Resources Safety & Health
Queensland

Recognised Standard 18

Management of Heat in Underground Coal Mines

Resources Safety and Health Queensland

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Coal Mining Safety and Health Act 1999

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Recognised standards

This document is issued in accordance with PART 5—RECOGNISED STANDARDS and Section 37(3) of the *Coal Mining Safety and Health Act 1999*.

PART 5 - RECOGNISED STANDARDS

71 Purpose of recognised standards

A standard may be made for safety and health (a "recognised standard") stating ways to achieve an acceptable level of risk to persons arising out of coal mining operations.

72 Recognised standards

(1) The Minister may make recognised standards.

(2) The Minister must notify the making of a recognised standard by gazette notice.

(3) The CEO must publish on a Queensland government website each recognised standard and any document applied, adopted or incorporated by the standard.

(4) In this section—

Queensland government website means a website with a URL that contains 'qld.gov.au', other than the website of a local government

73 Use of recognised standards in proceedings

A recognised standard is admissible in evidence in a proceeding if—

(a) the proceeding relates to a contravention of a safety and health obligation imposed on a person under part 3; and

(b) it is claimed that the person contravened the obligation by failing to achieve an acceptable level of risk; and

(c) the recognised standard is about achieving an acceptable level of risk.

PART 3 - SAFETY AND HEALTH OBLIGATIONS

37 How obligation can be discharged if regulation or recognised standard made

(3) …. if a recognised standard states a way or ways of achieving an acceptable level of risk, a person discharges the person's safety and health obligation in relation to the risk only by—

(a) adopting and following a stated way; or

(b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.

Where a part of a recognised standard or other normative document referred to therein conflicts with the *Coal Mining Safety and Health Act 1999* or the Coal Mining Safety and Health Regulation 2017, the Act or Regulation takes precedence.

This recognised standard is issued under the authority of the Minister for Resources.

[Gazetted 27 August 2021]

Contents

1 Purpose

The purpose of this recognised standard is to outline how to manage working in an underground coal mine in adversely hot and humid conditions, recognise the symptoms of the different heat related illnesses and support the development of the Safety and Health Management System (SHMS) for ensuring the health of persons by:

- Identifying risks which can contribute to heat related illnesses.
- Ensuring effective procedures/management plans and Trigger Action Response plans (TARPS) are in place to monitor and control those risks.
- Ensuring persons are appropriately trained in these procedures.
- Ensuring persons are appropriately trained in the physiological effects, early warnings signs and preventive measures associated with working in hot environments.

2 Scope

This recognised standard is applicable to underground coal mine operations where it is identified that temperatures in an underground operation may exceed 27 °C wet bulb temperature. Under these circumstances, the Senior Site Executive (SSE) must ensure the mine's SHMS provides for ensuring the health of persons in their area of work or travel, as defined by Section 369 of the Coal Mining Safety and Health Regulations 2017 (CMSHR). Where the effective temperature exceeds 29.4°C and the **CMSHR s369** (Managing risk from heat) allows for other specific activities, the safety and health management system should identify the risks and clearly identify additional controls for coal mine workers carrying out these activities. The information in this recognised standard shall apply to:

- Those responsible for managing / supervising coal mine workers who work in extremes of temperature.
- The coal mine workers who work in those environments.
- The personnel who provide medical support.

3 Introduction

Working in high temperatures may cause heat illness and even death, but may also cause loss of concentration leading to lowered productivity, and mistakes which can lead to accidents. Where humidity is relatively high, the hazard increases. More heat strain is placed on a person as Wet Bulb (WB) and Dry Bulb (DB) temperatures get closer. The absolute values of the temperatures are of less importance than the difference between them, it is the relative humidity that causes the problem by inhibiting body cooling by the evaporation of sweat. For example, 28°C WB/45°C DB causes less heat strain than 32°C WB/36°C DB.

When the WB temperature rises above 27°C, extra control measures shall be implemented. Where any work is conducted above 29.4^{o}C effective temperature the mines safety and health management system must include additional controls for this work.

Heat related factors that may have an impact on those working in the underground environment include:

- Temperature and humidity (moisture content) of the intake ventilating air from surface.

