DEPARTMENT OF OCCUPATIONAL SAFETY AND HEALTH
MINISTRY OF HUMAN RESOURCES
MALAYSIA

GUIDELINES ON

HEAT STRESS MANAGEMENT

AT WORKPLACE 2016

PREFACE

This guideline may be cited as the Guidelines on Heat Stress Management at Workplace.

This guideline provides guidance on how to recognize, estimate, prevent and treat heat stress at work. It also serves as a guide to employers in avoiding discomfort from hot environment at work. Risk assessment and risk control has been elaborated in this guideline based on heat stress estimation using wet bulb globe temperature (WBGT). Heat stress can increase stress and fatigue which can lead to serious health conditions for workers working in hot environments and may increase workplace accidents.

Findings from enforcement activities and heat stress assessment at various workplaces showed that many workplaces in Malaysia involving machineries or processes of extreme temperatures are at significant risk. Low awareness among employers and employees on exposure to heat stress is common and need to be addressed.
This guideline is meant to be used by employers having hot environment and activities at work. This guideline will be reviewed from time to time. Employers and occupational safety and health practitioners are encouraged to give their comments in writing to the Department of Occupational Safety and Health, Malaysia so that this guideline can be continuously improved.

All employers are requested to adopt and adapt this guideline as a source of reference in managing heat stress at workplace and to fulfill one of the general duties under the Occupational Safety and Health Act 1994 and the Factories and Machinery Act 1967.

I would like to thank and acknowledge those who have contributed in the development of this guideline.

Director General
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2016

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This guideline has been endorsed by the department's Policy Review Committee chaired by the Director General of The Department of Occupational Safety and Health (DOSH).

LIST OF ABBREVIATION

ACGIH : American Conference of Governmental Industrial Hygienist
AL : Action Limit
DOSH : Department of Occupational Safety and Health
FMA : Factories and Machinery Act 1967
ISO : International Organization for Standardization
OSHA : Occupational Safety and Health Act 1994
PPE : Personal Protective Equipment
Rh : Relative Humidity
SHW : Safety, Health and Welfare Regulation 1970
T_{db} : Dry Bulb Temperature
T_g : Globe Temperature
TLV : Threshold Limit Value
T_{nwb} : Natural Wet Bulb Temperature
V : Air Velocity
WBGT : Wet Bulb Globe Temperature

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this guideline is to provide guidance on how to recognize, estimate, prevent and treat heat stress at work. Parameters of heat stress are introduced in this guideline to guide employers in avoiding discomfort from hot environment at work. The guideline also elaborates on risk assessment and risk control based on heat stress estimation using wet bulb globe temperature (WBGT). A warm or hot environment can compromise concentration, vigilance, or steadiness of employees. It is one of the general duties of employer and self-employed person as prescribed under the Occupational Safety and Health Act 1994 [Act 514] to provide a safe working environment and without risk to their employees' health. Employees also have the duty to take reasonable care for their own safety and health and of others at work. The employers have to take practicable measures to ensure employees are protected from excessive heat exposure while at work.

1.2 SCOPE AND APPLICATION

The guidelines-

(a) establish primary factors which contribute to heat stress

(b) establish screening criteria as hazard identification using qualitative methods;

(c) establish measurement of environmental heat stress

(d) describe method used for risk assessment

(e) describe heat stress management and control; and

(f) specify other appropriate occupational safety and health measures.

This guideline applies to all economic sectors under the purview of Occupational Safety and Health Act 1994 [Act 514] where there are people at work. Typical heat stress measurements from various industries in Malaysia can be found in Appendix 1.

2.0 LEGAL REQUIREMENTS

This guideline provides practical guidance and advice on how to comply with the provisions of these Acts:

2.1 OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA) 1994

Section 15(1) and Section 15(2)(e) of Occupational Safety and Health Act 1994 stipulates the duty of employers and self-employed persons to their employees. The provision and maintenance of a working environment for the employees should be as far as is practicable, safe and without risk to health while at work.

2.2 FACTORIES AND MACHINERY ACT (FMA) 1967

Section 22(d) (i) stipulates effective and suitable provision shall be made for securing and maintaining such temperature in ensuring reasonable conditions of comfort and prevention from bodily injury to any person employed in a factory.

Section 22(d) (ii) stipulates, a standard of reasonable temperature may be prescribed by the Minister to prohibit the use of any methods of maintaining a reasonable temperature, which in his opinion are likely to be injurious.

Factories and Machinery (Safety, Health and Welfare, SHW) Regulation, 1970

Regulation 28(1) stipulates if operation of any machinery or any process that gives rise to undue heat, an Inspector may require that suitable provision to be made to reduce the effect thereof on any person employed to such extent that he may consider reasonable and practicable.

Regulation 28(2) stipulates if the Inspector is of the opinion that the temperature in a factory or part thereof, is unduly high, adequate means shall be provided to cool the air or to create adequate air movement, or both, in order to reduce the body temperature of any person employed.

Regulation 28(3) stipulates if any building constructed wholly or partly of materials having a high coefficient of heat transmission that were subjected to the heat of the sun, the material shall be lined with suitable insulating material or coated with white paint, white-wash or other heat reflecting material.

3.0 OVERVIEW

Human thermal body exchange occurs with environmental conditions and activity. For internal body temperature to be maintained around 36–37.5°C, there must be equilibrium between the amount of heat generated within the body and the heat transfer to or from it. The heat balance equation can be described below:

$$H = M - W = E + R + C + K + S$$

Where,

H= Heat balance

M= Metabolic heat production

W= External work

E=Evaporation

R=Radiation

C=Convection

K=Conduction

S=Storage

Total heat stress can be reduced by modifying one or more of the above factors. Figure 3.1 illustrates the heat balance between human body and the environment.

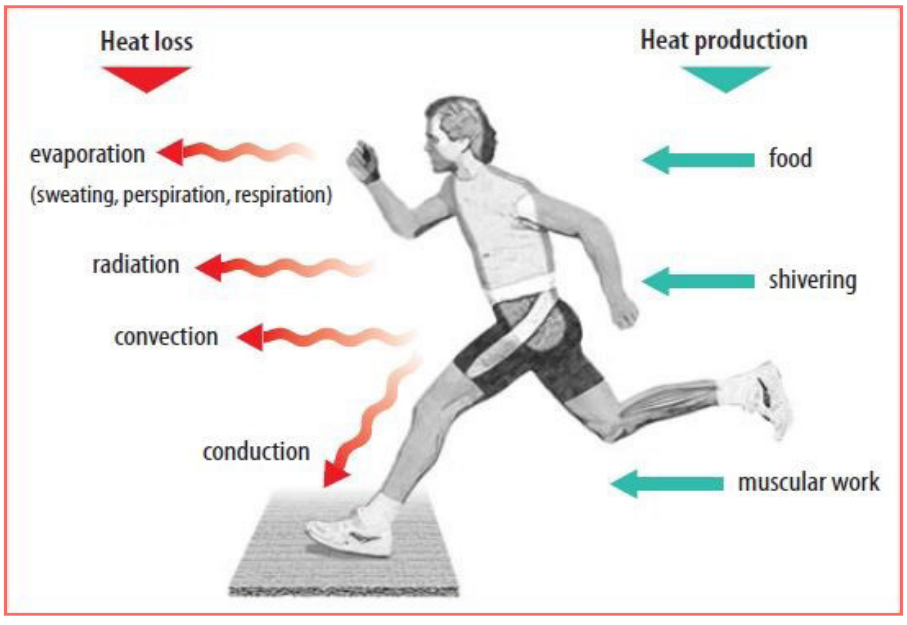

Figure 3.1: Heat production and heat loss from human body

Working in a hot environment or exposure to high temperatures can cause stress to the body. When this stress combined with physical activities, dehydrate and fatigue can lead to disruptions in the body (heat rash, heat cramps, heat exhaustion, heat stroke, heat collapse, heat fatigue). Heat stress is physical hazards which may cause health effects, either directly or indirectly to employees. It occurs when the body fails to regulate internal temperature and the temperature may not return to normal by itself.

Heat stress can be the cause of serious health problem for workers who have to work in hot environments, especially when the workers also exposed to high humidity conditions at the same time. It can also increase stress and fatigue, as well as providing greater opportunities for accidents at work. In 2012, an accident occurred at a local steel manufacturing plant, where an employee in furnace division fainted while having his meal and being diagnosed with heat stroke. Now, the worker is suffering with slurred speech and generalised body tremor. The employer has done medical removal protection to the victim by transferring him to the heat free environment. There were another three cases reported in year 2013 and 2014 due to heat related illness which has led to multiorgan failure. Those cases occurred among trainees during field training under the hot sun.

