Hot Environments – Health Effects and First Aid – Fact Sheets

WHAT IS HEAT STRESS?

"Heat stress" is the "net [overall] heat load to which a worker may be exposed from the combined contributions of metabolic heat, environmental factors (i.e., air temperature, humidity, air movement, and radiant heat), and clothing requirements." Metabolic heat is the heat produced by the body through chemical processes, exercise, hormone activity, digestion, etc. [Reference: 2016 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 2016. p.214.] Other heat-related terms are defined at the end of this document in the Glossary of Terms.

Heat may come from many sources. For example:

- In foundries, steel mills, bakeries, smelters, glass factories, and furnaces, extremely hot or molten material is the main source of heat.
- In outdoor occupations, such as construction, road repair, open-pit mining and agriculture, summer sunshine is the main source of heat.
- In laundries, restaurant kitchens, and canneries, high humidity adds to the heat burden.

In all instances, the cause of heat stress is a working environment which can potentially overwhelm the body's ability to deal with heat.

Most people feel comfortable when the air temperature is between 20°C and 27°C and when the relative humidity ranges from 35 to 60%. When air temperature or humidity is higher, people feel uncomfortable. Such situations do not cause harm as long as the body can adjust and cope with the additional heat. Very hot environments can overwhelm the body's coping mechanisms leading to a variety of serious and possibly fatal conditions.

How does the human body react to hot environments?

The healthy human body maintains its internal temperature around 37°C. Variations, usually of less than 1°C, occur with the time of the day, level of physical activity or emotional state. A change of body temperature of more than

1°C occurs only during illness or when environmental conditions are more than the body's ability to cope with extreme heat.

As the environment warms-up, the body tends to warm-up as well. The body's internal "thermostat" maintains a constant inner body temperature by pumping more blood to the skin and by increasing sweat production. In this way, the body increases the rate of heat loss to balance the heat burden. In a very hot environment, the rate of "heat gain" is more than the rate of "heat loss" and the body temperature begins to rise. A rise in the body temperature results in heat illnesses.

How does the body control heat gain and heat loss?

The main source of heat in normal conditions is the body's own internal heat. Called metabolic heat, it is generated within the body by the biochemical processes that keep us alive and by the energy we use in physical activity. The body exchanges heat with its surroundings mainly through radiation, convection, and evaporation of sweat.

Radiation is the process by which the body gains heat from surrounding hot objects, such as hot metal, furnaces or steam pipes, and loses heat to cold objects, such as chilled metallic surfaces, without contact with them. No radiant heat gain or loss occurs when the temperature of surrounding objects is the same as the skin temperature (about 35°C).

Convection is the process by which the body exchanges heat with the surrounding air. The body gains heat from hot air and loses heat to cold air which comes in contact with the skin. Convective heat exchange increases with increasing air speed and increased differences between air and skin temperature.

Evaporation of sweat from the skin cools the body. Evaporation occurs more quickly and the cooling effect is more noticeable with high wind speeds and low relative humidity. In hot and

humid workplaces, the cooling of the body due to sweat evaporation is limited because the air cannot accept more moisture. In hot and dry workplaces, the cooling due to sweat evaporation is limited by the amount of sweat produced by the body.

The body also exchanges small amounts of heat by conduction and breathing. By conduction, the body gains or loses heat when it comes into direct contact with hot or cold objects. Breathing exchanges heat because the respiratory system warms the inhaled air. When exhaled, this warmed air carries away some of the body's heat. However, the amount of heat exchanged through conduction and breathing is normally small enough to be ignored in assessing the heat load on the body.

What are the effects of heat on the body?

When the air temperature or humidity rises above the range for comfort, problems can arise. The first effects relate to how you feel. Exposure to more heat can cause health problems and may affect performance.

As the temperature or heat burden increases, people may feel:

- Increased irritability.
- Loss of concentration and ability to do mental tasks.
- Loss of ability to do skilled tasks or heavy work.

In moderately hot environments, the body “goes to work” to get rid of excess heat so it can maintain its normal body temperature. The heart rate increases to pump more blood through outer body parts and skin so that excess heat is lost to the environment, and sweating occurs. These changes place additional demands on the body. Changes in blood flow and excessive sweating reduce a person’s ability to do physical and mental work. Manual work creates additional metabolic heat and adds to the body heat burden. When the environmental temperature rises above 30°C, it may interfere with the performance of mental tasks.

Does everyone react to heat the same way?

The risk of heat-related illness varies from person to person. A person’s general health influences how well the person adapts to heat (and cold).

Those with extra weight often have trouble in hot situations as the body has difficulty maintaining a good heat balance. Age (particularly for people about 45 years and older), poor general health, and a low level of fitness will make people more susceptible to feeling the extremes of heat.

Medical conditions can also increase how susceptible the body is. People with heart disease, high blood pressure, respiratory disease and uncontrolled diabetes may need to take special precautions. In addition, people with skin diseases and rashes may be more susceptible to heat. Other factors include circulatory system capacity, sweat production and the ability to regulate electrolyte balance.

Substances – both prescription or otherwise – can also have an impact on how people react to heat.

Regulators reports that several studies comparing the heat tolerances of men and women have concluded that women are less heat tolerant than men. While this difference seems to diminish when such comparisons take into account cardiovascular fitness, body size, and acclimatization, women tend to have a lower sweat rate than men of equal fitness, size and acclimatization. This lower sweat rate means that there can be an increase in body temperature.

What are the illnesses caused by heat exposure?

Heat exposure causes the following illnesses:

Heat edema is swelling which generally occurs among people who are not acclimatized to working in hot conditions. Swelling is often most noticeable in the ankles. Recovery occurs after a day or two in a cool environment.

