

Hot Environments

1980

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

HOT ENVIRONMENTS

JOB HEALTH HAZARDS SERIES

U.S. DEPARTMENT OF LABOR

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July 1980

For sale by the Superintendent of Documents, U.S. Government
Printing Office, Washington, D.C. 20402

ABOUT THIS PAMPHLET

The purpose of this pamphlet is to give employers and employees an overview of the health hazards of work in hot environments, and to alert them to the precautions which should be taken to avoid excessive heat stress.

The following is general information only. It should not be considered as a substitute for any of the provisions of the Occupational Safety and Health Act of 1970 or for any regulations issued by the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA).

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INTRODUCTION

From iron workers to pastry bakers, a wide variety of Americans work in hot environments. It is difficult to determine just how many people must work in the heat, but hot, humid conditions are common to a wide range of industries:

- Iron and steel foundries
- Non-ferrous foundries
- Brick-firing and ceramics
- Glass products
- Rubber products
- Electrical utilities (particularly in boiler maintenance)
- Bakeries
- Confectioneries
- Restaurant kitchens
- Laundries
- Food canneries
- Chemicals
- Mining
- Smelters
- Steam tunnels
- Outdoor operations in hot weather (such as surface mining, dam building, roofing, and other construction)

Being uncomfortable is not the only problem with working in high temperatures and high humidity. Workers who are too suddenly exposed to working in a hot environment face additional and largely avoidable hazards to their safety and health. The employer should provide detailed instructions and preventive measures and provide adequate protection to prevent heat stress.

HOW THE BODY HANDLES HEAT

We human beings are warm-blooded, which means that, regardless of external conditions, our bodies maintain a fairly

constant temperature. The human body, like a furnace, burns fuel and manufactures heat; to keep internal temperatures within safe limits, the body must also get rid of its excess heat into the environment. This is accomplished, primarily, through the varying rate and depth of blood circulation and through the release of fluid through the skin (diffusion) and sweat glands. Under moderate conditions, automatic activities are kept in balance and controlled by the brain, which keeps tabs on body heat by monitoring the warmth of the blood. When the temperature of the blood exceeds 98.6°F., the brain takes measures to lower it. The heart begins to pump more blood, blood vessels expand to accommodate the increased flow, and the bundles of microscopic blood vessels (capillaries) which thread through the upper layers of the skin begin to be used. The blood circulates closer to the surface of the skin, and the excess heat is lost into the cooler atmosphere.

Heat loss from increased skin blood circulation is the usual method of maintaining a constant deep body temperature. However, if this is not adequate, the brain continues to sense over-heating and signals the sweat glands in the skin to shed large quantities of fluid in the form of perspiration (or sweat). By sweating and increased skin blood flow, the skin handles much of the body's heat-dissipating chores.

But as environmental temperatures approach normal skin temperature, the job of cooling the body becomes more difficult. Blood brought to the body surface cannot shed its heat if air temperatures are as warm or warmer than the skin. Under these conditions, the heart continues to pump blood to the surface, but the release of fluid onto the skin by the sweat glands becomes almost the only effective means of maintaining a constant body temperature.

The difficulty worsens when the humidity is high. Sweating does nothing to cool the body unless the moisture is removed from the skin by evaporation—and high humidity retards

evaporation. Hard work under these circumstances becomes even harder: the heart pumps a torrent of blood through enlarged circulatory vessels, the sweat glands pour liquids (and essential dissolved chemical compounds such as salt) onto the surface of the skin, and, all the while below the skin's surface, the production of metabolic heat continues.

The worker's ability to do the job is affected by working in hot environments. With so much blood going to the external surface of the body, relatively less goes to the active muscles. Strength declines, and the onset of fatigue comes sooner than it would otherwise. Psychological effects also may appear. Workers who must perform delicate or detailed work may find their accuracy suffering, and those who must assimilate information may find their comprehension and retention lowered.