The finding of heat stress assessment and enforcement conducted by DOSH, shows that employees are exposed to heat stress through high temperature process and machinery. The assessment also found that employers and employees are lack of knowledge and awareness of heat exposure and its risk to health. Clothing and personal protective equipment worn by employees are inappropriate and there is no proper work schedule for the employees. The findings confirmed the necessity of having standards or guidelines to evaluate heat stress exposure at work as a guidance to employers in Malaysia.

3.1 WHAT IS HEAT STRESS?

Heat stress is the overall heat load to which an employee 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. Heat stress occurs when the body's means of controlling its internal temperature starts to fail.

3.2 HOW DOES THE BODY REACT TO HEAT?

The body reacts to heat by increasing the blood flow to the skin's surface, and by sweating. This results in cooling as sweat evaporates from the body's surface and heat is carried to the surface of the body by the increased blood flow. Heat can also be lost by radiation and convection from the body's surface.

3.3 TYPICAL EXAMPLE OF A HEAT STRESS SITUATION

Someone wearing protective clothing and performing heavy work in hot and humid conditions could be at risk of heat stress because:

- sweat evaporation is restricted by the type of clothing and the humidity of the environment
- heat will be produced within the body due to the work rate and, if insufficient heat lost, core body temperature will rise
- as core body temperature rises the body reacts by increasing the amount of sweat produced, which may lead to dehydration
- heart rate also increases which puts additional strain to the body

- if the body is gaining more heat than it can lose, the deep body temperature will continue to rise
- eventually it reaches a point when the body's control mechanism itself starts to fail

The symptoms will worsen if someone remains working in the same conditions.

3.4 WHAT ARE THE EFFECTS OF HEAT STRESS?

Heat stress can affect individuals in different ways, and some people are more susceptible to it than others.

Typical symptoms are:

- An inability to concentrate
- Muscle cramps
- Heat rash
- Severe thirst - a late symptom of heat stress
- Fainting
- Heat exhaustion - fatigue, giddiness, nausea, headache, moist skin
- Heat stroke - hot dry skin, confusion, convulsions and eventual loss of consciousness. This is the most severe disorder and can result in death if not detected at an early stage

3.5 FACTORS THAT CONTRIBUTE TO HEAT STRESS

Many factors contribute to heat stress. To prevent heat stress, employers and employees must be able to recognize and understand source of heat and how the body removed excess heat. The most commonly used indicator of heat stress is air temperature. However, air temperature alone is not a valid or accurate indicator for heat stress. It should be always considered in relation to other environmental and personal factors.

The factors affecting heat stress are categorized as environmental and non-environmental factors as in Table 1. These factors may be independent, but together can contribute to an employee's heat stress.

Table 1 - Factors That Contribute To Heat Stress

ENVIRONMENTAL FACTORS	NON ENVIRONMENTAL FACTORS
Air Temperature Air Velocity Radiant Temperature Relative Humidity	Personal Factors - Clothing - Health Condition - Acclimatisation - Hydration Work Factors - Metabolic Heat - Work Rate (Light/Moderate/Heavy)

3.5.1 ENVIRONMENTAL FACTORS

i. Air temperature

This is the temperature of the air surrounding the body. It is usually given in degrees Celsius (°C).

ii. Radiant temperature

Heat radiation is the heat that radiates from a warm object. Radiant heat may be present if there are heat sources in the environment. Radiant heat can affect people who are exposed to direct sunlight or close to process area which emits heat. Examples of radiant heat sources include: the sun, fire, heaters, kiln walls, cookers, dryers, hot surfaces and machinery, boilers, furnaces molten metals etc.

iii. Air velocity

This describes the speed of air moving across the employee and may help cool them if the air is cooler than the environment.

Air velocity is an important factor in heat stress. For example:

- still or stagnant air in indoor environments that are artificially heated may cause people to feel stuffy. It may also lead to a build-up in odour.
- moving air in warm or humid conditions can increase heat loss through convection without any change in air temperature.
- physical activity also increases air movement, so air velocity may be corrected to account for a person's level of physical activity.
- small air movements in cool or cold environments may be perceived as a draught as people are particularly sensitive to these movements.

iv. Relative humidity

If water is heated and it evaporates to the surrounding environment, the resulting amount of water in the air will provide humidity. Humidity in indoor environments can vary greatly, and may be dependent on whether there are drying processes (e.g. paper mills, laundry) where steam is given off. High humidity environments have a lot of vapour in the air, which prevents the evaporation of sweat from the skin. In hot environments, humidity is important because less sweat evaporates when humidity is high (above 80%). The evaporation of sweat is the main method of heat reduction.

Relative humidity is the ratio between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at that air temperature. Relative humidity between 40% and 70% does not have a major impact on heat stress. In workplaces which are not air conditioned, or where the weather conditions outdoors may influence the indoor heat environment, relative humidity may be higher than 70%.

When non-breathable vapour-impermeable personal protective equipment (PPE) is worn, the humidity inside the garment increases as the wearer sweats because the sweat cannot evaporate. If an employee is wearing this type of PPE (e.g. asbestos or chemical protection suits) the humidity within the PPE will be high.

3.5.2 NON ENVIRONMENTAL FACTORS:-

i. Clothing insulation

Heat comfort is very much dependent on the insulating effect of clothing on the wearer. Wearing too much clothing or PPE may be a primary cause of heat stress even if the environment is not considered warm or hot. Clothing is both a potential cause of heat discomfort as well as a control for it as employees adapt to workplace climate. It is important to identify how the clothing contributes to heat comfort or discomfort. By periodically evaluating the level of protection provided by existing PPE and evaluating newer types of PPE, employer may be able to improve the level of heat comfort.

ii. Work Rate and Metabolic Heat

Metabolic heat is the heat produced by the body through chemical processes, exercise, hormone activity, digestion, etc. The more physical work we do, the more heat we produce. The more heat we produce, the more heat needs to be lost so we don't overheat. The impact of metabolic rate on heat stress is critical. A person's physical characteristics should always be borne in mind when considering their heat stress, as factors such as their size and weight, age, fitness level and sex can all have an impact on how they feel, even if other factors such as air temperature, humidity and air velocity are all constant.

3.6 GROUP OF EMPLOYEES AND INDUSTRIES AFFECTED

Employees exposed to hot indoor environments or hot and humid conditions outdoors are at risk of heat-related illness, especially those doing heavy work tasks or using bulky or non-breathable protective clothing and equipment. Some workers might be at greater risk than others if they have not built up a tolerance to hot conditions, including new workers, temporary workers, or those returning to work after a week or more off or if they have certain health conditions. Table 2 shows some environmental and job-specific factors that increase the risk of heat-related illnesses.

Table 2: Factors That Put Workers at Greater Risk

ENVIRONMENTAL	• High temperature and humidity • Radiant heat sources • Contact with hot objects • Direct sun exposure (with no shade) • Limited air movement (no breeze, wind or ventilation)
JOB-SPECIFIC	• Physical exertion • Use of bulky or non-breathable protective clothing and equipment

Heat exposure may occur in many workplaces. Examples of workplaces where people might suffer from heat stress because of the hot environment created by the process, or restricted spaces can be found in Table 3.

Table 3: Activities Exposed To Heat by Economic Sectors

SECTOR	EXAMPLE OF WORKPLACES	ACTIVITIES
Manufacturing	Glass and rubber manufacturing plants, chemical plants, conventional and nuclear power plants	Foundries and smelting operations, metal refining, support activities for oil and gas operations. Boilers, sterilisers and furnaces operations.
Mining and Quarrying	Limestone and granite quarries. Gold and bauxite mining.	Blasting, loading, site clearing, hauling and crushing
Construction	Building and residential construction	Tunneling, brick laying, bar bending, plastering, painting
Agriculture, Forestry and Fishing	Palm oil plantations, paddy fields,	Farming, logging, harvesting, seeding, animal feedings
Utilities	Gas processing plant, water processing plants , power plants	Heavy work under hot sun, cleaning
Transport, Storage and Communication	Depot, telecommunication substation	Mail delivery, manual handling, vehicle maintenance and cleaning, substation maintenance, cable installation
Wholesale and Retail Trades	Warehouse	Stock transfer and replenishment, Manual handling
Hotels and Restaurants	Bakeries, commercial kitchen, confectioneries	Cooking, bread/cake baking
Finance, Insurance, Real Estate and Business Services	Laundries, Landfills, Waste-water treatment plants, office building	Dry cleaning, drying and pressing (ironing), domestic waste collection and segregation, cleaning/painting of exterior building
Public Services and Statutory Authorities	Training centre (outdoor), federal/ state road, government hospital	Field Training, Fire-fighting, road-traffic control, clinical waste collection