- Temperature rise due to auto compression in adiabatic conditions (approx. 1 °C increase for dry bulb and 0.4°C increase for wet bulb per 100 m of depth increase respectively).
- Heat exchange with strata and groundwater.
- Heat exchange with casual water, sumps drains etc.
- Radiant heat emitted from equipment & machinery.
- Radiant heat from cementitious and polymeric compounds used for sealing and stabilisation.
- Radiant heat from waste areas (seals, open goaf).
- Radiant heat from oxidation of coal.
- Metabolic work activity of the coal mine worker (CMW).
- Protective clothing and protective equipment (e.g. Respiratory protection and high incident energy arc flash clothing).

3.1 Signs and symptoms of heat related illness

When working in hot conditions, the human thermo-regulatory system tries to maintain the body core temperature at 37°C. It does this by increasing blood flow to the skin to carry heat away from the core, and by causing sweating, the evaporation of which cools the skin and hence the blood. If this control is lost and the core temperature begins to rise, various physiological effects progressively result.

3.1.1 Initial symptoms

Initial symptoms will include:

- loss of interest in the task;
- difficulty in remaining alert; and
- the desire to seek more comfortable surroundings. Suppression of this desire may result in irritability.

These initial symptoms progress to a loss of co-ordination and dexterity, presenting significant safety and productivity implications.

3.1.2 Heat exhaustion

Heat exhaustion results from the failure of the blood flow to adequately remove heat. A decrease in blood volume may result from dehydration caused by an inadequate intake of fluids. Alternatively, if a combination of environmental heat stress and work rate causes an excessively fast heartbeat, then the time interval between successive contractions of the heart muscles may be insufficient to maintain an adequate supply to the heart and, as a consequence, the rate of blood flow will drop. Core body temperature may rise to 39°C. The symptoms of heat exhaustion are:

- tiredness, thirstiness, dizziness,
- numbness or tingling in fingers and toes,
- muscle cramps,
- breathlessness, palpitations, low blood pressure,
- blurred vision, headache, nausea, fainting,
- clammy skin that may be either pale or flushed.

3.1.3 Heat stroke

Heat stroke is the most serious of all heat-related illnesses and may occur when the body core temperature exceeds 41°C (it may reach 45°C), and the co-ordination of the involuntary nervous system including thermal regulation is affected. Irreversible injury to the kidneys, liver and brain may occur. Heat stroke carries a high risk of fatality from cardiac or respiratory arrest and must be treated as a medical emergency.

Some symptoms of heat stroke are similar to those of less serious heat illnesses, i.e. headaches, dizziness, nausea, fatigue, thirst, breathlessness and palpitations, but the onset of illness may be sudden and dramatic, and pre-existing heat exhaustion is not necessary.

Additional symptoms of heat stroke can include:

- cessation of perspiration, the skin remains hot but is dry and may adopt a blotchy and red colouration, and the lips may take on a bluish tinge.
- disorientation, which may become severe, including dilated pupils, a glassy. stare and irrational aggressive behaviour.
- shivering and other uncontrolled muscular contractions.
- loss of consciousness and convulsions.

3.1.4 Other heat related conditions

There are other conditions that may be caused or aggravated by working in hot / humid environments. These include but are not limited to:

- Skin disorders, particularly ‘prickly heat’ (Miliaria Rubra), but also complications such as irritant dermatitis, fungal infections and secondary infections.
- Ear infections and tropical ear.

4 Hazards of working in heat

Heat related illnesses may result from elevated temperatures, the level of humidity in the environment, the rate of work, and a person’s physical condition. For normal body function, heat exchange between the body and the environment needs to be balanced and relies on metabolic heat being dissipated to the environment through convection, radiation and evaporative heat transfer.

Many individual factors may increase the risk of heat stress, and as a guide can include:

- dehydration
- non-acclimatisation
- poor physical fitness
- age
- being overweight / obese
- fatigue
- sleep deprivation
- skin disease
- illness and medical conditions
- duration of exposure.

It is fundamental that all persons who go underground understand that in hot working conditions, high perspiration rates combined with excessive loss of body fluids may result in dehydration and electrolyte imbalance. This can impair both mental and physical work performance, and if prolonged or severe can pose a serious risk to health.

