

Occupational Thermal Exposure

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บทคัดย่อ

การสัมผัสกับอุณหภูมิที่สูงหรือต่ำเกินไปอาจเป็นอันตรายต่อสุขภาพได้ การสัมผัสกับความร้อนสูงในฤดูร้อนหรือในการทำงานผู้สัมผัสอาจเกิดอาการผิดปกติที่เรียกว่า heat stroke ผู้สัมผัสจะมีอาการเหงื่อออกมาก และเป็นลมสลบไป การสัมผัสกับความเย็นจัดในฤดูหนาวหรือในการทำงาน อาจก่อให้เกิดความผิดปกติต่อร่างกายที่เรียกว่า hypothermia ผู้สัมผัสจะรู้สึกหนาวสั่น ทั้งมือ นิ้วเท้า จมูก และในหูเย็นจัด อาการผิดปกติที่เกิดจากการสัมผัสกับอุณหภูมิที่ผิดปกติมากดังกล่าวอาจทำให้ถึงตายได้ ถ้าไม่ได้รับการดูแลจากแพทย์อย่างเหมาะสม และทันเวลา ในบทความนี้ได้นำเสนอมาตรการป้องกันและวิธีการสังเกตอาการผิดปกติของร่างกายในการสัมผัสกับสภาพแวดล้อมที่มีอุณหภูมิสูงหรือต่ำมาก เพื่อความปลอดภัยของท่าน

Abstract

Exposure to extreme thermal conditions is hazardous to health. Heat stroke and hypothermia can be fatal without appropriate immediate medical attention. Preventive measures and early recognition of the symptoms of thermal – related disorders are presented in this article.

A. Thermal Hazards

Exposure to extreme hot or cold is dangerous to health. Extreme of heat and cold can be more than uncomfortable. Excessive exposure to heat is referred to as heat stress and excessive exposure to cold suffered to as cold stress.

In a very hot environment, the most serious concern is heat stroke. Without immediate medical attention, heat stroke could be fatal. Heat stroke fatalities could occur in every summer. Heat exhaustion and fainting are less serious types which are not fatal but interfere with a person's ability to work.

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At very cold temperatures, the most serious concern is the risk of hypothermia-dangerous over cooling of the body. Another serious effect of cold exposure is freezing of the exposed extremities such as fingers, toes, nose and ear lobes. Hypothermia could be fatal in absence of immediate medical attention.

Before go further to thermal related illnesses, I would like students understand about the body's response to temperature. Students may know that the human body is equipped to maintain an appropriate balance between the metabolic heat that it produces and the environmental heat to which it is exposed. Sweating and the subsequent evaporation of the sweat are the body's way of trying to maintain an acceptable temperature balance. (Goetsch, D.L., 2000: 93)

As long as heat gain from radiation, convection, and metabolic processes does not exceed that lost through the evaporation induced by sweating, the body experience no stress or hazard. However, when heat gain from any sources is more than the body can compensate for by sweating, the result is heat stress.

B. Heat stress and Its Prevention

When your body temperature rises, you may become ill. Common symptoms of heat illness are headache, dizziness, muscle weakness or muscle cramps, nausea and vomiting.

To prevent heat - related illnesses, you should:

- stay indoor in air-conditioned areas when possible.
- drink plenty of water before starting an outdoor activity. Drink extra water all day.

2. การจัดการสิ่งแวดล้อม

- drink less tea, coffee and alcoholic beverages.
- wear lightweight, light colored, loose-fitting clothes.
- protect your self from the sun by wearing a hat or using an umbrella.
- increase the time you spend in daily outdoor activities slowly and gradually.
- schedule vigorous outdoor activities for cooler times of the day.
- try to avoid spending time outdoors during the hottest hours of the day - 10 a.m. to 4 p.m.
- take frequent breaks and drink water or other fluids every 15-20 minutes during an outdoor activity, even if you don't feel thirsty. Don't worry if you have clear, pale urine.
- ask your doctor about drinking extra fluids and about your medicines, if you have a chronic medical problem.