4.0 TYPES OF HEAT RELATED ILLNESS

Exposure to abnormal or prolonged amounts of heat and humidity without relief or adequate fluid intake can cause various types of heat related illness as the following:

Heat Rash

Heat rash is the most common problem in hot work environments. It causes discomfort and itchiness. Heat rash is caused by sweating and looks like a red cluster of pimples or small blisters. Heat rash may appear on the neck, upper chest, groin, under the breasts and elbow creases.

i. Heat cramps

These are muscle pains usually caused by the loss of body salts and fluid during sweating. Workers with heat cramps should replace fluid loss by drinking water and/or carbohydrate-electrolyte replacement liquids (e.g. isotonic drinks) every 15 to 20 minutes.

ii. Heat Exhaustion

This is the next most serious heat-related health problem. Heat exhaustion is the body's response to an excessive loss of the water and salt, usually through excessive sweating. The signs and symptoms of heat exhaustion are headache, nausea, dizziness, weakness, irritability, confusion, thirst, heavy sweating and a body temperature greater than 100.4°F (38°C).

iii. Heat Syncope

Heat syncope is a fainting (syncope) episode or dizziness that usually occurs with prolonged standing or sudden rising from a sitting or lying position. Factors that may contribute to heat syncope include dehydration and lack of acclimatisation. Symptoms of heat syncope include light-headedness, dizziness and fainting.

iv. Heat Stroke

This is the most serious form of heat injury and is considered a medical emergency. Heat stroke results from prolonged exposure to high temperatures and usually in combination with dehydration, which leads to failure of the body's temperature control system. The medical definition of heat stroke is a core body temperature greater than 105 degrees Fahrenheit (40.5°C), with complications involving the central nervous system that occur after exposure to high temperatures. Other common symptoms include nausea, throbbing headache, seizures, confusion, disorientation, and rapid, shallow breathing. Heat stroke can cause death or permanent disability if emergency treatment is not given.

Detailed explanation on signs and symptoms on heat related illnesses can be found in Appendix 2.

5.0 ASSESSMENT AND MEASUREMENT OF HEAT STRESS

5.1 ASSESSMENT OF HEAT STRESS

Systematically, before any heat stress measurement is carried out as part of monitoring the condition of workplace, we should identify the hazard and evaluate the risk. Simple checklist such as in Appendix 5 can be used as a guide.

The checklist will have few indicators based on personal risk factors and its qualitative values which provide us the decision whether the condition posed a risk to the workers. If any of the indicators lies within the high risk region (red colour) as found in the risk score table in Appendix 5, then the need to proceed with the heat stress measurement is required.

It is important to measure the heat stress load imposed to worker's body as it may affect the worker's ability to work and could lead to many heat related illness. There are many common indices being used by the industry to assess the level of risk to the workers like Wet Bulb Globe Temperature, Heat Stress Index, and many more. There are many standards being used to measure the exposure of the workers to the environmental conditions as shown in Appendix 3.

The wet bulb globe temperature (WBGT) index is the most widely used and accepted index for the assessment of heat stress in industry. Estimation of heat stress based on the WBGT can be referred to ISO 7243.

The WBGT index is an empirical index. It represents the heat stress to which an individual is exposed. The index was developed specifically for use in industrial settings. The practicalities of an industrial application necessitated a compromise between the requirement for a precise index and the need to be able to easily take controlled measurements. When the WBGT values are exceeded, a more advanced index (ISO 7933) Predicted Heat Strain or Required Sweat Rate method should be used to provide a more accurate estimation of heat stress.

This guidelines focuses on the evaluation of heat stress using WBGT values and compares them with the reference values of action limit and the Threshold Limit Value produced by ACGIH. A flow of heat stress assessment is shown in Figure 5.1 and Figure 5.2