SAFETY PROBLEMS

Certain safety problems are common to hot environments. Heat tends to promote accidents due to the slipperiness of sweaty palms, dizziness, or the fogging of safety glasses. And wherever hot surfaces, molten metal, steam, etc., exist, the possibility of burns from accidental contact also exists. Such mishaps are often caused by some secondary agent, such as water suddenly escaping into molten metal or the malfunction of pressure relief valves on water heaters and the like; in both cases a stream of hot steam can hit the worker in unprotected areas of the skin and cause burns.

But aside from these obvious dangers, the frequency of accidents, in general, appears to be higher in hot environments. One reason is that physical performance and mental alertness are lowered in the heat. Increased body temperature and physical discomfort help promote irritability, anger, and other emotional states which sometimes cause workers to commit rash or careless acts or to divert attention from

hazardous tasks. A worker's psychological state usually will have a substantial effect on safe performance.

HEALTH PROBLEMS

Excessive working exposure to a hot environment can bring about a variety of physical disorders among workers.

Heat Stroke

Heat stroke is the most serious of health problems while working in hot environments. It occurs when the human thermo-regulatory system simply breaks down under stress, and sweating stops. There may be little warning to the victim that a crisis stage has been reached. Just why this happens is not known, but when it does, the body's only effective means of getting rid of excess heat is gone.

A heat stroke victim's skin is hot, dry, and usually red or spotted. Body temperature is 105° or higher and rising. He or she is mentally confused, irritable and may complain of feeling chills. If the worker is not taken out of the hot environment at this early stage of heat stroke and cooled off rapidly, then more severe symptoms will occur, such as unconsciousness, delirium, and convulsions, leading to death.

An ambulance should be summoned immediately, but first aid is also vital. The worker should be removed to a cool area, his or her clothes thoroughly soaked with water, and the body vigorously fanned to increase cooling. Further treatment at a medical facility will continue the cooling process and monitor for a variety of complications which may accompany the disorder. Early recognition and treatment of heat stroke after it occurs are the only means of preventing permanent brain damage or death. Good physical fitness and heat acclimatization will increase a person's

heat tolerance but they will not give immunity against heat stroke. Those suffering from chronic disease, the obese, and the alcoholic are more susceptible. The person who has prior history of heat illness is also more prone to get this heat illness again.

Heat Exhaustion

Heat exhaustion includes several clinical disorders, all of which reveal similar symptoms. The condition is caused by the loss of fluid in sweating, sometimes by the loss of salt, and often by both. The worker with heat exhaustion still sweats, but experiences extreme weakness or fatigue, giddiness, nausea, or headache. In more serious cases, the victim may vomit and/or lose consciousness. The skin is clammy and moist, and complexion is pale or flushed, and the body temperature is normal or slightly higher. The unacclimatized, the physically unfit, and the obese are more prone to develop heat exhaustion.

In most cases, treatment is simple: have the victim rest in a cool place and give him or her plenty of lightly salted liquids. Mild cases may result in spontaneous recovery with this treatment. Severe cases may require care for several days. There are no known permanent effects. CAUTION — PERSONS WITH HEART PROBLEMS OR THOSE ON A “LOW SODIUM” DIET OR INTAKE MUST CONSULT A PHYSICIAN ON WHAT TO DO UNDER THESE CONDITIONS.

Heat Cramps

Heat cramps are painful spasms of the working muscles of those who sweat profusely in heat, who drink large quantities of water, but fail to replace their bodies' salt loss. The drinking of water tends to dilute the body's extracellular fluids, while it continues to lose salt. Soon, the low salt in the

muscles causes painful cramps. The affected muscles may be part of the arms, legs, or abdomen, but tired muscles (those used in performing the work) are usually the ones most susceptible to cramps. Cramps may occur during or after work hours, and may be relieved by drinking 1 glass of water containing $\frac{1}{2}$ teaspoon of salt. CAUTION — PERSONS WITH HEART PROBLEMS OR THOSE ON A “LOW SODIUM” DIET OR INTAKE MUST CONSULT A PHYSICIAN ON WHAT TO DO UNDER THESE CONDITIONS.

