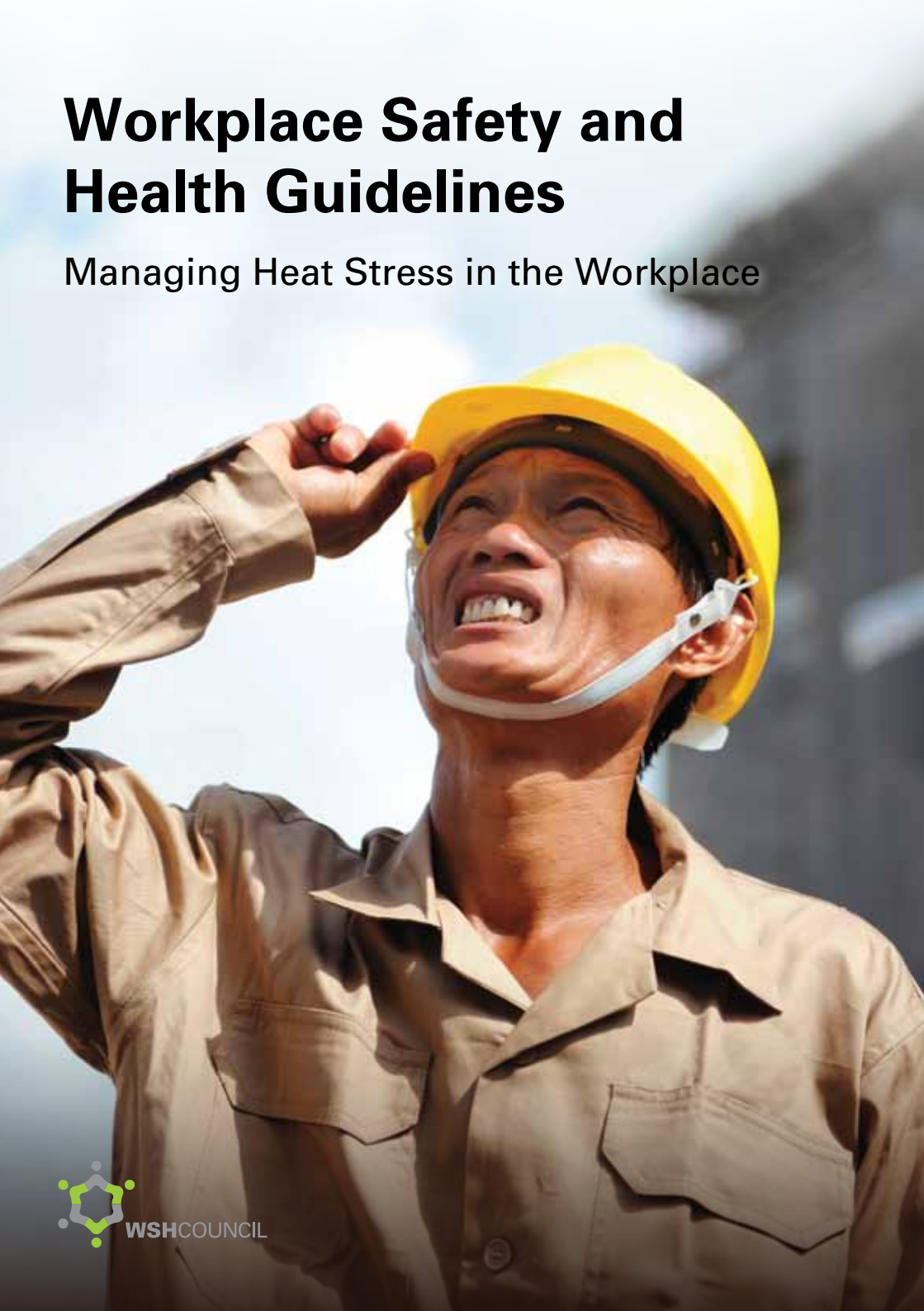
Workplace Safety and Health Guidelines

Managing Heat Stress in the Workplace



WSHCOUNCIL

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1. Introduction

Singapore's weather is becoming warmer. The ambient temperature has been increasing and this is also recorded in many places around the world—a phenomenon known as global warming.

Working in Singapore's hot and humid weather can put your workers at an increased risk of heat stress. This set of guidelines will help you to implement measures for and advice to your workers working in hot environments to prevent them from developing heat stress.

Heat stress, if not controlled well, can lead to the development of heat stroke. This can have serious consequences and all stakeholders are reminded that they are responsible under the Workplace Safety and Health (WSH) Act to ensure that measures are taken to minimise the risk of heat stress among their workers. The WSH (Risk Management) Regulations also require workplaces to conduct risk assessments and take measures to eliminate or reduce risks. These include ensuring that all workers are properly acclimatised to the local weather conditions before they are deployed to operate on the worksite.

Prevention is the key. Many factors that contribute to heat-related illnesses can be controlled to reduce the potential for harm.

2. Heat Stress

Heat is generated by the body as well as acquired from the external environment. When it is cold, the body generates heat through shivering. When there is an excess of heat, the body attempts to lose this extra heat through the evaporation of sweat from the skin surface.