When you get the signs of heat illnesses, you should go to a shady, cooler area right away. Remove any excess clothing and begin sponging your body with lukewarm tap water. Slowly sip water or other fluids. Get medical help right away if you have any of the following warning signs: hot, dry skin, but not sweaty, confusion or loss of consciousness, frequent vomiting, shortness of breath or trouble breathing. (Wellman Organization, 2007: online)

Working in extreme hot environment is not affect only to health, but also safety at work. Certain safety problems are common to hot environments. Heat tends to promote accidents due to the slipperiness of sweaty palms,

dizziness, or fogging of safety glasses. Wherever there exists molten metal hot surfaces, steam, etc., the possibility of burns from accidental contact also exists.

Aside from these obvious danger, the frequency of accidents, in general appears to be higher in hot environments than in more moderate environmental conditions. One reason is that working in a hot environment lowers the mental alertness and physical performance of an individual. Increase body temperature and physical discomfort promote irritability, and other emotional states which sometimes cause workers to overlook safety procedures or to divert attention from hazardous tasks.

B.1 Heat Induced Disorders

Excessive exposure to a hot work environment can bring about a variety of heat-induced disorders, such as heat stroke, heat exhaustion, heat cramps, fainting, heat rash and heat fatigue. (Centers for Disease Control, 2007: online)

Heat stroke

Heat stroke is the most serious of health problems associated with working in hot environments. It occurs when the body's temperature regulatory system fails and sweating becomes inadequate. The body's only effective means of removing excess heat is compromised with little warning to the victim that a crisis stage has been reached.

A heat stroke victim's skin is hot, usually dry, red or spotted. Body temperature is usually 105°F or higher, and the victim is mentally confused, delirious, perhaps in convulsions, or unconscious. Unless the victim receives quick and appropriate treatment, death can occur.

4 การจัดการสิ่งแวดล้อม

For 1973-1976, annual reports from the California Department of Health Services alone show seven fatalities among 1,128 acute occupational heat-related illnesses. About 10-15 percent of these patients required hospitalization, and an additional 40 percent were absent from work for varying periods after their illnesses, the remainder returned to work after medical treatment. (Centers for Disease Control, 2007: online)

The health status of a worker is important in determining the response to heat exposure. Certain preexisting conditions can render a person more susceptible to heatstroke; these include obesity, drug abuse, alcoholism, acute or chronic illnesses, fatigue, poor physical condition, overeating, use of anticholinergic and certain psychotropic drugs, lack of sleep and lack of acclimatization.

And person with signs or symptoms of heat stroke requires immediate hospitalization. However, first aid should be immediately administered. This includes removing the victim to a cool area, thoroughly soaking the clothing with water, and vigorously fanning the body to increase cooling. Further treatment at a medical facility should be directed to the continuation of the cooling process and the monitoring of complications which often accompany the heat stroke. Early recognition and treatment of heat stroke are the only means of preventing permanent brain damage or death.

Heat Exhaustion

Heat exhaustion includes several clinical disorders having symptoms which may resemble the early symptoms of heat stroke. Heat exhaustion is caused by the loss of large amount of fluid by sweating, sometimes with

excessive loss of salt. A worker suffering from heat exhaustion still sweats but experiences extreme weakness or fatigue, giddiness, nausea, or headache. In more serious cases. The victim may vomit or lose consciousness. The skin is clammy and moist, the complexion is pale or flushed, and the body temperature is normal or slightly elevated.

In most cases, treatment involves having the victim rest in a cool place and drink plenty of liquids. Victims with mild cases of heat exhaustion usually recover spontaneously with this treatment. Those with severe cases may require extended care for several days. There are no known permanent effects. Please take caution, persons with heart problems or those on a low sodium diet who work in hot environment should consult a physician about what to do under these conditions.

Heat Cramps

Heat cramps are painful spasms of the muscles that occur among those who sweat profusely in heat, drink large quantity of water, but do not adequately replace the body's salt loss. The drinking of large quantity of water tends to dilute the body's fluids, while the body continues to lose salt. Shortly thereafter, the low salt level in the muscles causes painful cramps. The affected muscles may be part of the arms, legs, or abdomen, but tired muscles are usually the ones most susceptible to cramps. Cramps may occur during or after work hours and may be relieved by taking salted liquids by mouth. Please take caution that persons with heart problems or those on a low sodium diet who work in hot environment should consult a physician about what to do under these conditions.