IDENTIFICATION OF THERMAL HAZARDS FLOW CHART

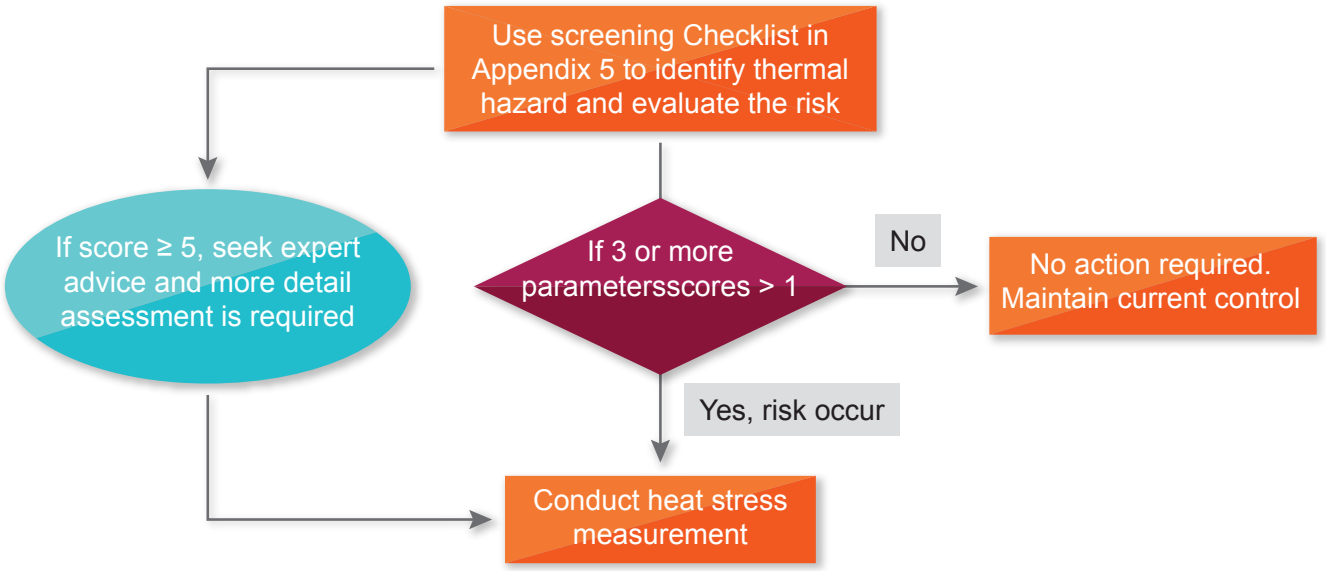

Figure 5.1: Screening Flow Chart

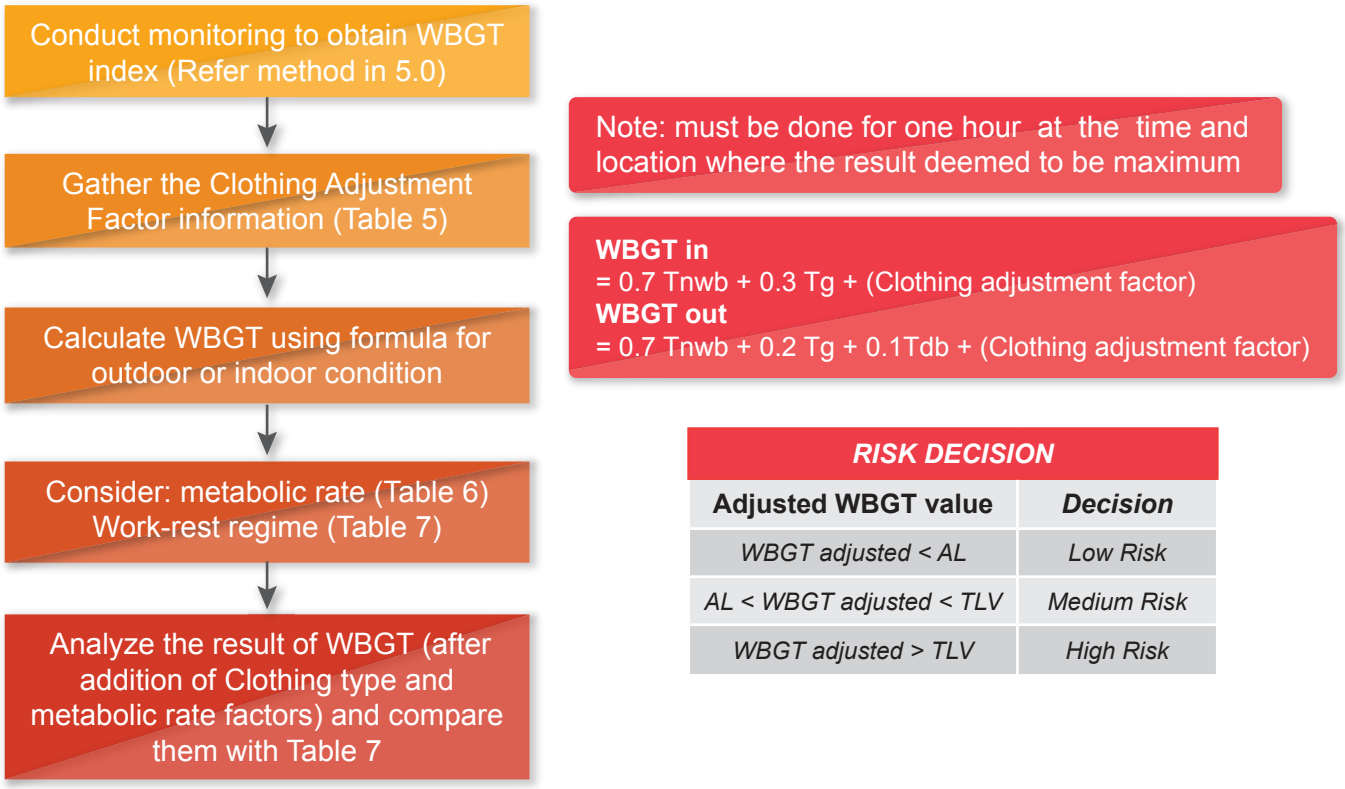

Figure 5.2: Heat Stress Measurement Flow Chart

5.2 METHOD OF MEASUREMENT AND PARAMETERS

5.2.1 THE MEASUREMENT OF HEAT STRESS

5.2.1.1 POSITION OF MEASURING EQUIPMENT

ISO 7243 states that for rapid determination of the WBGT index, it is sufficient to carry out one measurement at 1.1 meters from the floor level where the heat stress is maximum. The equipment will be placed as near as possible to the source of heat.

Figure 5.3: Typical Heat Stress Instruments

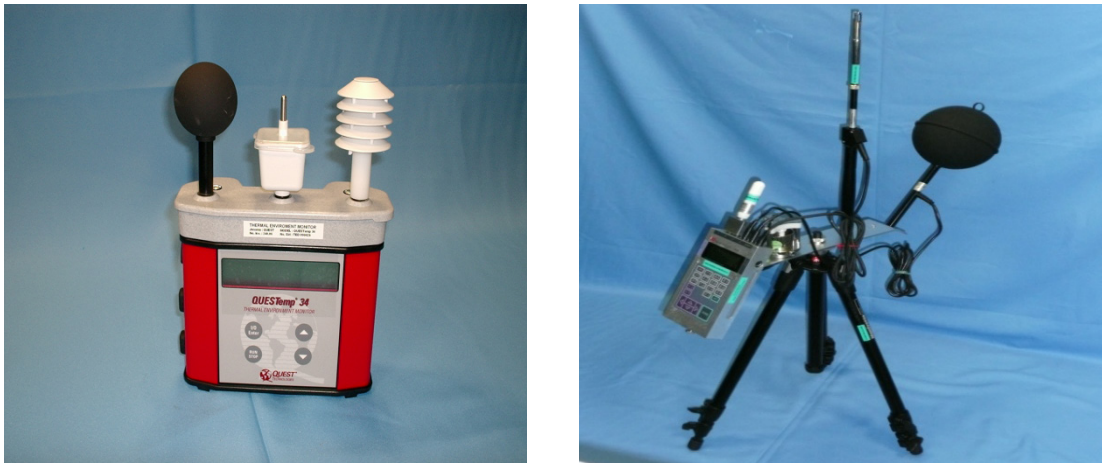

Figure 5.4: Heat Stress Sensors

Table 4: Equipment for Heat Stress Measurement

NO	SENSORS	NAME OF EQUIPMENT AND FUNCTION
1.		**Dry Bulb Sensor** To measure air temperature by using a thermometer freely exposed to the air but shielded from radiation and moisture.
2		**Natural Wet Bulb Sensor** To measure air temperature by using an ordinary thermometer, but the only difference is that the bulb of the thermometer is covered by the wet cloth / wick.
3		**Globe Temperature Sensor** To measure air temperature by using a black globe with a thermometer inserted in the center.
4		**Air Velocity Sensor** To measure air velocity by sensing the pressure produced by the movement of the air.

5.2.2 MEASUREMENT PARAMETERS

The parameters to be measured are:

i) Dry Bulb Temperature, T_{db}

ii) Natural Wet Bulb Temperature, T_{nwb}

iii) Globe Temperature, T_g

iv) Relative Humidity, Rh

v) Wet Bulb Globe Temperature, WBGT

vi) Air Velocity, V

The parameters are defined as the following:

i. Dry Bulb Temperature, T_{db}

Measured by a thermal sensor, such an ordinary mercury in glass thermometer, that is shielded from direct radiant energy sources.

ii. Natural Wet Bulb Temperature, T_{nwb}

Measured by exposing a wet sensor, such as wet cotton wick fitted over the bulb of a thermometer, to the effects of evaporation and convection. The term natural refers to the movement of air around the sensor.

iii. Globe Temperature, T_g

The temperature measured inside a blackened, hollow, thin copper globe.

iv. Relative Humidity, Rh

The ratio of the quantity of water vapour actually present in any volume of air to the quantity of water which is required to saturate that volume of air (at the same temperature). Relative humidity can be obtained from Psychrometric Charts in Appendix 7.

v. Wet Bulb Globe Temperature, WBGT

Composite temperature used to estimate the effect of temperature, humidity, wind speed, and solar radiation on human. The WBGT is used to determine appropriate exposure and activity levels to high temperatures.

vi. Air Velocity, V

Wind, whether generated by body movements or air movements, is the rate in feet per minute (fpm) or meters per second (m/sec) at which the air moves and is important in heat exchange between the human body and the environment because of its role in convective and evaporative heat transfer.

5.3 SAMPLING DURATION

The time base for measurement of WBGT shall be taken in total one hour corresponding to the maximum heat stress. i.e. generally in the middle of the day or when the heat-generating equipment is in operation. In addition, the measurement time is set to be taken at intervals of every five minutes that will give a total of 12 samples for one hour at specific areas.

5.4 SAMPLING METHODS

5.4.1 ENVIRONMENTAL MEASUREMENTS

Environmental heat measurements should be made at, or as close as possible to, the specific work area where the worker is exposed. When a worker is not continuously exposed in a single hot area but moves between two or more areas having 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 for each level of environmental heat to which employees are exposed.

5.4.2 WET BULB GLOBE TEMPERATURE INDEX

Wet Bulb Globe Temperature (WBGT) should be calculated using the formula shown in Equation 1 and 2:

Equation 1

For indoor and outdoor conditions with no solar load, WBGT is calculated as:

$$WBGT_{in} = 0.7\ T_{nwb} + 0.3\ T_g$$

Equation 2

For outdoors with a solar load, WBGT is calculated as

$$WBGT_{out} = 0.7\ T_{nwb} + 0.2\ T_g + 0.1\ T_{db}$$

where:

WBGT = Wet Bulb Globe Temperature Index

T_{nwb} = Natural Wet-Bulb Temperature

T_{db} = Dry-Bulb Temperature

T_g = Globe Temperature

5.5 MODIFICATION FACTORS OF CLOTHING

Clothing type at work is important because it will affect the final temperature for WBGT. The ACGIH has designated the modification of clothing as shown in Table 5.

Table 5: Clothing-Adjustment Factors for Some Clothing Ensembles*

CLOTHING TYPE	ADDITION TO WBGT (ºC)
Work clothes (long sleeve shirt and pants)	0
Cloth (woven material) coveralls	0
Double-layer woven clothing	3
SMS polypropylene coveralls	0.5
Polyolefin coveralls	1
Limited-use vapor-barrier coveralls	11

Source: Table 1 Clothing adjustment factors from TLV s and BEIs by ACGIH 2015

* Clothing Adjustment Factors cannot be added for multiple layers.

5.6 THE EMPLOYEES METABOLIC RATE

Metabolic rate is influenced by employee's job scope and the duration of heat exposure at work. Table 6 provides broad guidance for selecting the work rate category to be used in Table 7. Table 7 provides the screening criteria for allocations of work and rest.

TLV and action limit are applied as guidance to establish heat stress management programme. The values represent conditions which it is believed that nearly all heat acclimatised, adequately hydrated, unmediated and healthy workers maybe repeatedly exposed to without adverse health effects. The goal of TLV is to maintain the body core temperature within 1ºC of normal (37ºC), without exceeding 38ºC.