Heat stress occurs when the accumulation of heat in the body exceeds the ability of the body to remove the extra heat. The normal human body maintains the core temperature within a very narrow range. Outside these limits, vital organs will fail, the person can become unconscious and die.

The main body mechanism to lose extra heat is through the evaporation of sweat. Sweating alone without evaporation causes the body to lose water without losing much heat. Evaporation takes place when sweat changes from liquid to gaseous state. Sweat will evaporate more when the air has a lower moisture content (low relative humidity) and less evaporation will take place when the air has high moisture content (high relative humidity). During intense physical work, the body can lose more than one litre of fluid per hour through sweating. When a large amount of body fluid is lost through sweating, dehydration can occur and this impairs blood circulation and the regulation of body temperature. Therefore, water replacement, through drinking, and the maintenance of adequate hydration, is important for the human sweating mechanism to continue to function optimally.

However, heat stress can still occur even as the body is trying to remove the excess heat. There are numerous syndromes associated with excess body heat, the most relevant being heat cramps, heat exhaustion and heat stroke.

2.1 Heat Cramps

Heat cramps is one of the earliest signs of heat stress. The most common symptom is the tonic contraction of muscles ("cramping") which usually happens in the legs. It is often the result following heavy physical work and is due to fluid and electrolyte losses caused by heavy sweating.

This can be treated by rest, replacement of the fluid and electrolytes (through drinking water or isotonic "sports drinks") and massaging the affected muscles.

2.2 Heat Exhaustion

Heat exhaustion occurs when the loss of water and electrolytes from the body is so high, that it affects the blood flow to vital organs. It commonly presents as a sensation of "feeling weak", dizziness or fainting. Other symptoms include headaches, blurring of vision and abdominal pain. The worker would be sweating heavily and his body temperature would usually be higher than normal.

Treatment is through cessation of physical activity, cooling of the body and active replacement of fluids and electrolytes. Transfer the worker to a shady or air-conditioned area (if available), remove extra layers of clothing and sponge the person down with a wet towel or cloth while fanning him. Restore circulation by laying him down and elevating the legs about 30 cm (1 foot) above ground. Replacement of fluids by drinking may not be adequate and intravenous administration of fluids (in a hospital) may be necessary.

2.3 Heat Stroke

When the body is unable to remove extra heat, the core temperature may continue to increase to cause heat stroke. The affected person may be incoherent or unable to talk clearly, unconscious and lose control of his bladder and bowel functions. In some cases, the sweating mechanism may also fail, resulting in a "hot body" that is not sweating. As the body temperature rises, damage will occur to the vital organs of the body, such as the brain, kidney and liver. If not treated quickly, death will occur.

First aiders and workers themselves must be alert to the early signs and symptoms of heat stress. Workers who feel unwell, dizzy, or have headaches, and painful cramps, should seek immediate attention.

Heat stroke must be suspected as one of the causes if a worker collapses at the workplace, without signs of external injury.

In the treatment of heat stroke, the first important step is to cool the body. Transfer the worker to a shady or air-conditioned area (if available), remove extra layers of clothing and sponge him down with a wet towel or cloth while fanning him. If the worker is conscious and if it is possible, he should be encouraged to drink water. Restore circulation by laying him down and elevating the legs about 30cm (1 foot) above ground. As the above is being done, arrangement should be made to call for an ambulance and evacuate the worker to a hospital.

The signs and symptoms of heat stress can change in a worker. First aiders should not use absence or presence of sweating as a guide to diagnosis and initiate treatment. They should always attempt to cool the body as long as there is the slightest suspicion that the worker is suffering from heat stress.

2.4 Factors in the Workplace that Contribute to Heat Stress

The factors that contribute to heat stress in the workplace can be divided broadly into three groups:

a. Personal Worker Factors
b. Type/ Nature of Work
c. Work Environment

2.4.1 Personal Worker Factors

Personal worker factors include heat acclimatisation, hydration, medication and illness. Workers coming from a colder country would need their bodies to "get used" to the hot temperatures in Singapore. This process, in which the human body learns to function in hot environments, is called heat acclimatisation. Hydration, or the amount of water drunk by the worker, is an important factor. Workers in hot environments or doing strenuous work must be encouraged to drink enough water. The employer must ensure that drinking water is made readily available to all workers. Workers who are ill, on medication, or who have just recovered from illnesses are at higher risks of developing heat stroke. For this group of workers, depending on the circumstances, a short period of re-acclimatisation may be beneficial.

Other risk factors of developing heat stroke include immune suppression, older age, diabetes, obesity, alcohol consumption and certain medications.

2.4.2 Type / Nature of Work

The work load (heavy or light), rate of work (fast or slow), type of work (strenuous or sedentary) and clothing worn (e.g., special heavy or impermeable clothing requirements) can also contribute to heat stress. Employers must be aware of the overall burden and demand of the work that their workers are doing, and allocate manpower and resources appropriately, to reduce the risk of heat stress. Whenever practical, regular rest periods during heavy work should also be instituted.

2.4.3 Work Environment

The work environment refers to the temperature, humidity and ventilation at the workplace. Although these factors are often beyond the control of employers, work should be planned or scheduled with this consideration in mind. Extremely strenuous work should be scheduled to avoid the hottest time of the day and adequate ventilation must be provided to workers in confined spaces.

