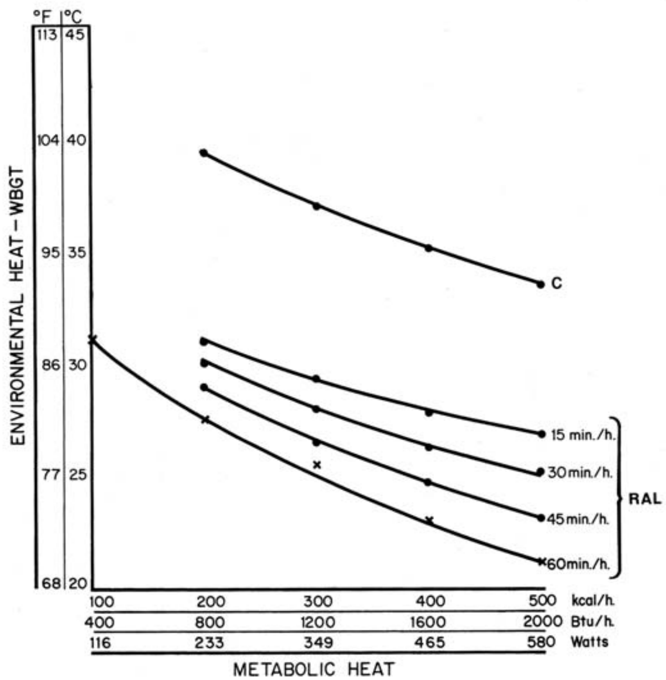

Figure 1. Recommended Heat-Stress Alert Limits (unacclimitized workers)

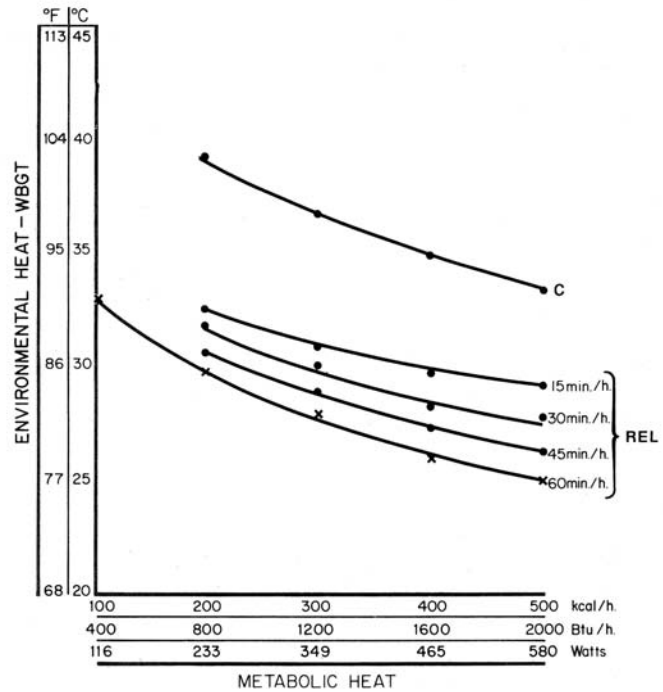

Figure 2. Recommended Heat-Stress Exposure Limits (acclimatized workers)

The figures' curves indicate recommended work/rest regimens of external heat (measured as wet-bulb globe temperatures) and internal (metabolic) heat. The 'C' curve is the Ceiling Limit, indicating that workers should not be exposed to such conditions without adequate heat-protective clothing and equipment.

[1] NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, rev. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113.

APPENDIX C

Use of Personal Monitoring Methods to Reduce Heat-Related Illnesses[1,2]

Periodic monitoring of the heart rate, oral temperature, extent of body weight loss, and/or recovery heart rate should always include the determination of baseline values for deciding whether individuals are fit to continue work that day.

Heart Rate: Calculate your heart rate limit by subtracting your age from 180. Your heart rate at peak work effort should not exceed this number for more than 3 or 4 minutes. If it does, stop work immediately, find some shade, drink, and rest until your heart rate returns to a more normal pace. Repeat as necessary.

Oral Temperature: Use a clinical thermometer right after stopping work but before drinking anything. Try to avoid open-mouth breathing prior to inserting the thermometer. If the oral temperature taken under the tongue exceeds 99.7°F, shorten the next work cycle by one-third, and maintain the same rest period. An oral temperature of 100.4°F (deep body temperature of 102.2°F) should be considered reason to terminate exposure even when temperature is being monitored.

Body Weight: Monitor hydration status on a regular basis. Thirst is a poor indicator of hydration because significant dehydration has already taken place when the thirst sensation occurs. Workers should be familiar with their weight when they are fully hydrated and should strive to maintain this weight. Weight loss should not exceed 1.5% of total body weight in a work day. If it does, fluid and food intake should increase. Alcohol and caffeinated beverages should always be avoided when working under heat stress conditions. Workers should attempt to re-hydrate themselves until they achieve their baseline weight. Body water loss can be measured by weighing the worker at the beginning and end of each work day and by using this equation:

(pre-activity weight – post-activity weight) ÷ pre-activity weight x 100 = percent body weight loss

Recovery Heart Rate: Following a normal work cycle, compare a pulse rate taken at 3 minutes of seated rest, P3, with the pulse rate taken at 1 minute of rest, P1. Interpret the results using the following table:

Heart Rate Recovery Patter	P3		P1 minus P3
Excessive heat strain:	≥ 90 bpm	and	≤ 10 bpm
Moderate strain:	≥ 90 bpm	and	≥ 10 bpm
Sufficient recovery:	<90 bpm	and	>10 bpm

[1] NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, rev. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113.

[2] ACGIH® [2006]. Documentation of the threshold limit values and biological exposure indices. 7th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists; 2002–2006 Suppl.

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