4.1 Assessing the risk

Several factors can influence the heat load on the body and should be considered when assessing

the risk. These include:

- Air temperature (WB and DB)
- Radiant heat exchange
- Humidity
- Air movement
- Level of physical work
- Amount and type of clothing worn

Thick, multiple-layered or impervious clothing particularly impede heat loss and can cause additional risk especially during physically demanding tasks. Using personal protective equipment (PPE) such as respiratory protection may also affect a person's tolerance to hot environments. It is not possible to estimate the strain placed on the body by examining any one of these factors in isolation. There have been a number of heat stress indices developed which integrate these variables and give a single value that represents the amount of heat risk in a given situation.

In the mining industry, ET is the most frequently used and widely accepted index of heat stress. ET is straightforward and easy to use and takes WB temperature, DB temperature and air velocity into account. It is important to consider all these factors – e.g. a good air movement over the body has a cooling effect through increasing the bodies radiant heat exchange with the surrounding air and increasing the bodies capacity for evaporating perspiration, whereas high relative humidity will reduce the body's evaporative capacity and thus its ability to lose heat by sweating. Although ET can be calculated, it is more easily derived by use of a nomogram, reproduced in Appendix I. The nomogram provided in Appendix 1 is used for calculating "*Normal*" Effective Temperature (NET) index and shall be used over the "Basic" Effective Temperature (BET) index as NET takes into account persons being clothed. Conversely BET assumes workers are naked from the waist up and will underestimate the heat risk.

Mines need to carry out heat surveys to determine the areas of the mine that could give rise to potential problems, so remedial measures can be properly targeted. This may require readings to be taken at each working place.

4.2 Controlling the hazards

Where possible, work activities carrying an increased risk of heat illness should be avoided, however, there are times when there is no alternative to working in hot conditions, and these circumstances require special consideration. Risk analysis should be conducted, safe systems of work and appropriate control measures introduced to control the duration and extent of exposure. A strategy needs to be introduced to reduce the hazard through controls such as mine design, work design and equipment selection. Control measures should follow the hierarchy of control.

The mine's SHMS should include evaluation of the following considerations, where relevant, in the risk analysis process:

4.2.1 Site / area monitoring

- Where an Explosion Risk Zone Controller (ERZC) has to measure and record the effective temperature of a working place, the SHMS shall detail this procedure. This shall ensure that coal mine workers who are exposed to the environment in these places are managed in accordance with **CMSHR s.369** in all circumstances. The average effective temperature across different working places cannot be applied to reduce the actual effective temperature at any particular working place.
- The effective temperature accepted shall be the average of three (3) determinations of effective temperatures made with an interval of five (5) minutes each between the first and second determination and between the second and third determinations.

- Each determination shall be made at a distance of not less than 1.52 metres from any other determination and in the case of a working face, the determinations shall extend across such working face.
- In the case of the working face, if any of the three determinations exceed the effective temperature limit then two more determinations must be made at that same location and no further away than 1.52 metres. The additional determinations at that location should be made at five (5) minute intervals and the effective temperature accepted for that area will be the average of those three determinations.
- An ERZC should take readings where people are regularly working at different areas across the longwall face maingate, midface or tailgate of where goaf wash comes out and they believe that the temperature is different, or if asked by a CMW.

4.2.2 Safe environment

Ventilation

- Minimum standards of temperature and airflow, including accuracy of measuring instruments, measurement locations and frequency and duration of measurement.
- Mine heat loads, both fixed sources (such as conveyor drives) and moving sources (such as diesel equipment).
- Climatic (seasonal) and daily variations in temperature and humidity must be considered, as well as the natural radiant heat emitted from the strata.
- Machinery selection (fixed and mobile plant), including impact of equipment selection on both heat (temperature) and moisture (humidity) increases in the general ventilating air, in the workplace and at the machine operator.
- Airflow layout, including choice of development and coal extraction methods and ventilation methods for the overall mine and individual districts.
- Use of ventilation stream to remove heat sources: such as goaf gases, temperature from fixed plant, from the work areas to return airways.

Engineering control of the environment

- Air velocity over the skin where the person is working.
- Wet bulb and dry bulb temperatures where the person is working, including accuracy of measuring instruments, measurement locations and frequency and duration of measurement.
- Humidity, which reflects the difference between the dry and wet bulb temperatures and is a key factor in whether sweat evaporates from the skin or drips and therefore is a measure of how “efficient” sweating is in the particular workplace.
- Microclimate cooling which includes air-conditioned cabins, “cold” vests and other means to cool the environment in the immediate vicinity of the person.
- Air conditioning including either microclimate air-conditioned cabins, chilled service water, or “bulk” air cooling of the intake air to the entire mine or to a particular district.
- Removal of casual water – whilst this does not directly reduce the wet bulb temperature in the area, it does help maintain a lower humidity and reduces the flow of heat from the strata into the air.