Fainting

A worker who is not accustomed to hot environments and who stands erect and immobile in the heat may faint. With enlarged blood vessels in the skin and in the lower part of the body due to the body's attempts to control internal temperature, blood may pool there rather than return to the heart to be pumped to the brain. Upon lying down, the worker should soon recover. By moving around, and thereby preventing blood from pooling, the patient can prevent further fainting.

Heat Rash

Heat rash, also known as prickly heat, is likely to occur in hot, humid environments where sweat is not easily removed from the surface of the skin by evaporation and the skin remains wet most of the time. The sweat ducts become plugged, and a skin rash soon appears. When the rash is extensive or when it is complicated by infection, prickly heat can be very uncomfortable and may reduce a worker's performance. The worker can prevent this condition by resting in a cool place part of each day and by regularly bathing and drying the skin.

Heat Fatigue

Heat fatigue refers to the temporary state of discomfort and mental or Psycho logic strain arising from prolonged heat exposure. Workers unaccustomed to the heat are particularly susceptible and can suffer, to varying degrees, a decline in task performance, coordination, alertness, and vigilance. The severity of heat fatigue will be lessened by a period of gradual adjustment to the hot environment or so called heat acclimatization.

Heat Effect on Male Reproductive Health

In 1941, McLeod and Hotchkiss first noted the detrimental effect of elevated temperature on sperm production. In their experiment, 6 healthy men were exposed to heat in a high-temperature cabinet. They found a dramatic drop in sperm count after 3 weeks, with a mean duration of 50 days. Also, the role of frequent hot baths and hot tubs has subsequently been described as potential causes of infertility. There are also report that sperm densities decrease in the summer months in men who work outdoors, supporting the theory that environmental heat may impair spermatogenesis. (Infertility-male Club, 2006: online)

An epidemiological study found that exposure to extreme and high occupational temperatures could increase risks of testicular cancer. (Find Articles Company, 2007: online)

Occupational Asthma and Extreme Temperature

Approximately 15 percent of adults with asthma experience occupational asthma. Occupational asthma is a type of asthma caused by exposure to inhaled irritants in the workplace. Occupational asthma is often a reversible condition, which means the symptoms may disappear when the irritants that caused the asthma are avoided. However, permanent damage can result if the person experience prolonged exposure. Occupational asthma often begins with a cough or other asthma symptoms, such as wheezing and chest tightness, that may occur during exposure to the irritants such as dusts, gases, fumes and vapors. Sometimes, occupational asthma symptoms do not appear until several hours after the exposure, even while at home after work. At the onset of the disease, symptoms may subside during weekends and vacations. However, during later stages of occupational asthma, symptoms may begin occurring

during exposure to other, more common asthma triggers such as temperature change, humidity, emotional excitement or stress. (Medicine Health Company. 2007: online and Virginia University Health System, 2004: online)

Heat Acclimatization

One of the best ways to reduce heat-induced illnesses is to minimize heat in the workplace. However, there are some work environments where heat production is difficult to control, such as when furnaces or sources of steam or hot water are present in the work area or when the workplace itself is outdoors and exposed to varying warm weather conditions.

Human are, to a large extent, capable of adjusting to the heat. This adjustment to heat, under normal circumstances, usually takes about a week, during which time the body will undergo a series of changes that will make continued exposure to heat more endurable.

On the first day of work in a hot environment, the body temperature, pulse rate, and general discomfort will be higher. With each succeeding daily exposure, all of these responses will gradually decrease, while the sweat rate will increase. When the body becomes acclimated to the heat, the worker will find it possible to perform work with less stress and strain.

Gradual exposure to heat gives the body time to become accustomed 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 environments and who have gotten accustomed to lower temperatures. Hot weather conditions of the summer are likely to affect the worker who is not acclimatized to heat. Likewise,

workers who return to work after a leisurely vacation or extended illness may be affected by the heat in the work environment. Whenever such circumstances occur, the worker should be gradually reacclimatized to the hot environment.