Table 6: Metabolic Rate of Employees by Job Category (ACGIH 2015)

WORK CATEGORY	METABOLIC RATE	EXAMPLES
Rest	115 W	Sitting
Light	180 W	Sitting with light manual work with hands or hands and arms and driving. Standing with some light arm work and occasional walking.
Moderate	300 W	Sustained moderate hand and arm work, moderate arm and leg work, moderate arm and trunk work, or light pushing and pulling. Normal walking. Moderate lifting.
Heavy	415 W	Intense arm and trunk work, carrying, shovelling, manual sawing, pushing and pulling heavy loads, and walking at a fast pace. Heavy materials handling.
Very Heavy	520 W	Very intense activity at fast to maximum pace.

Source: Table 3 metabolic rate from TLV s and BEIs by ACGIH 2015

Table 7: Screening criteria for TLV and AL based on ACGIH TLV

SCREENING TLV					SCREENING AL			
% WORK	LIGHT	MODERATE	HEAVY	VERY HEAVY	LIGHT	MODERATE	HEAVY	VERY HEAVY
75 - 100	31.0	28.0	-	-	28.0	25.0	-	-
50 - 75	31.0	29.0	27.5	-	28.5	26.0	24.0	-
25 - 50	32.0	30.0	29.0	28.0	29.5	27.0	25.5	24.5
0 - 25	32.5	31.5	30.5	30.0	30.0	29.0	28.0	27.0

Source: Table 2 screening criteria for TLV and action limit from TLV s and BEIs by ACGIH 2015

6.0 RISK EVALUATION

The risk of heat-related stress depends on the WBGT. In general, the following criteria in Table 8 can be used to make a decision on the severity of the risk.

Table 8: Risk Decision

RISK DECISION	
ADJUSTED WBGT VALUE	DECISION
WBGT adjusted < Action Limit	Low Risk
Action Limit < WBGT adjusted<TLV	Medium Risk
WBGT adjusted > TLV	High Risk

Low Risk: There is a minimum risk of excessive exposure to heat stress

Medium Risk: Implement general control as in Table 9 which includes drinking of water and pre-placement medical screening.

High Risk: Further analysis may be required. This may include monitoring heat strain (physiological responses to heat stress), sign and symptom of heat-related disorders. In addition, job-specific control should be implemented.

6.1 HEAT STRESS EVALUATION AND CONTROL

Based on risk decision obtained, preventive and control measures are recommended to be implemented as in Table 9.

Table 9: Recommended Control Measures According To Risk Decision

LOW RISK (WBGT ADJUSTED < ACTION LIMIT)	MEDIUM RISK (AL<WBGT ADJUSTED<TLV)	HIGH RISK (WBGT ADJUSTED > TLV)
• Continue work • Monitor	General Controls	Implement all general control and applicable job specific control
	• Information, instructions and training • Regular drinks of water • Self-limitation to heat exposure • Health screening and surveillance o Pre placement medical screening	Applicable Job Specific Control • Engineering Controls o Reduce workers activity by providing mechanical aids o Enclose or insulate hot surfaces o Shield workers from radiant heat o Provide air conditioning o Provide adequate ventilation o Reduce humidity where applicable o Rapid cooling area • Administrative controls o Acclimatize workers o Supervision of workers • Work in pairs or groups • Ensure first aid is available • Established emergency procedure

LOW RISK (WBGT ADJUSTED < ACTION LIMIT)	MEDIUM RISK (AL<WBGT ADJUSTED<TLV)	HIGH RISK (WBGT ADJUSTED > TLV)
• Continue work • Monitor	General Controls	Implement all general control and applicable job specific control
	• Encourage reporting symptoms to management • Encourage healthy life styles o Diet o Exercise • Monitor employees with existing medical condition • Personal protective equipment • Cool work rest area	Applicable Job Specific Control o establish work- rest regime to minimize heat exposure o Provide and encourage regular intake of fluid/oral rehydration salt drinks o Dress appropriately o Changing the way of work is done o Regular health screening if required based on employee's medical condition which includes physiological monitoring • Specific personal protective equipment o cool vest o reflective suit o heat transfer suit o cool bandanas

6.2 ACCLIMATISATION

Acclimatisation is the process in which an individual body adjusts to a gradual change in its environment (such as a change in temperature, humidity, photoperiod, or pH), allowing it to maintain performance across a range of environmental conditions. Complete heat acclimatisation generally takes seven to fourteen days. Loss of acclimatisation occurs gradually when a person is moved permanently away from a hot environment. However, a decrease in heat tolerance occurs even after a long weekend. As a result of reduced heat tolerance, it is often not advisable for anyone to work under very hot conditions on the first day of the week.

New employees should acclimatise before assuming a full workload. It is advisable to assign about half of the normal workload to a new employee on the first day of work and gradually increased on subsequent days. Although well-trained, physically fit workers tolerate heat better than people in poor physical condition, fitness and training do not substitute for acclimatisation.

The steps involved in acclimatisation are:

(a) A gradual increase in perspiration, which means more and more heat loss.

(b) The sweat becomes "less salty" as the sweat glands learn to conserve salts. This prevents a salt deficiency in the body which, if it did occur, could lead to muscular cramps.

(c) There is a loss of weight which helps heat loss by reducing the amount of insulating fat and reduces energy consumption.

(d) As the change proceeds, the worker drinks more to replace the fluid lost by sweating.

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8.0 APPENDICES

APPENDIX 1: TYPICAL MEASUREMENTS OF WBGT IN SOME INDUSTRIES IN MALAYSIA

NO	TYPE OF INDUSTRIES	ADJUSTED WBGT (°C)
1	Bricks	26.8 – 30.0
2	Casting	28.8 – 33.1
3	Rubber	30.4 -35.3
4	Confectioneries	30.2 – 31.6
5	Oil and Gas	27.8 – 32.9
6	Aluminum /Metal	31.9 – 33.1
7	Palm Oil Mill	32.3 – 36.7
8	Foundry	30.2 – 40.9
9	Sawmill	31.3 – 34.7
10	Ceramic	29.1 – 35.3
11	Premix plant	27.08 – 31.1
12	Coating	31.04 – 34.8

APPENDIX 2: HEALTH EFFECTS

TYPES OF HEAT ILLNESS	PHYSIOLOGIC DISTURBANCE	PREDISPOSING FACTORS	SYMPTOMS	FIRST AID
Heat rash	Plugging of sweat gland ducts with retention of sweat and inflammatory reaction	• Unrelieved exposure to humid heat with skin continuously wet with unevaporated sweat	• The mildest form of heat rash (**miliaria crystallina)** affects the sweat ducts in the top layer of skin. This form is marked by clear, fluid-filled blisters and bumps (papules) that break easily. • A type that occurs deeper in the skin (**miliaria rubra**) is sometimes called prickly heat. Signs and symptoms include red bumps and itching or prickling in the affected area. • Occasionally, the fluid-containing sacs (vesicles) of miliaria rubra become inflamed and pus-filled (pustular). This form is called **miliaria pustulosa.** • A less common form of heat rash (**miliaria profunda**) affects the dermis, a deeper layer of skin. Retained sweat leaks out of the sweat gland into the skin, causing firm, flesh-colored lesions that resemble goose bumps.	1. Try to work in a cooler, less humid environment when possible 2. Keep the affected area dry
Heat cramps	Loss of electrolytes in sweat. Water intake dilutes electrolytes. Water enters muscles, causing spasm.	Heavy sweating during hot work Drinking large volumes of water without replacing salt loss	Muscle cramps or spasm - Common area calf, arms , abdominal wall and back - weakness - Nausea and vomiting - Headache	1. Worker to rest in shady, and cool area. 2. Worker should drink water or other cool beverages 3. Wait a few hours before allowing worker to return to strenuous work 4. Worker must seek medical attention if cramps don't go away