3. Duties under the Workplace Safety and Health Act and its Subsidiary Legislations

3.1 WSH Act

The intent of the WSH Act is to inculcate good safety habits and practices in all individuals in the workplace; from top management to the front line worker. It requires every person in the workplace to take reasonably practicable measures to ensure the safety and health of every worker in the workplace.

Employers have a duty to provide a reasonably practicable working environment that is safe and without risk to their employees' health.

Employees not only have a duty to take reasonable care for their own health and safety but also that of others in the workplace.

In the WSH (General Provisions) Regulations, reasonable practicable measures have to be taken by the occupier to ensure that persons at work in the factory are protected from excessive temperatures and hamful radiations. In a compressed air environment (e.g., during tunnelling works), the WSH (Construction) Regulations specify that the temperature in any working chamber, man-lock or medical lock in a worksite shall not exceed 29°C and the relative humidity shall not exceed 85%.

The employer or occupier should under the WSH (Incident Reporting) Regulations report heat stroke cases to the Ministry of Manpower. This can be done electronically via ***http://mom.gov.sg/iReport***

For full details on the WSH Act, visit MOM website at http://www.mom.gov.sg/workplace-safety-health/wsh-regulatory-framework/Pages/workplace-safety-health-act.aspx

4. Risk Assessment

Under the WSH (Risk Management) Regulations, risk assessments are to be conducted to address the safety and health risks posed to any person who may be affected by the activities in the workplace. Risk assessment is the process of:

1. Identifying and analysing safety and health hazards associated with work
2. Assessing the risks involved and
3. Prioritising measures to control the hazards and reduce the risks

Figure 4.1: Discussion on risk assessment by supervisors.

Risk assessment allows us to identify the hazards in the workplace and implement effective risk control measures before they escalate into accidents and injuries.

Under the new WSH (Risk Management) Regulations, every workplace, including factories, should conduct risk assessments for all routine and non-routine work undertaken.

Useful Guides on Risk Management

- Guide to WSH (Risk Management) Regulations
- Quick Guide to Risk Assessment
- Risk Assessment Guidelines
- Activity Based Risk Assessment Form
- Trade Based Risk Assessment Form

For more information on risk assessment, refer to the Guidelines on Risk Assessment at http://www.mom.gov.sg/workplace-safety-health/safety-health-management-systems/Pages/risk-management.aspx

5. Measurement of Environmental Heat Stress

Heat stress can be assessed by measuring one or more of environmental, work, or worker factors, and then utilising the appropriate heat stress index. An environmental heat stress index is one of the indicators of risk for heat injuries and should be used in conjunction with other factors to assess overall risk.

Several heat stress indices have been developed and these include the Wet Bulb Globe Temperature (see Appendix) and the Heat Stress Index.

The Meteorological Services Division of National Environment Agency (NEA) is implementing a 3G Weather Observation System comprising more than 60 online automatic weather stations covering many parts of Singapore including offshore islands. The system is a web-based application which allows easy access by users and it provides near real-time Heat Index readings over 17 spatially distributed locations in Singapore automatically on a daily 24-hour basis.

There are two heat index readings available, Heat Stress 1 which is the heat index in a well-ventilated and shaded place, and Heat Stress 2 which is the heat index in a well-ventilated space outdoors under the sun. When fully commissioned, there will be around five stations with Heat Stress 2 information and around 17 stations providing Heat Stress 1 information. The Heat Stress readings and other weather information will be provided in a Meteorological Services Division website that will be launched in the future.

Employers may then refer to the website readings from their nearest online automatic weather station, and adopt the appropriate risk management strategy. However, these readings are indicative of outdoor conditions and may not accurately reflect indoor conditions like confined spaces.

6. Preventive Actions

6.1 Heat Acclimatisation

Newly assigned workers, especially those who come from a colder climate must be acclimatised to the hot weather. This will allow the body to adapt slowly to the hot environment. New workers would need at least one to two weeks to adjust to the local weather conditions and workload. They should not start working at full workload in the hot environment upon arrival. Workers should undergo a 14-day heat acclimatisation (HA) programme in the first two weeks of employment. HA comprises daily exposure to heat stress (working under hot environment) for up to 14 days. HA can take the form of gradual increase in work duration under the hot environment over two weeks, for example, increasing from 2 hours per day to the full work duration over 14 days.

For example, the worker's workload should be gradually increased, starting with two hours of work and heat exposure on the first day and increasing it by an hour every day. For the rest of the day, they may be assigned to other tasks which do not require them to work under the hot environment. For example, if the workers are working outdoors, they should not be working under the direct sun during the hottest part of the day (11 am to 3 pm) during their first two days of work. On the third day, they may be exposed for an hour more, increasing their hours by one hour every subsequent day. See Figure 1 for an example of a suitable acclimatisation schedule.