- Chilled service water, which is particularly effective in workplaces that use water continuously.
- Provision and location of services and rest and recovery areas, which helps to reduce the impact of working in heat by allowing personnel to cool down during rest breaks, to eat meals when less thermally stressed, and to have ready access to cool, potable drinking water.

Location and use of equipment

- The location of static equipment that generates heat should be considered prior to installation.
- Optimisation of the running time of mobile equipment will give obvious safety benefits (e.g. machines should not be left idling unnecessarily).
- Equipment should also be selected for the duty to be performed.

Control of water to minimise equipment

- Where possible, elimination of standing water and the amount of water that is introduced underground. Obvious water sources include leaks, spillages, flushing pipes during extensions/retractions, excessive sprays, machine cooling water, and natural strata water.
- Allowing water to accumulate into puddles / swillies will increase the humidity of the passing air, so that should also be avoided. Any spillage should be collected and removed through pipes.
- Suitable pump ranges should be maintained, at least to strategic locations where they can be accessed if and when required.
- If operations are planned that will generate spilled water e.g. washing down mobile plant, the planning of the work should also address water management.

4.2.3 Safe systems of work

Health and safety

- Acclimatisation: the need for extra caution in the first week back at work after not being exposed to thermal stress for more than about 14 days should be considered. Some mines may need a formal acclimatisation protocol.
- Hydration protocols.
- 'Paced' or 'Self-paced' work. In self-paced work, the person recognises, for example, that they are over-heating or concentration is being affected (cognitive decay) and adjusts accordingly. Any underground task that is not self-paced needs special attention. Paced work can include persons working in teams or persons working to deadlines. Consider task rotation or work/ rest regimes.
- Fitness for duty, especially the issues of persons who have, or develop, risk factors that significantly elevate their risk of developing heat illness when working in heat.
- Monitoring of the people in the workplace. Some operations may need a formal biomonitoring program for those working in heat. This maybe especially required for activities being undertaken under CMSHR s369(3)
- Medical treatment, including provision of competent medical treatment both on and off the mine site.

Heat stress index

There are other methods that can be used for measuring and calculating heat stress index. These may be used in addition to effective temperature. The selected index must be suited to the identified risks of heat in the workplaces at the mine and specify the trigger levels and protocols that apply.

Examples of recognised indices documented in literature are contained in:

- "Thermal Standards and Measurement Techniques" by Ramsey and Beshir. (under the heading "Evaluating the Hot Workplace: An Example" pp683)
- "Subsurface Ventilation and Environmental Engineering" by McPherson.
- "Thermal Work Load (TWL) as an index of thermal stress" by Brake Bates & Matthew.
- "Heat Stress Standard & Documentation Developed for use in the Australian Environment" by Di Corleto, Coles and Firth.

Job design and work planning

- Decrease the work rate, in terms of metabolic heat production, by use of laboursaving devices, adoption of less physical work methods and reducing the amount of "overhead" work.
- Work rate issues, particularly ensuring individual workers have the ability to regulate their work rate to avoid over-heating.
- Work scheduling and exposure control. In the underground environment the cooler/warmer periods are only relevant seasonally, rather over a short period of time, mining activity can lead to an increase in temperature in a particular area. For example: The temperature in a longwall for instance, can change swiftly, if the goaf caving changes, either flushing out gas or increasing velocity across the face. Therefore providing for job rotation and/or regular rest periods (where practicable) can assist in these instances.
- Mechanisations, to either decrease the work rate (see above) or reduce the exposure of the worker to thermal stress (e.g. by installing local air movers or fans to increase air velocity over the skin).
- Clothing and PPE, to ensure that clothing, including underwear, is vapour permeable (cotton) and that all PPE take the impact of heat stress on the worker into account.
- Mining method, to reduce the metabolic load, to reduce the temperatures in the workplace, or increase the local airflows over the skin.