B.2 Recommended Preventive Measures

In 1969, an international panel of scientists convened by the World Health Organization recommended keeping a worker's deep body temperature at or below 38 degrees Celsius or 100.4 degrees Fahrenheit to prevent heat illnesses. In response to this, NIOSH (72 National Institute of Occupational Safety and Health) developed in 1972 a Criteria Document for Occupational Exposure to Hot Environments, which recommended the following preventive measures: (Centers for Disease Control, 2007: online)

- (1) acclimatizing new workers and workers returning from vacation or absence because of illness,
- (2) implementing a work/rest regimen matched to the severity of the worker's heat exposure (TLVs),
- (3) scheduling hot operations for the coolest part of the day,
- (4) making drinking water and salt readily available to replace the water and salt lost by sweating,
- (5) making protective clothing available to workers, as appropriate,
- (6) reducing environmental heat by engineering controls,
- (7) monitoring environmental heat at the job site,
- (8) performing pre-employment and periodic medical examinations to define those at increased risk, and

(9) instructing workers and supervisors about preventive measures and early recognition of the symptoms of heat-related disorders.

C. Cold Stress and Its Prevention

Temperature hazards are generally thought of as extremes of heat. This is natural because most workplace temperature hazards do relate to heat. (Goetsch, D.L., 2000: 99) However, temperature extreme at the other end of the spectrum-cold-can also be hazardous.

About 700 deaths a year in the U.S. attributed to hypothermia, which results when the body's internal temperature drops below 95 degrees Fahrenheit. (Greaney, P.P., MD., 2007: online)

There are four factors that contribute to cold stress: cold temperature, cold wind, dampness and cold water. These factors, alone or in combination draw heat away from the body. The wind chill factor can intensify the effects of cold stress. Wind chill is a combination of temperature and velocity and is a crucial factor to determine the risk of cold injury. For instance, if the actual air temperature of the wind is 10 degrees Fahrenheit and its velocity is 15 mph, this combination causes a still-air temperature effect of -18 degrees Fahrenheit for exposed skin.

C.1 The Effects of Cold Stress

When body temperature drops, even a few degrees below its normal temperature of 98.6 degrees Fahrenheit, the body uses its defense mechanisms to help maintain its core temperature. Continuous exposure to cold will cause a

person to shiver, which generates heat by speeding up the body's metabolic rate. The body will also begin to shift blood flow away from the extremities and outer skin to the core (chest and abdomen). This allows exposed skin and extremities to cool rapidly and increases the risk of frostbite and hypothermia. Combine these with cold water and trench foot may occur. Following is a description of cold-induced injuries/illnesses, as well as symptoms and treatments.

Hypothermia

Hypothermia results when the body is unable to produce enough heat to replace the heat lost to the environment. Symptoms normally begin when the body temperature drops below 95 degrees Fahrenheit the various symptoms of hypothermia that can be observed are uncontrollable shivering, sensation of cold, weakened pulse, slow or irregular heartbeat, slow, slurred speech, incoherence and confusion, irregular breathing, memory lapses, fatigue and exhaustion.

Susceptibility to hypothermia is increased by sedative drugs and alcohol. Sedatives interfere with the transmission of impulses from the nerve endings in the skin to the brain. This can cause a person to miss natural signals that he or she is in danger. Alcohol dilates blood vessels near the skin's surface. This, in turn, increases the amount and rate of heat loss, which results in an even lower body core temperature.

Frostbite, Frostnip and Trenchfoot

The less severe disorders that can result from cold stress are frostbite, frostnip and trenchfoot.

Frostbite is similar to burns in that it has 3 degrees. With first degree frostbite, there is freezing but no blistering or peeling, with second-degree frostbite, there is freezing accompanied by death of skin and/or tissue. The first sign of frostbite is typically a sensation of cold and numbness. These symptoms may be accompanied by tingling, stinging, aching, or cramps. Frostbite of the outer layer of skin results in a whitish, waxy look. Deep frostbite results in tissue that is cold, pale and solid.

Frostnip is less severe than frostbite. It causes the skin to turn white and typically occurs on the face and other exposed parts of the body. There is no tissue damage with frostnip. However, if the exposed area is not either covered or removed from exposure to the cold, frostnip can become frostbite.

Trenchfoot is a condition that manifests itself as a tingling, itching, swelling and pain. If these symptoms are not treated, this condition can lead to more serious injury including blistering, death of tissue and ulceration. Trenchfoot is caused by continuous exposure of the feet simultaneously to a cold, but not freezing and moisture.