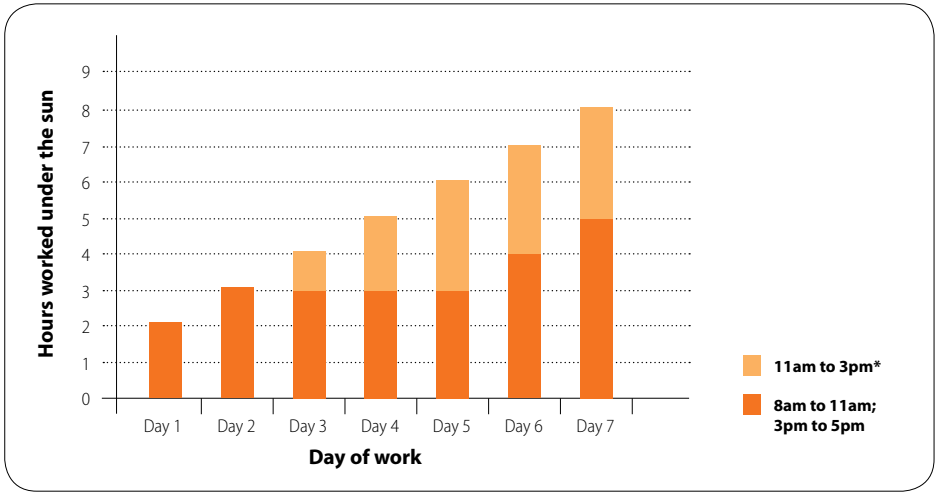

Figure 1: Example of acclimatisation schedule
*** Assuming that the lunch hour is from noon to 1pm and that there are regular rest breaks.**

The schedule in Figure 1 is for work under the sun and the worker should not be working under direct sun during the other hours. The timings can be adjusted to suit workers who may need a longer period to acclimatise.

During the period of acclimatisation, workers should be closely supervised and be given the flexibility to have more rest breaks or a longer acclimatisation period if this is needed. Work targets should not be excessive. They should be monitored closely for symptoms of heat stroke and they must report to their supervisors if they feel unwell during the acclimatisation period. Where practicable, such workers can wear arm bands or helmet tags to allow for easy identification.

Acclimatisation is lost during periods when there is no exposure to heat stress. Workers returning from a prolonged leave (more than one week) should be re-acclimatised. Workers returning from prolonged illness should consult a doctor before going back to work; they should also be re-acclimatised.

6.2 Adequate Water Intake and Drinking Facilities

Workers should start the day well-hydrated by making sure that they are not thirsty and that their urine colour is clear or light yellow. Workers should also be encouraged to keep themselves hydrated all the time by drinking sufficient water to quench their thirst. Urine colour is not a good indicator of hydration state during physical exertion.

When working in hot environments, each worker should be encouraged to quench their thirst all the time and consume at least to 500 ml of water every hour. Supervised drinking or "water parades" can help ensure this.

Figure 6.2.3: Worker should carry bottled water when at work and drink water frequently.†

† Use hard plastic bottles. Reusing disposable plastic bottles may pose a health risk.

Figure 6.2.3: Provide cool drinking water at convenient and accessible locations (e.g., on top of buildings and deck of ships where practicable).

6.3 Work Schedule and Provision of Mechanical Aids

Heavy physical work or work under the sun should be scheduled to the cooler parts of the day (early morning or late afternoon) where possible.

Alternate work and rest periods, for example, 5 minutes of rest with every 25 minutes of work should be adopted under moderately hot conditions. Under severe conditions, the duration of rest period must be increased.

Mechanical aids (e.g., lifting equipment and power tools) should be used to reduce physical workload, where possible.

Figure 6.3: Workers' rest point under shade.†

† Workers can sponge or rinse themselves with ice or tap water (for instance, during breaks or meals). Body cooling is important especially on days when environmental heat stress is high.

6.4 Shaded Areas for Work and Rest

Shaded areas (e.g., temporary shelters) should be provided for workers who have to spend a significant amount of time under the sun. Such areas can also be set up on top of buildings/ deck of ships, and so on, where practicable.

Cool shaded rest areas should be provided for workers to have their breaks away from heat. Cool drinking water should also be provided at the rest areas.

6.5 Clothing in Outdoor Environment

Workers should wear loose-fitting light-coloured clothing while working in the hot environment and hats can be used, if appropriate.

6.6 Worker Training and Reporting

All workers must be educated on the dangers of complacency, risk factors, symptoms and seriousness of heat-related disorders, the preventive measures they can take and the importance of immediate reporting to their supervisors and seeing a doctor, if they or their fellow workers feel unwell.

Workers should complete the Construction Safety Orientation Course (CSOC) before starting work.

Workers should work with their fellow workers as buddies and watch out for symptoms of heat stroke for each other.

6.7 Fitness to Work

Workers should pass their pre-employment medical examinations. Workers who are ill should report to their supervisors and see a doctor before starting work to assess their fitness to work.

Worksites can implement daily checks for symptoms of flu and cold such as blocked nose, cough, sore throat, headache, and so on. Workers with these symptoms should seek medical attention.

Workers should also be encouraged to adopt a healthy lifestyle with a well-balanced diet with sufficient intake of nutrients and vitamins in their diets, adequate sleep and exercise. Workers should avoid the excessive intake of coffee and alcohol.