Hydration protocols

The concepts of adequate hydration are fundamental issues in the management of heat stress by individuals and mine management, and the plan must provide for persons to be properly hydrated through:

- Provision of a supply of sufficient cool, potable water readily accessible to the work area
- Appropriate hydration testing and response actions, and
- Ensuring that persons do not start work without being properly hydrated and maintain their hydration during the shift.
- If a Coal Mine worker is affected by a heat related situation, he/she must pass a rehydration test, prior to commencing their next shift.

4.2.4 Safe behaviours

Prior to work

To minimise the effects of heat, CMWs need to present themselves for work in good condition. This may include:

- maintaining a healthy diet and eating prior to attending work, as this aids hydration.
- ensuring a good quality rest period prior to attending work.
- keeping alcohol intake within national guidelines and avoiding drinking alcohol 8-12 hours before the start of the shift.
- avoiding taking strenuous exercise immediately before or after the shift.
- increasing fluid intake prior to the start of the shift by drinking non-caffeine based drinks i.e. water, milk, etc. to ensure proper hydration. It should be noted that the lighter the colour of the urine (e.g. clear to light straw colour), the better the level of hydration
- informing relevant personnel if on regular medication (whether taken before or during shift) or if suffering from a medical condition as these may impact on one's hydration, circulation or sweating capacity and may affect their ability to regulate body temperature thus increasing their susceptibility to heat stress.

During Work

Behaviours to adopt during the shift to minimise risk may include:

- Wearing clothes that allow sweat to evaporate.
- Pacing work. It has been found that frequent, short breaks give more benefit than occasional, long breaks from manual effort.
- Job rotation. In addition to pacing work, if the more arduous tasks can be shared, no one member of the team is put at additional risk.
- Regular drinking to maintain an adequate hydration level. A potential sweat loss of one litre per hour has to be replaced, and it is recommended that regular, small drinks are taken rather than fewer, large drinks, which can cause cramps.
- Salt should NOT be added to the water, as this is likely to interfere with the kidneys' normal physiological control mechanisms. Water can be made more palatable by the addition of flavourings.
- Avoiding drinks containing caffeine, such as tea, coffee, colas and some 'anti-sleepiness' drinks during the shift. Caffeine is a diuretic and encourages fluid loss. Similarly, energy drinks should be taken in moderation, as excessive consumption can result in a salt, particularly potassium, imbalance.
- Monitoring hydration levels. This can be simply accomplished by observing the colour of the urine stream: the darker the colour, the less hydrated the individual. If this is noted, then immediate remedial action in the form of taking on extra fluids can be initiated. Urine colour charts for objective comparison are available and their use is encouraged.
- Use of electrolytes or supplements as a rehydration source.
- Regular food intake. Like water intake, small meals should be taken at regular intervals throughout the shift, rather than waiting until mid-shift to start eating.

4.2.5 Treatment of heat affected persons

To effectively manage and treat heat affected CMWs, consideration should be given to the following:

- access to emergency first aid treatment facilities onsite to assist in the cooling of heat affected CMWs.
- access to appropriate offsite treatment facilities.
- development of site guidelines and training in the basic management of heat related illness for first responders.

4.2.6 Emergency Response

CMWs conducting self-escape or emergency response may be exposed to heat for extended periods. Consideration should be given to reducing potential for heat illness including but not limited to:

- using primary Escape ways as the preferred escape route of choice, as intake airways are predominantly cooler than return roadways.
- using breathing apparatus, such as compressed air breathing apparatus (CABA) and long duration breathing apparatuses equipped with ice, to provide a constant supply of cool, fresh air to the wearer. This Provides greater thermal comfort to the wearer, compared to the heated air generated by self contained self rescuers (SCSRs).

4.2.7 Mines Rescue Services

Mines Rescue Services undertaking training or emergency response in hot and humid conditions will be managed by the operational procedures developed by the accredited corporation. These will be followed by the corporation in carrying out the mines rescue services at the mine.

5 System requirements

5.1 Roles, responsibilities and resources

The roles, responsibilities and competencies of all coal mine workers having accountability and responsibility must be defined and assigned as per Recognised Standard 22 – Management Structures in Coal Mines. These include competencies for persons responsible for managing/supervising coal mine workers who work in temperatures above 27°C WB and 29.4°C EF.

The roles and responsibilities assigned to persons may also include service providers.