C.2 Cold Stress Prevention

Acclimatization to cold is much slower and often less evident. It may take months, and it will not protect workers from extreme cold. (Ergonomics a Schools Company, 2007: online)

Individuals who work in a cold environment are at greatest risk for cold-induced injuries/illnesses. The United State Occupational Safety and Health Administration (OSHA) has listed the following as major risk factors for cold-related stresses. (Greaney, P.P. Md., 2007: online)

- Wearing inadequate or wet clothing increases the effects of cold on the body.
- Taking certain drugs or medications such as alcohol, nicotine, caffeine and medication that inhibits the body's response to the cold .
- Having a cold or certain diseases, such as diabetes, heart, vascular, and thyroid problems, may make a person more susceptible to the winter elements.
- Being a male increases a person's risk to cold-related stresses. Men experience far greater death rates due to cold exposure than women, perhaps due to inherent risk-taking activities, body-fat composition or other physiological differences.
- Becoming exhausted or immobilized, especially due to injury or entrapment, may speed up the effects of cold weather.
- Aging – the elderly are more vulnerable to the effects of harsh winter weather.

There are numerous strategies for preventing cold stress. Some of them are simple, common-sense strategies that employees should learn and practice. These include wearing appropriate protective clothing, limiting the duration of exposure to cold, replacing fluids (this is just as important in cold environments as it is in hot environments), eating a proper diet to ensure that the body is able to generate metabolic heat, and keeping the feet and all other extremities dry.

Modern safety and health professionals in settings where cold stress is an issue should establish a cold stress prevention component as part of their overall safety and health program. The American National Safety Council

recommends that such a program contain the following elements: (Goetsch, D.L. 2000: 101)

1. Medical supervision and screening.

Medical screening involves identifying individuals who are particularly susceptible to cold stress (who are in poor physical condition, overweight, and/or have cardiovascular problems). Medical supervision involves medical checkups.

2. Orientation and training

Employees should learn about the hazards associated with extremes of cold and how to protect themselves and fellow workers, including the use of proper clothing, appropriate work scheduling, proper work practices, and first aid procedures.

3. Work practices

Employees should understand and use proper work practices including regularly scheduled fluid replacement and periodic rest break in a warm environment.

4. Engineering and administrative controls

Responsible company officials should reduce hazard levels as much as possible through the application of appropriate engineering and administrative controls. The following list summarizes engineering and administrative controls.

- Use central or spot heating, warm air jets, contact warm plates, or radiant heaters to provide warmth.
- Shield the work area from wind.

- Cover the handles of metal tool with insulating material.
- Remove metal chairs or cover them with insulating material.
- Provide heated tents or shelter and require worker to use them periodically for warming breaks.
- Provide warmed drinks for fluid replacement (nonalcoholic, caffeine-free, properly balanced).
- Require an acclimatization period of all new workers.
- Use the buddy system and rotate the employees frequently.
- Design the job to minimize sitting or standing still and design the job so that as many tasks as possible can be performed in a warm environment.

The following cold-weather working precautions have been recommended by Dr.Greaney P.P.

- Provisions should be made to allow new employees to adjust to cold working conditions.
- Employees should be educated on proper re-warming techniques, first aid treatment, appropriate clothing practices, eating and drinking requirements and recognition of cold-related injuries/illnesses.
- Employees should work in a buddy system when temperatures are very low as a protective observation measure.
- The workload should not be so intense that it causes heavy sweating.

- When possible, employers should schedule work during the warmest hour of the day and allow employees to set their own work pace and take breaks as needed.

- Eye protection should be provided to employees who may be exposed to ice crystals.

ACGIH (The American Conference of Governmental Industrial Hygienists) has recommended removal and treatment if a worker exposed to cold shows signs or symptoms of cold stress or injury, the worker must be removed from further exposure and treated by an appropriate first aid attendant or a physician. (Queen's Printer, Canadian Governments, 2007: online)

D. Thermal Stress Indices

There are several thermal stress indices (OSHA, 2007: online) such as ET Index (The Effective temperature index), HSI Index (The Heat-Stress index), Humidex, and WBGT Index (The Wet Bulb Globe Temperature index).