Heat Stress Prevention Tips	
Acclimatisation	Newly assigned workers, especially those who come from a colder climate must be acclimatised to the hot weather. They should not start working at full workload in the hot environment upon arrival.
Adequate water intake and drinking facilities	Encourage workers to drink sufficient water to quench their thirst. Cool drinking water should be provided at convenient locations, close to their work areas.
Work schedule	Alternate work and rest periods under hot conditions. Rest periods must be increased when the weather is hotter. Heavier work should be scheduled for the cooler parts of the day.
Shaded areas for work and rest	For workers who have to spend a significant amount of time under the sun, shaded areas should be provided for them to have their breaks away from the heat.
Clothing	Workers should wear appropriate loose-fitting and light-coloured clothing while working in the hot environment suitable to the task.
Fitness to work, training and reporting	All workers should pass their medical examinations and must know the symptoms and seriousness of heat-related disorders, the preventive measures and importance of immediate reporting to their supervisors and seeing a doctor. They should watch out for symptoms of heat stroke for each other.

7. Checklist for Prevention of Heat Stress in the Construction Industry

Company Name : _____

Work Location : _____

Work Description : _____

Preventive Measures	Yes	No	Remarks
Acclimatisation			
Are all new workers and those returning from the colder climates acclimatised to work in the hot environment? (Refer to the recommended acclimatisation schedule.)			
Sufficient Water Intake and Drinking Facilities			
Is there a daily supervised water parade? (E.g., before starting work and/or during lunch or tea breaks.)			
Are workers provided with cool drinking water at convenient locations close to their work areas?			
Work Schedule			
Wherever possible, is heavy physical work scheduled during the cooler part of the day? (The hottest period of the day is usually between 11 am and 3 pm.)			
Are workers permitted to take short breaks particularly in very hot weather or heavy physical work? (E.g., 5-minute rest for every 25 minutes of heavy or hot work.)			
Shaded Areas for Work and Rest			
Are workers provided with shaded areas where they can work or rest?			
Clothing in Outdoor Environment			
Are workers wearing loose-fitting and light-coloured clothing?			

Preventive Measures	Yes	No	Remarks
Worker Training and Early Reporting			
Have all the workers been educated on the symptoms of heat-related disorders and the measures to take or observe before starting work?			
Have all the workers attended the Construction Safety Orientation Course (CSOC)?			
Have the workers been instructed to immediately report to their supervisor if any of them is feeling unwell and has to consult a doctor?			
Is there a buddy system where the workers can look out for each other?			
Are supervisors and safety officers trained to recognise and provide emergency first-aid treatment for heat-related disorders?			
Fitness to Work			
Have all the workers undergone and passed the pre-employment medical examination? (E.g., workers with diabetes and heart diseases may be more prone to heat disorders.)			
Have the workers been advised to see a doctor if they are feeling unwell and if they experience vomiting, diarrhoea or a fever?			

Comments on assessment:

_____

_____

_____

Recommended actions to control the risk of heat stress:

_____

_____

_____

Name and designation of person who conducted the assessment:

_____

Date: _____

8. Recommended Reading List

- ACGHI®, 2009 TLVs® and BEIs® with 7th ed., Documentation, CD-ROM
- NIOSH Safety and Health Topic: Heat Stress, http://www.cdc.gov/niosh/topics/heatstress
- OSHA Technical Manual on Heat Stress, http://www.osha.gov.dts/osta/tom/otm_iii/otm_iii_4.html
- Preventing Heat Stress at Work, Worksafe BC, http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/heat_stress.pdf
- Prevention of Heat Stroke at Work in a Hot Environment, Occupational Safety and Health Branch, Labour Dept, Hong Kong, http://www.labour.gov.hk/eng/public/oh/heat.pdf
- Risk Assessment for the Prevention of Heat Stroke, Occupational Safety and Health Branch, Labour Dept, Hong Kong, http://www.labour.gov.hk/eng/public/oh/HeatStress.pdf
- Weather Wise, Meteorological Services Division, National Environmental Agency.
- Work in Hot or Cold Environments 2001, WorkCover NSW Health and Safety Code of Practice, http://www.workcover.nsw.gov.au/formspublications/publications/Documents/cop_2001_work_hot_cold%20environments_0309.pdf
- Workplace Safety and Health Act.
- Workplace Safety and Health (General Provision) Regulations.
- Workplace Safety and Health (Risk Management) Regulations.
- Workplace Safety and Health (Construction) Regulations.
- Workplace Safety and Health Guidelines: Landscape and Horticultural Works, https://www.wshc.sg/wps/themes/html/upload/cms/file/Landscaping%20new.pdf

9. Acknowledgements

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DSO National Laboratories	A/P Fabian Lim Chin Leong
Singapore Armed Forces (SAF)	LTC (Dr) Ng Wee Tong
Meteorological Services Division, National Environment Agency (NEA)	Dr Chew Kian Hoe
National Environment Agency (NEA)	Mr Lim Kew Leong
ExxonMobil	Ms Kim Ng
Ministry of Manpower (MOM)	Dr Kenneth Choy
Ministry of Manpower (MOM)	Dr Ler Teck Siang
Workplace Safety and Health Council (WSH Council)	Mr Han Kin Sew

Photographs courtesy of Jian Huang Construction Co Pte Ltd and Spazio Construction Pte Ltd.