Those in the organisation that allocate t tasks also have the responsibility to ensure the risk is at an acceptable level with respect to the management of heat. Likewise, those who are in a position to identify and report problems should also do so.

5.2 Trigger Action Response Plans (TARPs)

The site's Safety and Health Management System should clearly indicate the trigger levels, including how they are to be determined and what actions should be taken.

Responsibilities must be assigned to manage specific trigger actions. The establishment of trigger levels provides set criteria by which mine personnel can initiate a predetermined action. These actions would result in, but not be limited to:

- The collection of additional data to ascertain a course of action,

- The initiation of response plans,
- The withdrawal of persons to a place of safety.

Trigger levels should be:

- Consistent with legislative requirements
- measurable or observable,
- reviewed and monitored to ensure currency,
- identified by risk assessment,
- relevant to the risk being considered,
- reflective of the level of risk and the degree of response required, i.e. initiate predetermined actions,
- set to a level that recognises the time taken to initiate effective response. i.e. if an effective response will take considerable time then the trigger should be conservative and possibly involve a staged response approach.

5.3 Training and communication

Training and education are important requirements for CMWs required to work in heat and those expected to provide treatment for heat affected CMWs. Training must cover the following:

- recognition of signs, symptoms and treatment of heat illness,
- awareness of the risk associated with working in hot and humid environment,
- controls to be implemented to ensure persons are not affected by heat illness,
- consideration of education on the use of electrolytes or supplements as a rehydration source,
- their roles and responsibilities in achieving conformance with the heat management provisions of a system, including emergency preparedness and response requirements,
- measurement of environmental conditions,
- the correct type of personal protection to be worn,
- physical fitness and other personal factors,
- emergency procedures that must be followed,
- the recognition of symptoms is of particular importance for lone workers, who will usually have to self-monitor. If lone working is necessary, a system of welfare checks over and above normal supervision should be put in place,
- hydration, pacing and the working in heat protocols.

The training needs should be relevant to the specific hazard of working in heat, and all personnel whose work may be impacted by the hazard must receive appropriate training.

The site's Safety and Health Management System must establish and maintain processes for internal communication between various levels and functions of the mine, and the receipt, documentation and response to relevant communications of the hazards being addressed. This includes communication of any active TARP triggers to CMWs likely to be affected.

5.4 Monitoring and review

The site's SHMS shall provide for continuous improvement. This is to ensure that provisions relating to heat stress management are reviewed to ensure continued suitability, adequacy and effectiveness. The management review process shall ensure that the necessary information is collected to allow the mine to carry out this evaluation. This review shall be documented.

The heat stress management provisions developed in the SHMS must be reviewed at regular intervals and/ or following heat related incidents to ensure its continued suitability, adequacy and effectiveness.

5.5 Auditing and record keeping

The site's heat management system must be subjected to regular audits to maintain relevance and ensure continuous improvement. The aim of the audit is to ensure the heat management system is properly implemented, maintained and effective. The audit should cover the associated risk assessment, procedures, TARP and training records.

The frequency of the audit program should be based on the risk of the hazard concerned and the results of previous audits.