TYPES OF HEAT ILLNESS	PHYSIOLOGIC DISTURBANCE	PREDISPOSING FACTORS	SYMPTOMS	FIRST AID
Heat Stroke	Failure of thermoregulation (lack of sweating) leading to loss of evaporative cooling and an uncontrolled accelerating rise in temperature. Two types of heat stroke: 1.Classical heat stroke is where there is little or no sweating (usually occurs in children, persons are chronically ill and elderly 2. Exertion where body temperature rises because of strenuous exercise or work and sweat usually present.	• Sustained exertion in heat • Obesity and lack of physical fitness Recent alcohol intake • Dehydration • Individual susceptibility • Chronic cardiovascular disease	• **High body temperature.** A body temperature of 104 F (40 C) or higher is the main sign of heatstroke. • **Altered mental state or behavior.** Confusion, agitation, slurred speech, irritability, delirium, seizures and coma can all result from heatstroke. • **Alteration in sweating.** In heatstroke brought on by hot weather, your skin will feel hot and dry to the touch. However, in heatstroke brought on by strenuous exercise, your skin may feel moist. • **Nausea and vomiting.** You may feel sick to your stomach or vomit. • **Flushed skin.** Your skin may turn red as your body temperature increases. • **Rapid breathing.** Your breathing may become rapid and shallow. • **Racing heart rate.** Your pulse may significantly increase because heat stress places a tremendous burden on your heart to help cool your body. • **Headache.** Your head may throb.	1.Call for a medical emergency 2. Move the worker to a shaded, cool area and remove outer clothing (including socks and shoes). 3. Wet the worker's skin, place cold wet compresses or ice on head, face, neck, armpits, and groin; or soak their clothing with cool water. 4. Circulate the air around the worker to speed cooling

TYPES OF HEAT ILLNESS	PHYSIOLOGIC DISTURBANCE	PREDISPOSING FACTORS	SYMPTOMS	FIRST AID
Heat Syncope/ Orthostatic dizziness	Pooling of blood in dilated vessels of skin and lower parts of body Heat induced dizziness and fainting induced by temporarily insufficient flow of blood to brain while a person is standing.	• Dehydration • Lack of cclimatisation	• Fainting, • Dizziness • Light-headedness during prolonged standing or suddenly rising from a sitting or lying position	1. Move the worker to a shaded, cool area to sit or lie down. 2. Encourage the worker to slowly drink water, clear juice, or a carbohydrate-electrolyte replacement liquid
Heat exhaustion	Dehydration Depletion of circulating blood volume Circulatory strain from competing demands for blood flow to skin and to active muscles	• Sustained exertion in heat • Lack of cclimatisation • Failure to replace water lost in sweat	• Cool, moist skin with goose bumps when in the heat • Heavy sweating • Faintness • Dizziness • Fatigue • Weak, rapid pulse • Low blood pressure upon standing • Muscle cramps • Nausea • Headache	1. Take workers to a clinic or emergency room for medical evaluation and treatment and call for medical emergency. 2. Someone should stay with worker• until emergency medical services arrive. 3. Move the worker to a shaded, cool area and remove outer clothing (including socks and shoes). 4. Encourage the worker to frequently drink water, clear juice, or a carbohydrate-electrolyte replacement drink. 5. Wet the worker's skin, place cold• wet compresses or ice on head, face, or neck.

Factors influencing heat related illneses

The following factors influence person's adaptation to heat:

1. Body fat
   - Extra weight may have trouble maintaining good heat balance.
2. Age
   - 50 year old and older have poor general health and low level of fitness will make people more susceptible to feeling the extremes of heat
3. Medical conditions
   - People with cardiovascular disease, respiratory disease and uncontrolled diabetes may take special precaution
   - People with skin disease and rash are more susceptible to heat.
4. General physical health factors
   - Circulatory system capacity
   - Sweat production
   - Ability to regulate electrolyte balance
   - Pregnancy
5. Gender
   - Female are less heat tolerant than men

   Gender differences seem to diminish when such comparisons take into account cardiovascular fitness, body size, and acclimatisation. Women tend to have a lower sweat rate than men of equal fitness, size and acclimisation. The lower sweat rate means that there can be an increased in body temperature.

How human body reacts to heat due to environmental /non-environmental factor

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 human body control heat gain and loss

The main source of heat in normal conditions is the body's own internal heat. This is known as 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.

1, Radiation

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).

2. Convection

Convection is a 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.

3. Evaporation

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.

APPENDIX 3: ISO STANDARDS REFERENCES RELATED TO HEAT STRESS

ISO STANDARDS		
HOT	**MODERATE**	**COLD**
7243 (WBGT)	7730 (PMV/PPD)	11079 (IREQ and WCI)
7933 (SWreq)	10551 (Subjective)	
9886 (Physiology)	9886 (Physiology)	9886 (Physiology)
13732 (surfaces)		
Supporting Standards		
11933 (Principles); 7726 (instruments); 8996 (metabolic rate); 9920 (clothing); 12894 (subject screening); 13731 (vocabulary and units)		
Application		
Vehicles: 14505-1 Principles, 14505-2 Teq*, 14505-3 human subjects; 14415 (disabled, aged person); 15265 (risk assessment); 15743 (working in cold); 15742 (combined environments).		

*Teq= Temperature equivalent

Source: Parsons K. 2006.

APPENDIX 4: HEALTH SCREENING FOR HEAT STRESS EXPOSED WORKERS

1. General Physical Examination:

    - Skin hydration
    - Monitor body temperature regularly
    - Monitor blood pressure and pulse rate

2. Employee with chronic heat exposure required to do health screening as below if further investigation required;

    - A blood test to check for low blood sodium or potassium and the content of gases in your blood
    - A urine test to check the concentration and composition of your urine and to check your kidney function, which can be affected by heatstroke
    - Muscle function tests to check for rhabdomyolysis — serious damage to your muscle tissue
    - Imaging tests to check for damage to your internal organ

APPENDIX 5: HEAT STRESS MEASUREMENT

PART A: WORKPLACE DESCRIPTION

1. Date of measurement:
2. Company Name and address:
3. Process description (exposure to heat):
4. Number of Workers (exposed to heat):
    - 4.1 Working hours:
    - 4.2 Duration of exposure:
5. Heat sources:
6. Equipment used:
    - 6.1 Serial Number:
    - 6.2 Date of last calibration:
7. Availability of:
    - 7.1 First aid box:
    - 7.2 First aider:
    - 7.3 First aid room:

MEASUREMENT DATA															
No.	Work Section/ Location (refer to plant layout)	Time measured	Weather Condition	Wet Bulb °C (T_{nwb})	Dry Bulb °C (T_{db})	Globe °C (T_g)	Relative Humidity (Rh)	Clothing Type (Table 5)	Metabolic rate (Table 6)	Work rest regime (Table 7)	WBGT (indoor) °C	WBGT (outdoor) °C	Adjusted WBGT °C	Standard Exposure limit TLV & AL °C	Risk Decision

PART B: HEAT STRESS SCREENING CHECKLIST

- **Observation Checklist for Heat Stress Risk Assessment**
- Six set of questionnaires are provided with each representing one of the six basic parameters.
- Each parameter is described and a risk score is given to each. The higher the score, the higher the risk that it may contribute to heat stress.
- Observe the environment, taking note of the descriptions provided, and tick the box that best fits the workplace you are observing. This will provide you with a estimated risk score for that parameter. You may tick more than one box if the environment is changing, or if the employee is moving between environments.

If you do not see a description that best fits the work situation you are assessing, or are unsure, then tick the "**Don't know**" box at the bottom of that table. This introduces an uncertainty into the assessment and requires that you conduct a more detailed qualitative assessment.

1. Air Temperature

What is air temperature and what should you look out for?

- Air temperature is described as the temperature of the air surrounding the human body.
- Consider the air temperature surrounding the worker and think about how you would describe it.

SUBJECTIVE DESCRIPTIONS OF AIR TEMPERATURE	SCORE	TICK
• Neutral	0	
• Warm	2	
• Hot	3	
• Very Hot	4	
Don't know		

2. Radiant Temperature

What causes radiant temperature and what should you look out for?

- Thermal radiation is the heat that radiates from a warmer to a colder object. Radiant heat may be present if there are heat sources in an environment.
- Examples include; the sun, fire and flares; electric fires; furnaces; steam rollers; ovens, walls in kilns, cookers, dryers; hot surfaces & machinery, exothermic chemical reactions, tunnel walls in deep mines, etc.
- Observe the surroundings and identify heat sources. Consider how close the workers are to these heat sources. Do they need to wear protective clothing to prevent burns? etc.