10. Appendix

Wet Bulb Globe Temperature (WBGT) Index

The environmental conditions which influence the heat equilibrium of the body and its physiological responses are air temperature, humidity, air movement and the temperature of surrounding objects. The physiological effects of these conditions are influenced by the intensity of the work, the health status of the worker, and the clothing worn.

There are various indicators available for assessing thermal environment. The most widely used indicator is the Wet Bulb Globe Temperature (WBGT). It is a simple and quick technique of measuring the environmental factors which correlate with deep body temperature and physiological response to heat. It can be performed by semi-skilled personnel.

The WBGT index requires knowledge of three measurements—the natural wet bulb temperature (Tnwb), the globe temperature (Tg), and the dry bulb air temperature (Ta). The measurement of these factors is explained in the next section.

For outdoors with a solar load (i.e., radiation from the sun), WBGT is calculated using the following formula.

$$WBGT = 0.7\ Tnwb + 0.2\ Tg + 0.1\ Ta$$

For indoor or outdoor conditions without a solar load, WBGT is calculated as

$$WBGT = 0.7\ Tnwb + 0.3\ Tg$$

For example:
In an outdoor environment, the air temperature is 30 °C, the globe temperature is 40 °C, and the natural wet bulb temperature is 25 °C. Hence the WBGT is

$$\begin{aligned} WBGT &= 0.7\ Tnwb + 0.2\ Tg + 0.1\ Ta \\ &= 0.7 \times 25^{o}C + 0.2 \times 40^{o}C + 0.1 \times 30^{o}C \\ &= 17.5^{o}C + 8^{o}C + 3^{o}C \\ &= 28.5^{o}C \end{aligned}$$

How are the environmental factors measured?

Instruments used for measuring environmental factors or for determining the WBGT index should always be located so that the readings obtained will be truly representative of the environmental conditions to which the worker is exposed to. Sensors should, at least, be the same height as the worker. Before obtaining the readings, there must be sufficient time for the instrument to reach equilibrium with the environmental conditions after it has been set up.

Dry Bulb or Air Temperature

The dry bulb temperature (Ta) is the temperature of the ambient air as measured with a thermometer. The simplest type of thermometer used for measuring dry bulb temperature is liquid-in-glass thermometer (see Figure 10.1). Under field (outdoor with solar radiation) conditions, the sensing element should be shielded from direct radiant energy, for example, by using an aluminium foil.

Natural Wet Bulb Temperature

The natural wet bulb temperature (Tnwb) is the temperature measured by a thermometer which has its sensor covered by a wet cotton wick and exposed to the natural prevailing air movement unshielded from radiation. One inch or 2.5 cm of wet wick should be exposed to the air above the top of the reservoir. The wick should be wet to the tip at all times with distilled water (see Figure 10.1).

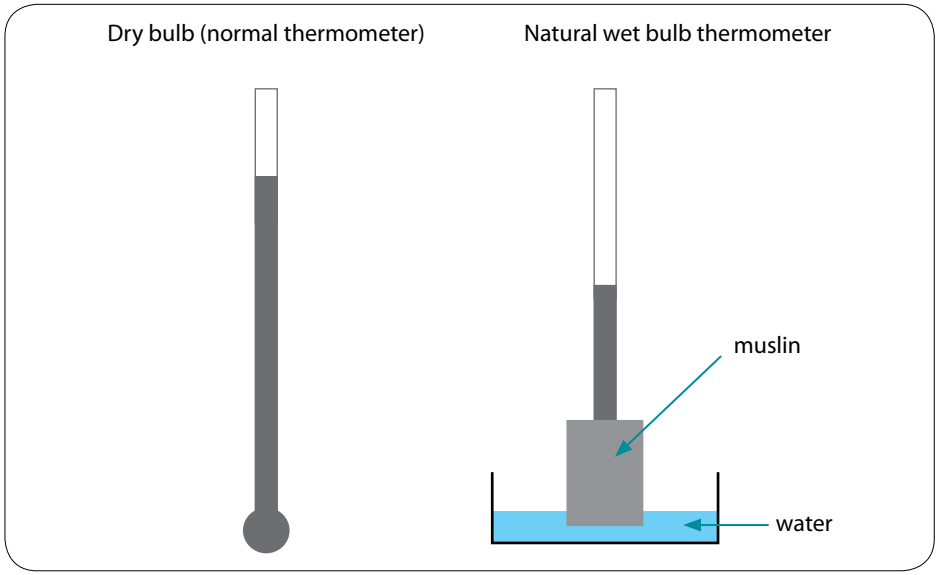

Figure 10.1: **Dry bulb and natural wet bulb thermometers.**

Globe Temperature

The globe temperature (Tg) is the temperature measured by a black globe thermometer. It is a thin-wall, blackened copper sphere, with a thermometer at its center (see Figure 10.2).

The temperature attained by the globe thermometer depends on the transfer of radiant heat (solar or infrared radiation) between it and the surrounding, and the convective heat exchange with the ambient air, which in turn depends on ambient temperature and air movement.