Fainting

A worker who is not used to hot environments and who stands erect and immobile in the heat may simply black out. With enlarged blood vessels in the skin and in the lower part of the body, blood may pool there rather than return to the heart to be pumped to the brain. Once lying down, the worker should soon recover. By moving around, and thereby preventing blood from pooling, further fainting can be prevented.

Heat Rash

Heat rash, also known as prickly heat, is likely to occur in hot and humid environments where sweat is not easily removed from the surface of the skin by evaporation. The sweat ducts are plugged, the sweat glands inflamed, and a rash soon appears. When extensive, or when complicated by infection, prickly heat can be so uncomfortable as to reduce a worker's performance. This condition can be prevented by resting in a cool place at regular intervals and by taking a shower after each workshift.

Transient Heat Fatigue

Transient heat fatigue refers to the state of discomfort and psychological strain arising from prolonged heat exposure. Workers unused to the heat are particularly susceptible, and

can suffer, to varying degrees, a decline in task performance, coordination, alertness, vigilance, and become irritable and depressed. The severity of transient heat fatigue can be lessened by a period of gradual adjustment to the hot environment.

PREPARING FOR THE HEAT

One of the best ways to prevent heat stress for workers is to minimize heat in the workplace. Some difficult cases may arise, however, particularly when furnaces or sources of steam or water vapor are present in the work area, or when the workplace itself is outdoors and exposed to varying warm weather conditions.

Humans are, to a large extent, capable of adjusting to the heat. This adjustment to heat, under normal circumstances, will take about a week, during which time the body will undergo a series of changes that make further heat exposures more endurable.

On the first day of work in the hot environment, body temperature, pulse rate, and general discomfort will be higher. With each succeeding daily exposure, however, all will gradually decrease as the worker becomes acclimatized to heat. When the major part of body adjustment is complete, the worker should find it possible to perform work with less strain and with a reduction in distress.

Gradual exposure over a period of a week gives the body time to get used to higher environmental temperatures. HEAT DISORDERS IN GENERAL ARE MORE LIKELY TO OCCUR AMONG WORKERS WHO HAVE NOT BEEN GIVEN TIME TO ADJUST TO WORKING IN THE HEAT, OR AMONG WORKERS WHO HAVE BEEN AWAY FROM HOT CONDITIONS AND WHO HAVE GOTTEN USED TO LOWER TEMPERATURES. The hot spells of the summer

are likely to catch the worker unacclimatized; so might the first day back on the job after a leisurely vacation or extended illness or injury.

Once again, workers should take care. The effects of heat exposure depend on just how well the individual is conditioned for hot environments. Workers should not try to show off how well they can tolerate heat stress when actually they approach exhaustion. When overheated, recovery may not be possible without artificial cooling.

LESSENING STRESSFUL CONDITIONS

Many businesses have considered the problem of heat stress and have taken measures to lessen it. Heat stress depends, in part, on the amount of heat the worker's body produces while he or she performs a job. The amount of heat produced during hard, steady work is much higher than that produced while simply standing quietly and pressing buttons. Therefore, THE KEY TO LOWERING HEAT STRESS ON THE JOB MAY EITHER BE TO MAKE THE WORK EASIER OR TO LESSEN ITS DURATION BY PROVIDING ADEQUATE REST TIME. Mechanizing work procedures can reduce the worker's body heat production only modestly. Mechanization can, however, often make it possible to isolate workers from the heat source (perhaps in an air-conditioned booth), and it can increase overall productivity by decreasing the time needed for rest.

Number and Duration of Exposures

Rather than overtax themselves with a small number of lengthy exposures to the heat, workers should, wherever possible, be permitted to distribute the workload evenly over the course of the day by breaking up long periods of work into shorter work-rest cycles. Rest simply gives the body an opportunity to get rid of excess heat, slows down the produc-

tion of internal body heat, and provides greater blood flow to the skin.

Outdoor jobs are especially subject to weather changes. A hot spell or an unusual rise in humidity can create overly stressful conditions for a few hours or days in the summer. Several work practices are common on such days.