D.1 ET Index

The effective temperature index combines the temperature, the humidity of the air, and air velocity. This index has been used extensively in the field of comfort ventilation and air-conditioning. ET remains a useful measurement technique in mines and other places where humidity is high and radiant heat is low.

D.2 HSI Index

The Heat-Stress Index was developed by Belding and Hatch in 1965. Although the HSI considers all environmental factors and work rate, it is not completely satisfactory for determining an individual worker's heat stress and is also difficult to use.

D.3 Humidex (Canadian Centre for Occupational Health and Safety, 2007: online)

Humidex is measure of how hot we feel. It is an equivalent temperature index for the general public to express the combined effects of warm temperatures and humidity. It provides a number that describes how hot people feel, much in the same way the equivalent chill temperature, or “wind chill factor” describes how cold people feel. Humidex is used as a measure of perceived heat that results the combined effect of excessive humidity and high temperature.

The Weather Service of Environment Canada uses humidex number to inform public when conditions of heat and humidity are possibly uncomfortable as shown in Table I below:

Table I Degree of comfort

Humidex	Degree of comfort
20-29	comfortable
30-39	some discomfort
40-45	great discomfort
Above 45	dangerous
Above 54	heat stroke imminent

source: Canadian Centre for Occupational Health and Safety, 2007: online

Please reminds that humidex is intended for the general public to express combined effects of warm temperatures and humidity. It is not intended to monitor conditions that may result in occupational heat-related illnesses. Industrial hygienists recommend using The WBGT index to measure workplace conditions. Furthermore, direct comparison between WBGT and humidex is not possible because there are no conversion tables or mathematical formulas to do such conversions. (Canadian Centre for Occupational Health and Safety, 2007: online)

D.4 WBGT Index

The Wet Bulb Globe Temperature is a composite temperature used to estimate the effect of temperature, humidity and solar radiation on humans. It was developed by the United States Marine Corps at Parris Island in 1956 to reduce heat stress injuries in recruits and has been revised several times. (wikipedia encyclopedia, 2007: online)

It is derived from the following formula:

Outdoor with solar radiation

$$\text{WBGT} = 0.7T_w + 0.2 T_g + 0.1 T_d$$

where

T_w = Natural wet-bulb temperature (humidity indicator)

T_g = Globe thermometer temperature (to measure solar radiation)

T_d = Dry-bulb temperature (normal air temperature)

Temperatures may be in either Celsius or Fahrenheit

Indoors, or when solar radiation is negligible.

$$\text{WBGT} = 0.7T_w + 0.3 T_g$$

Average WBGT

$$\text{WBGT}_{\text{av}} = \frac{(\text{WBGT}_1)t_1 + (\text{WBGT}_2)t_2 + \dots + (\text{WBGT}_n)t_n}{T_1 + t_2 + \dots + t_n}$$

when t = working time period (min)

when t = working time period (min)

E. Thermal Comfort (Ergonomics a school Company, 2007: online)

A suitable physical climate is needed if you are to feel comfortable and to be efficient at work. The workers may feel comfortable when they are barely aware of the climatic conditions. It is only when the temperature decreases or increases beyond anyone comfort limits that he or she become aware of discomfort.

For temperature, the comfort zone is about 20-22 degrees Celsius for a clothed person in the winter, and 20-24 degrees Celsius in the summer. An increase in temperature above the comfort level may make people tired and sleepy. A decrease in temperature may make people restless and less attentive. People vary in their feelings about what is a comfortable temperature, and this depends on what they are doing and what they are wearing.

Age and gender can also make a difference. Old people, people with disabilities, babies and young children typically feel more comfortable at higher temperatures. Women notice that they are feeling cool quicker than men, which may be related to their different body size, but is also related to a difference in the how quickly women respond to changes in temperature. Women reduce the blood flow to their extremities faster than men if they cool down, resulting in colder fingers and toes. This reduction in blood flow is a way of regulating body temperature.

For the elderly, it is important to avoid large contrasts in temperature, for instance, when moving between one room to another, as this may affect their cardiovascular health.