The standard six-inch globe thermometer requires 15 to 20 minutes to be stabilised; whereas small globe thermometers with a 4.2 cm (1.65-inch) diameter, require about five minutes.

Figure 10.2: **WBGT monitor (including Globe thermometer).**

Heat Stress Monitor

Portable direct reading heat stress meters or monitors (see Figure 10.3) are also available for measuring WBGT index. These instruments can calculate both the indoor and outdoor WBGT values according to the WBGT formulas.

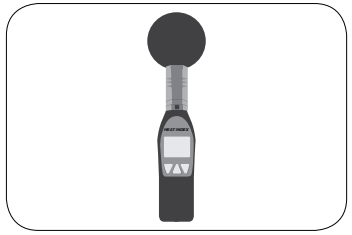

Figure 10.3: **Example of portable heat index monitor.**

What are the permissible limits?

The risk of heat-related stress depends on the WBGT. In general, the following criteria can be used for risk assessment.

- WBGT < 31°C: Low risk
- WBGT 31°C – 31.9°C: Moderate risk
- WBGT 32°C and above: High risk

(See section on Heat Stress Evaluation and Control below.)

There are two sets of permissible WBGT, namely the Threshold Limit Values (TLV®) WBGT for acclimatised workers (Table 1A) and Action Limit WBGT for unacclimatised workers (Table 1B). The permissible WBGT values depend on two basic parameters: metabolic demands of the task and work-rest cycle (percentage or proportion of work within an hour).

The TLV® WBGT as recommended by the American Conference of Governmental Industrial Hygienists (ACGIH®) represents conditions under which it is believed that nearly all heat acclimatised, adequately hydrated, un-medicated and healthy workers may be repeatedly exposed to without adverse health effects. The goal of the TLV is to maintain the body core temperature within 1°C of normal (37°C), that is, without exceeding 38°C.

Table 1A

TLV (WBGT values for acclimatised persons)

	TLV (WBGT in °C)			
Allocation of Work in a Cycle of Work & Rest	**Light**	**Moderate**	**Heavy**	**Very Heavy**
75% to 100% work	31.0	28.0	–	–
50% to 75% work	31.0	29.0	27.5	–
25% to 50% work	32.0	30.0	29.0	28.0
0% to 25% work	32.5	31.5	30.5	30.0

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Acclimatised persons are persons who are adapted to working in the hot environment. Acclimatisation comprises the daily exposure to heat stress for up to 14 days and can be the gradual increase in work duration under the hot environment.

The Action Limit WBGT is established to protect unacclimatised workers and represents conditions for which a heat stress management programme should be considered.

Table 1B

Action Limit (WBGT values for unacclimatised persons)

	Action Limit (WBGT in °C)			
Allocation of Work in a Cycle of Work & Rest	**Light**	**Moderate**	**Heavy**	**Very Heavy**
75% to 100% work	28.0	25.0	–	–
50% to 75% work	28.5	26.0	24.0	–
25% to 50% work	29.5	27.0	25.5	24.5
0% to 25% work	30.0	29.0	28.0	27.0

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Metabolic Rate Demands

To determine the degree of heat stress exposure, the metabolic demands or work rate must be considered. Correct assessment of work rate as important as environmental assessment in evaluating heat stress. Table 2 provides broad guidance for selecting the work rate to be used in Table 1.

Table 2

Metabolic Rate Categories and the Representative Metabolic Rate with Example Activities.

Category	Metabolic Rate (W)*	Examples
Rest	115	Sitting.
Light	180	Sitting with light manual work with hands or hands and arms, and driving; standing with some light arm work and occasional walking.
Moderate	300	Sustained moderate hard and arm work, moderate arm and leg work, moderate arm and trunk work, or light pushing and pulling; normal walking.
Heavy	415	Intense arm and trunk work, carrying, shovelling, manual sawing; pushing and pulling heavy loads; and walking at a fast pace.
Very heavy	520	Very intense activity at fast to maximum pace.

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Unacclimatised persons are those who are not adapted to working in the hot environment and this can include those who come from countries with a colder climate. A person can become unacclimatised during periods when there is no exposure to heat stress, for example workers returning from a prolonged leave (more than one week). These workers should be re-acclimatised.

* The effect of body weight on the estimated metabolic rate can be accounted for by multiplying the estimated rate by the ratio of actual body weight divided by 70 kg (154 lb).

Clothing Adjustment Factor

The WBGT-based heat exposure assessment was developed for the traditional work uniform—a long-sleeved shirt and pants. If workers are required to wear non-traditional clothing, an appropriate clothing adjustment factor should be added to the measured WBGT, in accordance with Table 3.