SUBJECTIVE DESCRIPTIONS OF AIR TEMPERATURE	SCORE	TICK
• There are no heat sources in the environment	0	
• Heat source is present but the workers are not working in close proximity to it. • Heat source surface feels warm to touch and there is no risk of contact burns occurring.	1	
• Heat source surface feels hot to touch. • Heat source makes workers feel hot when they stand near it.	2	
• Heat source surface feels very hot to the touch and may burn the skin. • Workers cannot work in close proximity to the heat source for more than 10 minutes without wearing PPE.	3	
• Contact with heat source will cause burning • Workers cannot work in close proximity to the heat source for more than 5 minutes without wearing PPE.	5	
• Workers are not permitted to work in the environment without PPE to protect them from the radiant heat in that environment.	6	
Don't know		

3. Air Velocity

Air velocity explained

- Air velocity is the speed of air moving across the worker and may help cool the worker if it is cooler than the environment.
- Think about the temperature of the air moving across the worker because the temperature will affect the heat loss or heat gain to the worker.
- To help you, four categories of air velocity are provide. They are **Still**, **Low**, **Moderate** and **High**
    1. **Still** air, is where there is no noticeable flow of air;
    2. **Low** air speed, is when you can just feel air movement on exposed flesh;
    3. **Moderate air speed,** is when you can feel air movement (e.g. a light breeze) on exposed flesh;
    4. **High** air speed may be similar to the air speed on a windy day, or at or near fans or other machines or equipment that generate air movement.
- Things to look out for include: Is there a wind source? Have fans been introduced to reduce the temperature (e.g. during specialist maintenance work?). Can the workers feel hot or warm air blowing on any exposed skin? Is the moving air colder or warmer that the ambient air temperature

SUBJECTIVE DESCRIPTIONS OF AIR TEMPERATURE	SCORE	TICK
• Cold air at a low/moderate/high air speed (e.g. workers standing in front of an air conditioning unit, compressed air supply into clothing for cooling of worker	-1	
• Still air in a neutral environment	0	
• Warm air & low air speed	1	
• Still air in a warm environment	2	
• Still air in a hot environment.	3	
• Warm air at a moderate air speed, or • Still air in a very hot environment, or • Hot air and moderate air speed	4	
• Very hot air at a high air speed.	5	
Don't know		

4. Humidity

Humidity explained

- If water is heated and it evaporates to the surrounding environment, the resultant amount of water in the air of that environment will provide humidity. High humidity environments have a lot of vapour in the air and this prevents the evaporation of sweat from the skin. Humidity is important because less sweat evaporates from when humidity is high. The evaporation of sweat is the main driving force for heat loss in humans.
- When **vapour impermeable PPE is worn**, the humidity inside the garment increases as the wearer sweats because the sweat cannot evaporate. If an employee is wearing this sort of PPE (e.g. asbestos, chemical protection suits etc) the humidity within the microclimate of the garment may be high.
- Examples include: Humidity in indoor environments will probably vary greatly, and may be dependent on whether there are drying processes (paper mills, laundry etc) where steam is given off. Indoor environments that are susceptible to outdoor conditions may also be humid on humid days.
- Humidity is very difficult to estimate. Profuse sweating may be an indication of high humidity, but it may also be an indication of a high physical activity.
- Things to looks out for include: Is the environment susceptible to outdoor conditions, especially in hot weather? Are there any dryers or other machines producing steam? Do workers complain about the humidity? Are they wearing vapour impermeable PPE?

SUBJECTIVE DESCRIPTIONS OF AIR TEMPERATURE	SCORE	TICK
• No humidity. Air is dry, with no drying processes or other mechanisms for increasing the humidity in the workplace.	0	
• Humidity seems to be somewhere between very humid and very dry.	2	
• Air is very humid. Examples may be near drying machines, laundry machines, chemical processes where steam is given off.	5	
• Vapour impermeable PPE is worn	6	
Don't know		

5. Clothing

Clothing explained

- Clothing interferes with our ability to lose heat to the environment. So much so, that heat stress is a risk in situations where workers may be wearing PPE, even if the environment is not considered warm or hot. It is important therefore, to identify whether the clothing the worker is wearing may be contributing to the risk of heat stress.
- It is impossible to list or describe all the clothing that may be worn in industry. Therefore, general descriptions of clothing are provided.
- Observe the worker and look through the list for an ensemble that may best describe the type of clothing they are wearing. Where workers don or remove clothing depending on the job or task, it may be necessary to conduct a quantitative heat stress risk assessment.
- Additional information may be obtained by contacting the manufacturer or a supplier of the PPE for further advice.

SUBJECTIVE DESCRIPTIONS OF AIR TEMPERATURE	SCORE	TICK
• Shorts and a T-shirt. No protective or work clothing worn.	-1	
• Light work clothing	0	
• Cotton coverall, jacket	2	
• Double cloth coveralls, apron, rain coat, water barrier materials	3	
• Light weight vapour barrier suits	5	
• Fully enclosed suit with hood and gloves	6	
Don't know		

6. Work Rate

Work rate explained

Work rate, or metabolic rate, is essential for a heat stress risk assessment. It describes the heat that we produce inside our bodies as we do physical activity. The more physical work performed, the more heat produced and the more heat that needs to be lost so as not to overheat.

Observe the workers, note their movements, posture, speed, effort, weight of materials they handle, parts of their bodies responsible for their movement etc? Review your manual handling assessment for information of the components of the task.

Five categories of metabolic rate (with descriptions)are provided :

1. **Resting**
2. **Low**
3. **Moderate**
4. **High**
5. **Very High**

SUBJECTIVE DESCRIPTIONS OF AIR TEMPERATURE	SCORE	TICK
Resting Worker is resting as part of a work/rest schedule or is awaiting instructions etc. Worker is not involved in any tasks at all.	-2	
Low Sitting or standing to control machines. Light hand work (writing, drafting, sewing, bookkeeping, drafting etc). Hand and arm work (small bench work, using tools such as table saws; drills, inspecting, assembling or sorting light materials, operating control panel, turning low torque hand wheels, very light assembly operation etc). Standing with light work at machine or bench while using mostly arms (drill press, milling machine, coil taping, small armature winding, machine with light power tools, Inspecting or monitoring hot processes). Arm and Leg work (driving a car, operating foot pedals or switch). Walking in easily accessible areas (can walk upright). Lifting: 4.5Kg loads for fewer than 8 lifts/min; 11kg fewer than 4 lifts/min	0	

SUBJECTIVE DESCRIPTIONS OF AIR TEMPERATURE	SCORE	TICK
Moderate Hand and arm work (mailing filing). Arm and leg work (off-road operation of trucks, tractors and construction equipment). Arm and trunk work (operating air hammer, tractor assembly, cleaning or clearing light debris spillage, plastering, heavy welding, scrubbing while standing up, intermittently handling heavy objects/, weeding, hoeing, picking fruit and vegetables.) Carrying, lifting, pulling and pushing light loads (lightweight carts and wheelbarrows); Operating heavy controls (e.g. opening valves); Walking in congested areas (limited headroom), walking at 2 to 3 mph. Lifting: 4.5kg fewer than 10 lifts/min; 11kg fewer than 6 lifts/min	2	
High Intense arm and trunk work, (sawing by hand or chiselling wood, shovelling wet sand, transferring heavy materials, sledge hammer work, planting, hand mowing, digging). Intermittent heavy lifting (such as pick-and-shovel work). Pushing or pulling heavy loads (pallet trucks, skips, loaded cages, heavy wheelbarrows) Heavy manual handling and lifting (eg laying concrete block, and clearing heavy debris (eg cleaning and relining reactor vessels)). Heavy assembly work on a non-continuous basis. Lifting: 4.5kg 14 lifts/min; 11kg 10 lifts/min	4	
Very High Work at this rate cannot be sustained for long periods. Very intense activity at a fast maximum pace (e.g. intense shovelling, axe work, running). Heavy assembly, building or construction work; (climbing stairs, ramps or ladders rapidly) Walking faster than 4mph Lifting 4.5kg more than 18 lifts/min. 11kg more than 13 lifts/min.	6	
Don't know		

What to do with the results from screening checklist

Please tick the subjective score which corresponds to the score you gave each parameter. The black squares indicate that the score was not available for a particular category. For example, Metabolic Rate only has the following scores: -2, 0, +2, +4 and +6

The more scores you have that are higher than 1, the greater the risk of heat stress. When the score increase the risk also increase (also shown by colour shading from light red to dark red) so the risk of that parameter contributing to heat stress increases. If three or more of your scores are greater than 1, there may be a risk of heat stress.

If any score equal to or greater than 5, then the current heat stress indices may not be valid. In these situations, physiological monitoring (measurement of body temperature, body weight, pulse rate etc.) may be required. Seek expert advice if you are not competent in measuring, analysing and interpreting physiological measurements.

Risk Score Table

	SCORES										
	-3	-2	-1	0	1	2	3	4	5	6	Don't know
Air temperature	■	■	■		■				■	■	
Radiant temperature	■	■	■					■			
Air velocity	■	■								■	
Humidity	■	■	■		■		■	■			
Clothing	■	■			■			■			
Metabolic rate	■		■		■		■		■		

APPENDIX 6: CONTROL OF HEAT STRESS

In heat balance equation H = M - W = E + R + C + K + S, total heat stress can be reduced only by modifying one or more of the following factors;- metabolic heat production, heat exchange by convection, heat exchange by radiation or heat exchange by evaporation.