- Non-essential tasks are often postponed because of the heat.
- Workers in auxiliary jobs may be assigned to assist.
- Occasionally, younger and more physically fit workers may take over from the older and less physically fit.
- Extra helpers on a task can significantly reduce the heat exposures of the members of a working team. (The practice can be risky, however, when novices to the heat are suddenly exposed to working in it.)

Workplace Thermal Conditions

A variety of engineering changes may be tailored to the conditions of a specific enclosed workplace. For instance, improving the insulation on a furnace wall can reduce its surface temperature and the temperature of the area around it. In a laundry room, exhaust hoods installed over moisture sources will lower the humidity in the work area. In general, though, the simplest and least expensive methods of reducing heat and humidity are:

- Windows opened at the proper places
- All available fans turned on
- Any other method of creating air flow (exhaust ventilation or air blowers)

The Rest Area

Resting in cool surroundings considerably reduces the stress of working in a hot environment. There is no solid informa-

tion available on the ideal temperature for a rest area, but some laboratory data support setting the temperature near 76°F. To prevent sudden chill it is advisable to dry off the skin with a towel and shed the wet garments before entering a room which is much cooler than the work area. THE REST AREA SHOULD BE CLOSE TO THE WORKPLACE. The farther away the rest area, the more likely that it might be used infrequently, or that individual work periods may be lengthened in favor of prolonged rest periods. The shorter the work-rest cycle, the greater benefit to the worker. For more information on how much rest is needed at different levels of heat exposure and work intensity see the sources of information listed on p. 14 of this booklet.

Drinking Water

In the course of a day's work in the heat, a worker may sweat away as much as 3 gallons of fluid, fluid in which certain vital substances are dissolved. BECAUSE SO MANY HEAT DISORDERS ARE CAUSED BY DEHYDRATION AND LOSS OF SALT, IT IS ESSENTIAL THAT WATER INTAKE DURING THE WORKDAY BE ABOUT EQUAL TO THE AMOUNT OF SWEAT PRODUCED. Most workers drink less fluids than they should, because a worker's thirst is not an adequate drive to stimulate that much intake. A worker, therefore, should not depend on thirst to signal when and how much to drink. Instead, the worker should drink fluids every 15 or 20 minutes, and more than necessary to satisfy thirst. As to the best temperature of fluids, there is no scientific answer, but most people will tend not to drink warm fluids as readily as they will cool ones. Water must be cool (50–60°F), palatable, and conveniently close to the work area.

Unacclimatized workers lose much more salt in their sweat than do workers who are acclimatized to the heat, but all lose some. THE BEST WAY TO REPLACE THIS LOSS IS

TO HAVE A 0.1 PERCENT SALT SOLUTION AVAILABLE AS DRINKING WATER. A level tablespoon of table salt dissolved in 15 quarts of water will make such a solution. If salt tablets are used, they must be taken with ample water to prevent gastric irritation. Care is especially necessary during the first days of exposure to the heat. Workers should liberally salt their food and take whatever opportunity they can to ensure the replacement of lost salt. CAUTION — PERSONS WITH HEART PROBLEMS OR THOSE ON A “LOW SODIUM” DIET OR INTAKE MUST NOT BE GIVEN SALT. CONSULT A PHYSICIAN ON HOW TO CARE FOR PEOPLE WITH THESE CONDITIONS.

An unacclimatized person can sweat as much as one quart per hour. However, after a few hours sweating starts to diminish due to sweat gland fatigue. This occurs particularly in humid environments. The capacity for sweating varies greatly from one individual to another.

Protective Clothing

Any sort of clothing inhibits the transfer of heat between a person and the surrounding environment. Therefore, it makes sense that, in hot jobs where the air temperature is less than skin temperature, wearing clothing reduces the body's ability to lose heat into the air.