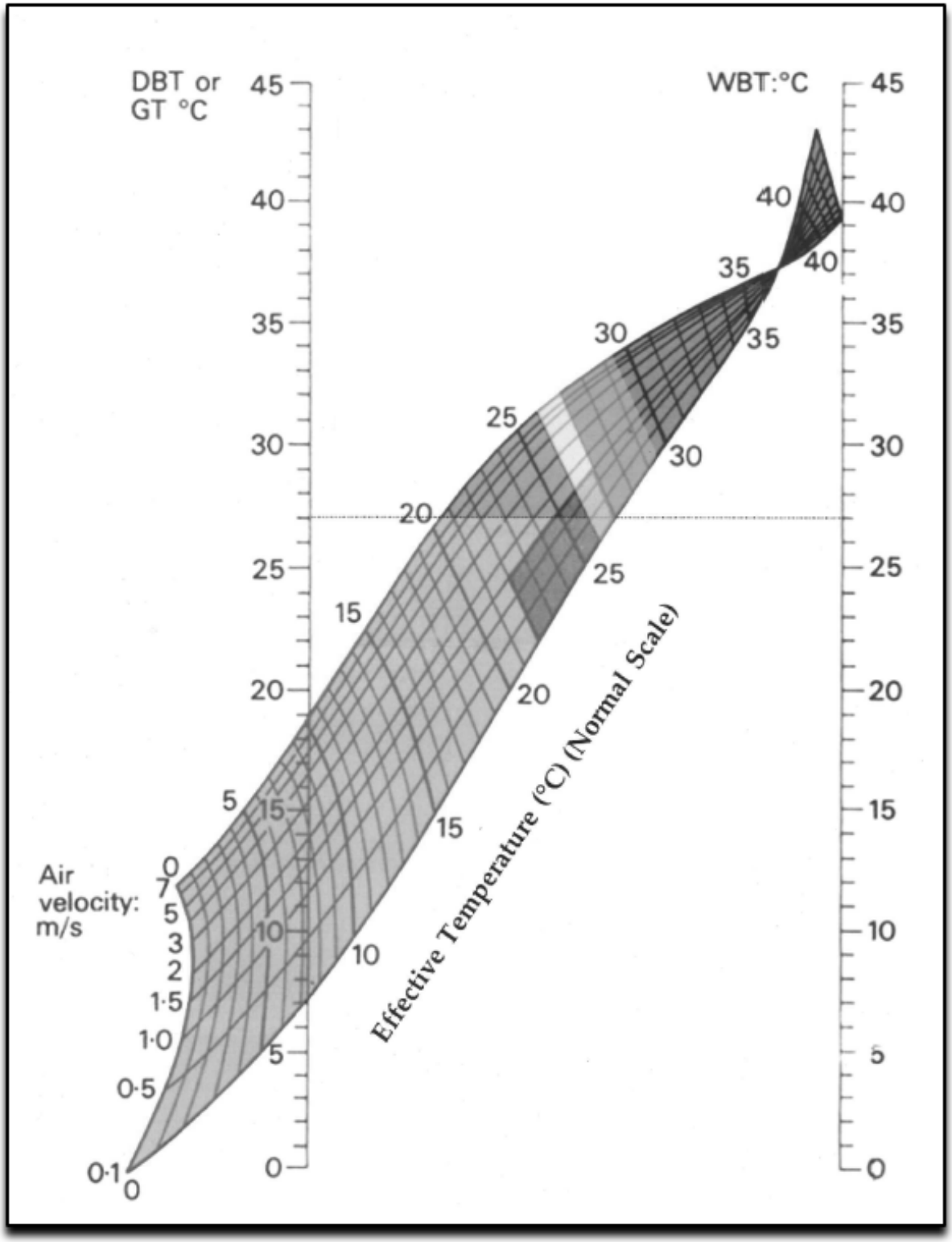
The mine shall establish and maintain procedures for the identification, maintenance and disposition of records.

6 Bibliography

1. Brake R., Donoghue, M. and Bates, G. (1998). **A New Generation of Health and Safety Protocols for Working in Heat**, in Proceedings, Qld Mining Industry Health and Safety Conference.
2. Brake R. et al, (2003). **Thermal Work Load as an index of thermal stress**.
3. Di Corleto, R., Coles, G. and Firth, I. (2001). **Heat stress standard & documentation developed for use in the Australian environment,** Australian Institute of Occupational Hygienists.
4. Di Corleto, R, Firth, I and Mat'e Joseph (Nov 2013) **A guide to managing heat stress: Developed for use in the Australian Environment,** Australian Institute of Occupational Hygienists
5. **Environmental Engineering in South African Mines.** (1989). The Mine Ventilation Society of South Africa.
6. **Guidelines for the Management of Work in Extremes of Temperature**. ISBN 0-47703605-8, Department of Labour, Wellington, NSW, September 1997
7. **Guidelines. Management and Prevention of Heat Stress**. ISBN 0 7309 8558 X Department of Minerals & Energy WA 1997.
8. Hansen M.A. and Graveling R.A. (1997) **Development of a code of practice for work in hot and humid conditions in coal mines**. Institute of Occupational Medicine.
9. ILO **Encyclopedia of Occupational Health and Safety – General Hazards - Heat Stress**.4th Edition.
10. ISO 7243. (1989). **Hot environments & estimation of the heat stress on working man, based on the WBGT-index (wet bulb globe temperature)**. ISO: Geneva.
11. ISO 7933. (1989). **Hot environments – Analytical determination and interpretation of thermal stress using calculation of required sweat rate**. ISO: Geneva.
12. MACPHERSON, R. 1962. **The assessment of the thermal environment.** A review. British Journal of Industrial Medicine, 19, 151-164.
13. McPherson M.J. (1993). **Subsurface Ventilation and Environmental Engineering**.
14. Parsons, K.C. (1999). **International standards for the assessment of the risk of thermal strain on clothed workers in hot environments.** Annals of Occupational Hygiene.
15. Pickering A.J. and Tuck M.A. (1997). **Heat: Sources, evaluation, determination of heat stress and heat stress treatment**. Heat and Noise in Underground Mining Symposium, (pp 147- 156).
16. Ramsey J.D. and Beshir M.Y. (1997). **Thermal Standards and Measurement Techniques, The Occupational Environment** edited by Salvatore R Di Nardi, Published by The American Industrial Hygiene Association.
17. Sawka, M.N., Wenger, C.B. and Pandolf, K.B. (1996). **Thermoregulatory responses to acute exercise-heat stress and heat acclimation**. In: Handbook of Environmental Physiology. American Physiological Society.