Environmental heat load (C, R and E) can be modified by engineering control;- ventilation, air conditioning, screening, insulation and modification of process or operation and protective clothing and equipment. Whereas, metabolic heat production can be modified by work practices and application of labour-reducing devices.

CLOTHING AND PERSONAL PROTECTIVE EQUIPMENT

CLOTHING

Clothing is one of the six main factors that determine how we feel temperature. It can assume one of two main functions in a hot environment.

It can maximize heat exchange, i.e. allowed a person to sweat freely and loose heat to the environment. It can protect a person from a hot environment. It can do this either by:

- Shielding a person from the hot environment, such as a very high radiant heat source; and/or
- Providing cooling to a person, usually by means of air or water flow, or by ice melting.

It is very important to note that the best form of body temperature control is for a person to sweat freely, and frequently replace lost fluids. When a person puts on clothing that protects or shields them from the hot environment, the free evaporation of sweat is stopped. This shuts off the body's most effective heat reduction system.

It is very important to weigh up carefully the need for and provision of protective clothing in hot environments. All other forms of control should be considered before opting for protective clothing. The situations where protective clothing cannot be avoided are those where the disadvantages of not wearing protective clothing equal or outweigh the disadvantages in wearing it. These include:

- Where people are working in front of a very high radiant heat source, and need to be protected from the "blast" of the heat;
- Where the environment is very hot and most control measures are not possible;
- Where a person may come into contact with objects or plant that will burn them.

Clothing that Maximises Heat Exchange

The WBGT Index is based on a person wearing a uniform, that is, a light shirt and trousers. Even clothing items such as overalls will reduce heat exchange.

In order to maximise heat exchange, a garment should be able to transmit moisture. Moisture can be transmitted through the fabric or through garment openings (neck, waist, ankle, arms). Light colours reflect radiant heat but must be kept clean.

Protective Clothing that Shields against Hot Environments

Clothing can be a mobile line of defence. Workers may wear heat reflective or insulating clothing, including gloves and face shields. Clothing may also be required to withstand molten metal splashes. An example of such clothing is the suit, a reflective garment that gives protection from radiant heat and is worn by fire service personnel. Although it is ready for instant wear, the disadvantage is that the suit does not allow evaporation of sweat, so is a trade-off between the protection it gives and the lack of cooling effect. The suit needs to be removed as soon as a person leaves the hot work area. It is possible to use a hood with an air vest or other garment. Heavy wool garments may be worn where there is risk of molten metal splashes.

Protective Clothing that Provides Cooling in Hot Environments

This type of garment can be used on its own, or can be worn under a "shielding" garment. Items that need to be considered when selecting cooling garments include:

- How accessible is the place the people will be working in?
- What time span is involved?
- How many people (and cooling garments) are going to be needed?
- What back-up facilities are required for the various types of cooling equipment, e.g. air supplies or freezing facilities? The advantages and disadvantages of various types are discussed below:

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Air Vest

This is a jacket worn over clothing and consists of two layers of fabric through which air is blown, coming out at two vents which project up onto the face. The effect of air blowing over the face has the advantage of a considerable cooling effect. The air must be of a quality that is safe for respiratory use. Air vests are quick and easy to put on and can be ready for use quickly. Disadvantages are the need to be attached to an airline. Care has to be taken not to get the line in a hot area, or get tangled up.

Cool Vest

This is a vest that has an insert of frozen liquid placed between fabrics and is worn on the upper trunk. An advantage of this vest is the freedom it gives to move around, since it has no attached lines. Disadvantage is the vest not available for immediate use unless liners are permanently frozen.

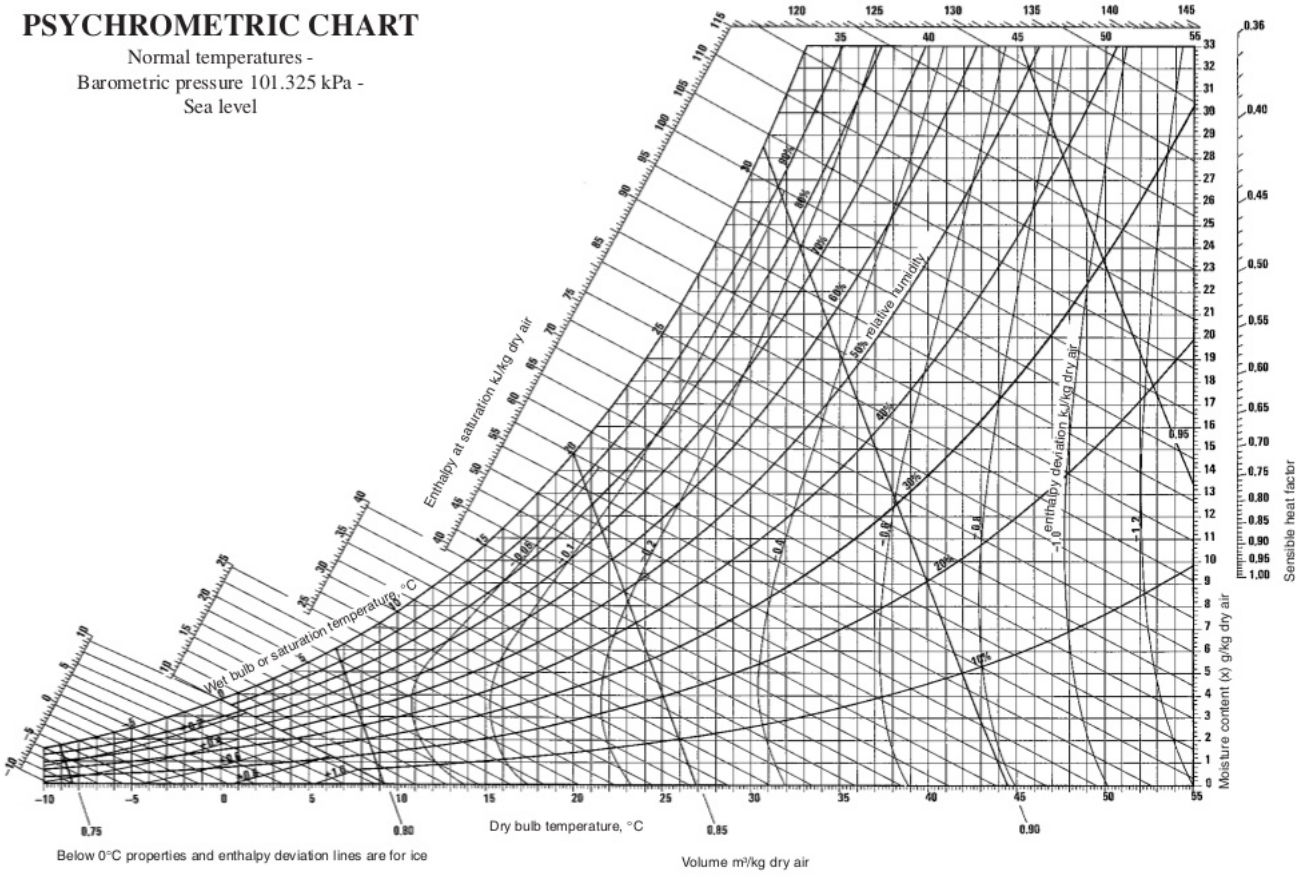
Heat Transfer Suits

These garments are worn next to the skin and consist of three pieces: pants, shirt and hood. Resembling thermal underwear, they contain tiny tubes which circulate ice-cooled water over most of the body. Only the face, feet and hands are not covered by the garment. Advantages include a constant and steady cooling effect to the whole body. Disadvantages are the need to

change the ice bottle every 20-30 minutes in very high temperatures. The tubes can block up and the pump can prove temperamental. Using ice blocks in the bottle rather than freezing it solid has helped with these problems. Because of the pump the suit can be clumsy in confined spaces, and the plastic tubing between the pump and the suit is vulnerable to snagging. Hygiene is important as the suits need to be washed after each use. Washing must be hand done as the suits cannot be dry-cleaned. Which type of protection you choose will depend on factors like access to the task, backup services and the individual preferences of staff. Evaporation of sweat is a very effective cooling technique. If sweat drips off, it does not cool and is wasted. An example of this is sweating that occurs under non-permeable garments.

APPENDIX 7: PSYCHROMETRIC CHARTS

Relative humidity can be obtained using the following chart:



Source: Ellis, 1972

NOTES

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