Table 3

Clothing Adjustment Factors for some Clothing Ensembles*

Clothing Type	Addition to WBGT (°C)
Work clothes (long-sleeved shirt & pants)	0
Cloth (woven material) coveralls	0
Double-layer woven clothing	3
SMS polypropylene coveralls	0.5
Polyolefin coveralls	1.0
Limited-use vapour-barrier coveralls	11.0

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

For example:
An acclimatised worker performs moderate physical work at a construction worksite from 3 pm to 4 pm without a rest. Polyolefin coveralls are worn. The air temperature is 30°C, the globe temperature is 40°C, and the natural wet bulb temperature is 25°C. Hence the WBGT is:

$$\begin{aligned} \text{WBGT} &= 0.7\ \text{Tnwb} + 0.2\ \text{Tg} + 0.1\ \text{Ta} \\ &= 0.7 \times 25^{\circ}\text{C} + 0.2 \times 40^{\circ}\text{C} + 0.1 \times 30^{\circ}\text{C} \\ &= 17.5^{\circ}\text{C} + 8^{\circ}\text{C} + 3^{\circ}\text{C} \\ &= 28.5^{\circ}\text{C} \end{aligned}$$

From Table 3, the clothing adjustment factor for Polyefin coveralls is 1.0.
The WBGT adjusted for clothing = (28.5 + 1.0)°C = 29.5°C.

For an acclimatised person, the permissible WBGT from Table 1A is 28°C [for moderate physical work at 100% work-rest cycle (i.e., no rest)].

As the WBGT is higher than the permissible level, the exposure is excessive.

Time-Weighted Average WBGT

When a worker is not continuously exposed in a single hot area but moves between two or more areas with different levels of environmental heat, or when the environmental heat varies substantially at a single hot area, environmental heat exposures should be measured for each area and each level of environmental heat the employees are exposed to. The time-weighted average (TWA) WBGT index should be calculated as being the mean of the WBGT values for each environment, weighted for the respective duration of exposure.

$$\text{TWA WBGT} = \frac{\text{WBGT}_1 \times T_1 + \text{WBGT}_2 \times T_2 + \ldots \text{WBGT}_n \times T_n}{T_1 + T_2 \ldots\ldots + T_n}$$

where WBGT1, WBGT2, …WBGTn are measured values of WBGT for the various work and rest intervals during the total time period; T_1, T_2,…Tn are the duration of the respective intervals in minutes.

Heat Stress Evaluation and Control

Based on metabolic rate category for the work and the appropriate proportion of work within an hour, a WBGT criterion can be found in Table 1A for the TLV WBGT and Table 1B for the Action Limit WBGT.

Low Risk (If TWA WBGT is less than Action Limit)
If the measured TWA WBGT adjusted for clothing is less than the Action Limit in Table 1B, there is little risk of excessive exposures to heat stress.

Moderate Risk (If TWA WBGT is more than Action Limit, but less than Threshold Limit)
If the measured TWA WBGT adjusted for clothing is above the Action Limit in Table 1B, but below the TLV in Table 1A, the general controls in Annex 1, which included drinking of water and pre-placement medical screening, should be implemented.

If there are reports of the symptoms of heat-related disorders such as fatigue, nausea, dizziness, and light-headedness, then the analysis should be reconsidered.

High Risk (If TWA WBGT is more than Threshold Limit)
If the measured TWA WBGT adjusted for clothing is above the TLV in Table 1A, then a further analysis is required. This may include monitoring heat strain (physiological responses to heat stress), and signs and symptoms of heat-related disorders listed below. An individual's exposure to heat stress should be discontinued when any of the following occurs.

In addition, job-specific controls (Annex 2) should be implemented.

- Sustained (several minutes) heart rate in excess of 180 beats per minute minus the individual's age in years, that is, above (180 – age),
- Body core temperature is greater than 38.5°C in acclimatised personnel; or greater than 38°C in unacclimatised workers,
- Recovery heart rate at one minute after a peak work effort is greater than 120 beats per minute, and
- There are symptoms of sudden and severe fatigue, nausea, dizziness or light-headedness.

By monitoring the environmental factors at the worksite, the level of heat stress that workers are exposed to can be determined. Taking this into consideration and the type of work being performed, heat stress can be effectively managed, thereby preventing heat disorders or heat-related injuries amongst workers.

Annex 1

Heat Stress Management and Controls—General Controls

- Provide verbal and written instructions, annual training and other information about heat stress and strain.
- Encourage workers to drink small volume (about one glass) of cool water every 20 minutes.
- Allow self-limitation of exposures and encourage co-worker observation to detect signs and symptoms of heat strain in others.
- Monitor and counsel those who abuse alcohol or other intoxicants, and those who take medications that may compromise normal cardiovascular, blood pressure, body temperature regulation, and renal or sweat gland functions.
- Encourage healthy lifestyles, ideal body weight and electrolyte balance.
- Adjust expectations of those returning to work after absence from hot exposure situations.
- Ensure workers have adequate salt intake from their diets.
- Consider pre-placement medical screening to identify those susceptible to systemic heat injury.
- Monitor the heat stress conditions and reports of heat-related disorders.

Annex 2

Heat Stress Management and Controls Job—Specific Controls

- Consider engineering controls that reduce the metabolic rate, for example, using mechanical devices for material handling.
- Provide general air movement, for example, using blowers or stand fans.
- Shield radiant heat sources, for example, by erecting temporary shelters shield against solar radiation.
- Consider administrative measures that set acceptable exposure times, allow sufficient recovery, and limit physiological strain.
- Consider personal protection that were demonstrated to be effective for the specific work practices and conditions at the location.

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Workplace Safety and Health Council
Website: www.wshc.sg
Email: contact@wshc.sg