Appendix 1: Calculating Normal Effective Temperature (NET)

The Normal Effective Temperature (NET) is the equivalent temperature in still, saturated air that appears to feel the same to an individual in the prevailing conditions. The NET nomogram is configured for lightly clothed subjects and includes appropriate correction for reduced evaporation and convection from the skin surface.



Appendix 2: Glossary

Acclimatisation	Acclimatisation results in an increased tolerance for person to work in heat.
Basic effective temperature (BET)	The Basic Effective Temperature (BET, or commonly ET in the mining industry) is the equivalent temperature in still, saturated air that appears to feel the same to an individual in the prevailing conditions. The BET nomogram is configured for subjects stripped from the waist up.
Dry bulb (DB) thermometer	Used to obtain air ambient temperature. It should be shielded from radiation without restricting airflow around the bulb.
Effective temperature (ET)	A heat stress index based on subjective thermal sensation. The index takes account of DB temperature, WB temperature, and air velocity.
Heat illness	Debilitating conditions brought on by exposure to heat stress and including skin disorders, heat syncope, heat exhaustion, heat stroke, neurological disorders (i.e. nausea, loss of coordination, lethargy, concentration lapses) and dehydration.
Heat strain	The psychological response to heat stress that may or may not result in heat illness.
Heat stress	The sum of environmental and metabolic heat loads on the body.
Heat stress index	The index eligible for selection for use in the sites safety and health management system that must be a recognised index that is technically documented. Eligible indices include but not limited to: • Effective temperature (ET) • Corrected effective temperature (CET) • Air cooling power (ACP) • Thermal work load (TWL)
Heat stroke	A life threatening advanced state of heat illness characterised by a failure of the body's thermo-regulatory system.
Monitoring	Monitoring is the measurement, calculation and recording of effective temperature at the mine.
Normal effective temperature (NET)	The Normal Effective Temperature (NET) is the equivalent temperature in still, saturated air that appears to feel the same to an individual in the prevailing conditions. NET takes into account subjects being lightly clothed and includes appropriate correction for reduced evaporation and convection from the skin surface.
Wet bulb (WB) thermometer	Used to obtain air moisture content. The natural wet-bulb temperature is obtained by wetted sensor which is exposed to natural air movement and unshielded from radiation.

Appendix 3: Abbreviations

ACP	Air Cooling Power
BET	Basic Effective Temperature
CABA	Compressed Air Breathing Apparatus
CMSHA	Coal Mining Safety and Health Act 1999
CMSHAC	Coal Mining Safety and Health Advisory Committee
CMSHR	Coal Mining Safety and Health Regulation 2017
CMW	Coal Mine Worker
DB	Dry Bulb
ERZC	Explosion Risk Zone Controller
ET	Effective Temperature
NET	Normal Effective Temperature
PPE	Person Protective Equipment
RSHQ	Resources Safety and Health Queensland
SCSR	Self Contained Self Rescuer
SEG	Similar Exposure Group
SHMS	Safety and Health Management System
SSE	Site Senior Executive
TARP	Trigger Action Response Plan
TWA	Time Weighted Average
TWL	Thermal Work Limit
WB	Wet Bulb
WBGT	Wet Bulb Globe Temperature