Heat rashes are tiny red spots on the skin which cause a prickling sensation during heat exposure. The spots are the result of inflammation caused when the ducts of sweat glands become plugged.

Heat cramps are sharp pains in the muscles that may occur alone or be combined with one of the other heat stress disorders. The cause is salt imbalance resulting from the failure to replace salt lost with sweat. Cramps most often

occur when people drink large amounts of water without sufficient salt (electrolyte) replacement.

Heat exhaustion is caused by loss of body water and salt through excessive sweating. Signs and symptoms of heat exhaustion include: heavy sweating, weakness, dizziness, visual disturbances, intense thirst, nausea, headache, vomiting, diarrhea, muscle cramps, breathlessness, palpitations, tingling and numbness of the hands and feet. Recovery occurs after resting in a cool area and consuming cool drinks (e.g., water, clear juice, or a sports drink).

Heat syncope is heat-induced dizziness and fainting induced by temporarily insufficient flow of blood to the brain while a person is standing. It occurs mostly among unacclimatized people. It is caused by the loss of body fluids through sweating, and by lowered blood pressure due to pooling of blood in the legs. Recovery is rapid after rest in a cool area.

Heat stroke is the most serious type of heat illness. Signs of heat stroke include body temperature often greater than 41°C, and complete or partial loss of consciousness. Sweating is not a good sign of heat stress as there are two types of heat stroke – "classical" where there is little or no sweating (usually occurs in children, persons who are chronically ill, and the elderly), and "exertional" where body temperature rises because of strenuous exercise or work and sweating is usually present.

Heat stroke requires immediate first aid and medical attention. Delayed treatment may result in death.

What are symptoms and first aid steps for heat exhaustion?

Symptoms of heat exhaustion may start suddenly, and include:

- Nausea or irritability.
- Dizziness.
- Muscle cramps or weakness.
- Feeling faint.
- Headache.
- Fatigue.
- Thirst.
- Heavy sweating.
- High body temperature.

First aid for heat exhaustion includes:

- Get medical aid. Stay with the person until help arrives.
- Move to a cooler, shaded location.
- Remove as many clothes as possible (including socks and shoes).
- Apply cool, wet cloths or ice to head, face or neck. Spray with cool water.
- Encourage the person to drink water, clear juice, or a sports drink.

What are the symptoms and first aid steps for heat stroke?

Heat exhaustion may quickly develop into heat stroke. Symptoms of heat stroke include:

- Hot, dry skin or profuse sweating.

- Confusion.
- Loss of consciousness.
- Seizures.
- Very high body temperature.

First aid for heat stroke includes:

- Call 911 immediately. Heat stroke is a medical emergency.
- Stay with the person until help arrives.
- Move to a cooler, shaded location.
- Remove as many clothes as possible (including socks and shoes).
- Wet the person's skin and clothing with cool water.
- Apply cold, wet cloths or ice to head, face, neck, armpits, and groin.
- Do not try to force the person to drink liquids.

What are the illnesses caused by long-term (chronic) heat exposure?

Regulators reports that certain heart, kidney, and liver damage are thought by some researchers to be linked to long-term heat exposure. However, the evidence supporting these associations is not conclusive.

Chronic heat exhaustion, sleep disturbances and susceptibility to minor injuries and sicknesses have all been attributed to the possible effects of prolonged exposure to heat.

Heat exposure has been associated with temporary infertility in both women and men, with the effects being more pronounced in men. Sperm density, motility, and the percentage of normally shaped sperm can decrease significantly when the temperature of the groin is increased above a normal temperature. Workers exposed to high heat loads should inform their family doctors of their exposure.

Laboratory study of animals has shown that exposure of the pregnant females to high temperatures may result in a high incidence of embryo deaths and malformations of the head and the central nervous system (CNS). There is no conclusive evidence of teratogenic effects of high temperatures in humans. Regulator's criteria document (Draft: 2013) recommends that a pregnant worker's body temperature should not exceed 39-39.5°C during the first trimester of pregnancy.

What are some of the terms used in this document (Glossary of Terms)?

Acclimatization – Physiological changes which occur in response to several days of heat exposure and make the body accustomed to a hot environment.

Convection – Process of heat exchange between the body and the surrounding air or fluid as a result of bulk flow of that air or fluid.

Dehydration – Loss or deficiency of water in body tissues caused by sweating, vomiting or diarrhea. Symptoms include excessive thirst, nausea, and exhaustion.

Heat cramps – Painful and often incapacitating cramps in muscles. Heat cramps are caused by depletion of salt in the body as a result of heavy sweating, and ingestion of water without replacing salt.

Heat exhaustion – Weakness, lassitude, dizziness, visual disturbance, feeling of

intense thirst and heat, nausea, vomiting, palpitations, tingling and numbness of extremities after exposure to a hot environment.

Heat rash (prickly heat or milliaria) – An itchy rash of small raised red spots on the face, neck, back, chest and thighs caused by a hot and moist environment.

Heat strain – Physiological and behavioural responses of the body as a result of heat exposure.

Heat stroke – Acute illness caused by overexposure to heat. Symptoms are dry, hot skin, high body temperature (usually over 105F) and mental dysfunction.

Heat syncope – Temporary loss of consciousness induced by insufficient flow of blood to the brain. Recovery is normally prompt and without any long-term ill effects.

Metabolic rate – Rate of energy (heat) production of the body which varies with the level of activity.

Natural Wet Bulb Temperature – Air temperature measured using a thermometer in which the bulb is covered with wet cotton wick and cooled by the natural movement of air.

Nausea – The feeling that one is about to vomit as experienced in seasickness.

Prickly heat – See Heat rash.

Radiation (heat) – Transfer of heat between hot and cold bodies without contact between them.

Relative humidity – The ratio of the water vapour content of air to the maximum possible water vapour content of air at the same temperature and air pressure.