F. Thailand Thermal Standards

The Ministry of Industry (MOI) and the Ministry of Labor (MOL) have enacted compatible thermal standards as show in Table II

Table II Thailand Thermal Standards

Work-Load	WBGT in Celsius	
	MOI	MOL
Light work	34.0	34.0
Medium work	32.0	32.0
Heavy work	30.0	30.0

Source: - The Secretariat of the Cabinet, 2006: 14
 - The Secretariat of the Cabinet, 2003: 7

G. Work-Load Assessment

Work-Load category is determined by averaging metabolic rates for the tasks and then ranking then as shown in Table III.

Table III Work-load Ranking

Work-load	Work-load (Kcal-hr)		
	MOI	MOL	U.S. ACGIH
Light work	Up to 200	Up to 200	Up to 200
Medium work	200-350	200-350	200-350
Heavy work	350-500	Max. 350	350-500

Source: - The Secretariat of the Cabinet, 2006: 14
 - The Secretariat of the Cabinet, 2003: 7
 - OSHA (Occupational Safety and Health Administration), 2007: online.

Where heat conditions in the rest area are different from those in the work area, the metabolic rate (M) should be calculated using a time-weighted average, as follows:

$$M_{AV.} = \frac{(M_1)t_1 + (M_2)t_2 + \dots + (M_n)t_n}{t_1 + t_2 + \dots + t_n}$$

M = metabolic rate

T = time in minutes

Some activity examples of work-load are shown in Table IV.

Table IV Some Activity Examples of Work-Loads

Work-load	Activities
Light work	writing, hand knitting, typing data recording, sewing, product inspection, watch repairing
Medium Work	floor cleaning, beating a carpet, driving a truck or tractor
Heavy work	railroad track laying, digging, barking tree, hammering.

Source: - The Secretariat of the Cabinet, 2006: 14

- The Secretariat of the Cabinet, 2003: 6

Some activity examples of metabolic rates are shown in Table V

Table V Assessment of Activity Metabolic Rates

Activities	Average kcal/min
Walking along	2.0 - 0.3
Sitting still	0.3
Standing still	0.6
Walking uphill	Add 0.8 for every meter rise
Light hand work	0.4
Heavy hand work	0.9
One arm light work	1.0
One arm heavy work	1.7
Both arms light work	1.5
Both arms heavy work	2.5
Light whole body work	3.5
Moderate whole body work	5.0
Heavy whole body work	7.0-9.0

Source: OSHA, 2007: online

H. American Thermal Standards

OSHA (Occupational Safety and Health Administration) has not set a limit or any regulations on heat exposure. Two other agencies, ACGIH (The American Conference of Governmental Industrial Hygienists and NIOSH (the National Institute on Occupational Safety and Health) have made heat exposure recommendations. Although these are not enforceable, you may find them useful ammunition in the fight against heat hazards. Some jurisdiction regions such as Federal Canada, British Columbia, Alberta, Manitoba, Quebec, New Brunswick and Nova Scotia have a thermal regulations similar to ACGIH TLVs for heat stress. (Canadian Centre for Occupational Health and Safety, 2007: online) ACGIH TLVs for heat exposure is shown in Table VI

Table VI ACGIH TLVs for heat Exposure

Work / rest regimen (each hour)	WBGT (in celsius)		
	Light	Moderate	Heavy
75% Work, 25% Rest	30.6	28.0	25.9
50% Work, 50% Rest	31.4	29.4	27.9
25% Work, 75% Rest	32.2	31.1	30.0
Continuous work	30.0	26.7	25.0

Source: OSHA, 2007: online

I. Conclusion / Recommendation

Heat stress is more popular than cold stress, especially in Thailand. Heat stress can be controlled by many measures such as acclimatization, fluid replacement,

engineering controls, Administrative controls and work practices, worker monitoring programs, and personal protective equipments. Cold stress is harder to be controlled. Cold acclimatization requires month or several months. In very cold conditions, both acclimatized and unacclimatized persons are recommended using appropriate protective clothing. Exposure to extreme thermal conditions is dangerous to health. Heat stroke and hypothermia can be causes of deaths without appropriate treatments.

In Thailand, compatible standards of heat exposure are enacted by MOI and MOL. WBGT is related to work-load without consideration of work/rest regimen. ACGIH TLVs for heat Exposure would be recommended. However, enforcement capacity and difficulty should be also considered.

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