But when air temperature is higher than skin temperature, clothing helps to prevent the transfer of heat from the air to the body. On a hot and sunny day, for instance, conditions may be intolerable for a worker wearing only shorts, and tolerable for another worker in shirt and trousers. The advantage of wearing clothing, however, is nullified if the clothes interfere too much with the evaporation of sweat, a vital cooling function. Garments made of thin cotton fabric help, evaporating the sweat by picking it up and bringing it to the surface. Loosely fitted garments are also advantageous

from the point of view of evaporation. In contrast, closely fit garments and synthetic fabrics interfere with evaporation. For hot humid environments, loosely woven fabrics are of advantage because they permit air movement close to the skin.

In dry climates, adequate evaporation of sweat is seldom a problem. In an industrial plant with a high level of heat radiating from a furnace, the wearing of clothing is an advantage to the worker. The proper clothing depends on the specific circumstance. Some cases may require special garments: insulated gloves, sponge-like insulated suits, aluminized reflective clothing, infrared reflecting face shields, etc. For extreme conditions, thermally-conditioned clothing has been designed. One such garment carries a self-contained air conditioner in a backpack, while another is hooked up to a compressed air source which feeds the air into the jacket or coveralls through a vortex tube which gives off cool air. Another possibility is to wear a plastic jacket which has big pockets filled with dry ice or frozen water containers. Caution should be exercised with the dry ice to prevent contact with bare skin. The plastic material used for the jacket must be cold resistant, otherwise it may break when the dry ice is placed in it. The pockets must be closed securely after the dry ice is inserted. Thick underwear or a woolen vest should be worn under the plastic jacket.

AWARENESS IS IMPORTANT

As with any safety or health hazard, the keys to preventing excessive heat stress are the employer's and employees' awarenesses that the hazard exists, and that the implementation of proper safety measures can serve to prevent injuries and illnesses on the job. THE RESPONSIBLE EMPLOYER WILL GIVE WORKERS IN HOT ENVIRONMENTS THE OPPORTUNITY TO ALLOW THEIR BODIES TO GET USED TO THE HEAT, AND TO REST AND DRINK SUFFICIENT WATER TO COPE WITH THE STRESS.

SPECIAL CONSIDERATIONS DURING PROLONGED HEAT SPELLS

During unusually hot weather conditions lasting longer than 3 days, the number of heat illnesses usually increases. This is due to several factors, such as progressive body fluid and salt deficit, loss of appetite, build-up of heat storage in living and work areas; and breakdown of air conditioning equipment. THE MOST SUSCEPTIBLE TO HEAT ILLNESSES ARE THE OBESE, THE CHRONICALLY ILL, AND THE OLDER INDIVIDUALS. IT IS THEREFORE ADVISABLE TO MAKE A SPECIAL EFFORT TO ADHERE TO THE PREVENTIVE MEASURES RIGOROUSLY DURING EXTENDED HOT SPELLS AND AVOID ANY UNNECESSARY OR UNUSUAL STRESSFUL ACTIVITY. Sufficient sleep and good nutrition are important for maintaining a high level of heat tolerance.

The most stressful tasks should be performed during the cooler parts of the day (early morning or at night). Double shifts and overtime, whenever possible, should be avoided. REST PERIODS SHOULD BE EXTENDED IN ACCORDANCE WITH THE INCREASE OF HEAT LOAD. One way to maintain production is to increase the workforce temporarily.

Careful consideration should be given to consumption of alcoholic beverages during prolonged periods of heat since alcohol can cause additional dehydration. Persons on special medication (for example, certain medications for blood pressure control, diuretics or water pills, may also cause dehydration) should consult their physician in order to determine if any side effects could occur during excessive heat exposure. It would also be beneficial to weigh yourself before beginning work and at the end of the workday to determine weight loss which may occur from progressive dehydration.

Daily fluid intake must be great enough to prevent significant weight loss during the workday and over the workweek.

SOURCES OF ADDITIONAL INFORMATION

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3. Heat Stress, in Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment. American Conference of Governmental Industrial Hygienists, pp. 58—66, 1979.

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DHHS (NIOSH) Publication No. 80-132