Resources Safety & Health Queensland

Guidance Note QGN32

Managing Exposure to Heat in Surface Coal Mines and Surface Areas of Underground Coal Mines

Resources Safety and Health Queensland

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Coal Mining Safety and Health Act 1999

Guidance Note – QGN32 Guidance note Managing Heat Stress in Surface Coal Mines and Surface Areas of Underground Mines.

This guidance note has been issued by the Coal Mines Inspectorate from the Resources Safety and Health Queensland to provide guidance to coal mines in managing heat exposure on site.

This guidance note is not a Guideline as defined in the Mining and Quarrying Safety and Health Act 1999 (MQSH Act) or a Recognised Standard as defined in the Coal Mining Safety and Health Act 1999 (CMSH Act).

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Contents

1 Purpose

The purpose of this guidance note is to provide practical guidance to coal mine operators, employers and employees about how to manage heat exposure at open cut coal mines and on surface areas of underground coal mines, in order to prevent heat related illness. While it is acknowledged that there is a plethora of technical guidance available in the public domain, it is not the intention of this guidance note to re-produce this material, rather to provide practical information which is relevant to the Qld coal mining industry. For this reason, numerous examples of managing heat exposure on coal mine sites have been attached. This guidance note provides information on:

- Identifying risk factors which can contribute to heat related illnesses.
- Methods for evaluating the thermal exposure risk on mine sites.
- Practical and effective guidance for controlling and managing heat exposure on coal mines.
- Defining what constitutes an acceptable level of risk (ALOR) for working in heat.
- Applying 'risk management' principals to control exposure to an acceptable level of risk.
- Emergency response and recognising the signs, symptoms and treatment of heat related illness.
- Developing education materials on working in heat for coal mine workers.

The management of heat risks in underground coal mines is not incorporated in the scope of this guidance note and should be managed separately in accordance with Recognised Standard 18 – Management of Heat in Underground Coal mines (1).

2 Scope

This guidance note applies to all Queensland surface coal mining operations and the surface operations of underground coal mines as defined under the Coal Mining Safety and Health Act 1999 ('the Act') (2) . This guidance note QGN32 relates to the requirements of Section 42 of the Act, where the Senior Site Executive (SSE) has obligations to establish a documented process within the sites SHMS to ensure that the exposure of CMWs to health hazards including exposure to the thermal environment is controlled to an ALOR. Relevant sections include:

(a) to ensure the risk to persons from coal mining operations is at an acceptable level; and

(c) to develop and implement a safety and health management system (SHMS) for all persons at the mine, including contractors and service providers;

(h) (ii) to ensure no work is undertaken by a coal mine worker at the mine until the worker - has received training about hazards and risks at the mine to the extent they relate to the work to be undertaken by the worker;

(i)(iv) to provide for - regular monitoring and assessment of the working environment, work procedures, equipment, and installations at the mine;

Specifically, this guidance note has been developed to assist coal mining operations satisfy requirements of section 143 of the Coal Mining Safety and Health Regulation 2017 (3).

s143 Heat stress

A surface mine's safety and health management system must include a procedure for protecting persons from heat that may lead to heat stress, heat exhaustion or heat stroke.

3 Introduction

Exposure to moderate to high ambient thermal conditions during summer is the predominant heat exposure risk within the Queensland surface mining industry, when maximum daily temperatures regularly exceed 30 degrees Celsius. The monthly temperature data across both the Surat and Bowen Basin regions, where the majority of coal mines are located, is shown below.

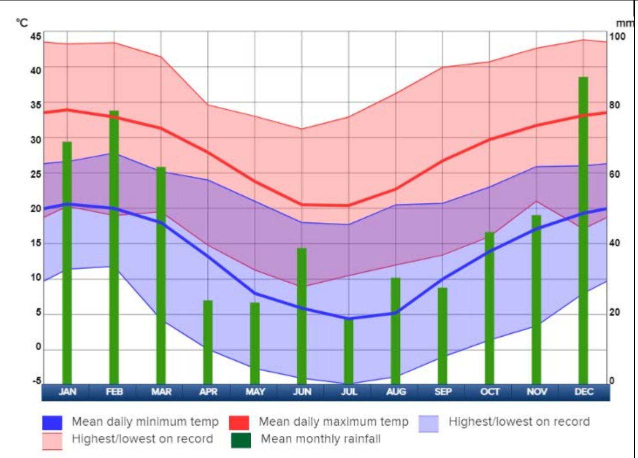


Figure 1 – Surat Basin (Miles Township) (4)

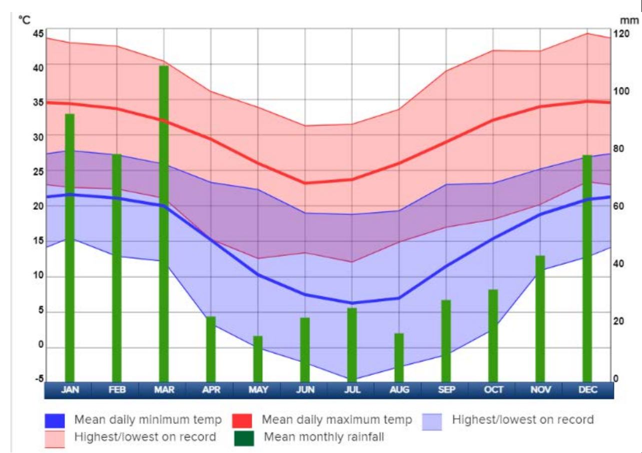


Figure 2 – Bowen Basin (Clermont Airport) (4)

Deliberate and systematic management of heat exposure is required to minimise the risk of over-exposure leading to adverse health and safety incidents. Historically there has been an under reporting of heat related incidents from surface mines in Queensland and this is likely due to a lack of understanding and consideration of heat exposure as a contributing factor, to a range of different symptoms and effects which are reported. Anecdotal information indicates that heat related incidents are often attributed to and classified according to non-work related predisposing factors identified with the individual, rather than to heat exposure, where the later may not be considered to be the primary factor.

While incidents of heat stroke are rare, mild to moderate symptoms of heat exhaustion and less severe incidents of heat related illnesses (including heat rash, syncope and cramps) are more common and typically present as ad-hoc individual events during the summer. In addition, workers often describe experiencing fatigue-like symptoms after being repeatedly exposed to moderate to high heat conditions for prolonged periods. These unpleasant physiological and psychological side effects have been referred to as ‘heat hangovers’ which can manifest as irritability, headaches, nausea, loss of appetite and general lethargy towards the end of shift and/or following shift. Based upon preliminary evidence in other outdoor industries located in Queensland, it appears the hangovers do not require excessively high core body temperatures. Rather, moderate body temperatures for extended periods, likely in excess of an individual’s capacity, appear to precipitate the hangovers (5).

The impact of heat exposure on workers can affect physical and mental performance and this may contribute indirectly to an increase in safety related incidents. For example, the performance of complex tasks (which require greater concentration and manipulation) may be adversely impacted when mental and physical impairment occurs as a result of heat exposure. Increased trends in incidents of work-related injury have coincided with elevated ambient temperatures and the warmer summer months of the year (6). Furthermore, the impacts of heat wave events have reportedly resulted in a 45% increase in workers compensation claims within the Brisbane region (7). This is consistent with Queensland surface mining data with serious accident frequency rates found to be ~27% higher during the summer months, from October to March, when compared with winter months (data from July 2017-June 2021) (8).

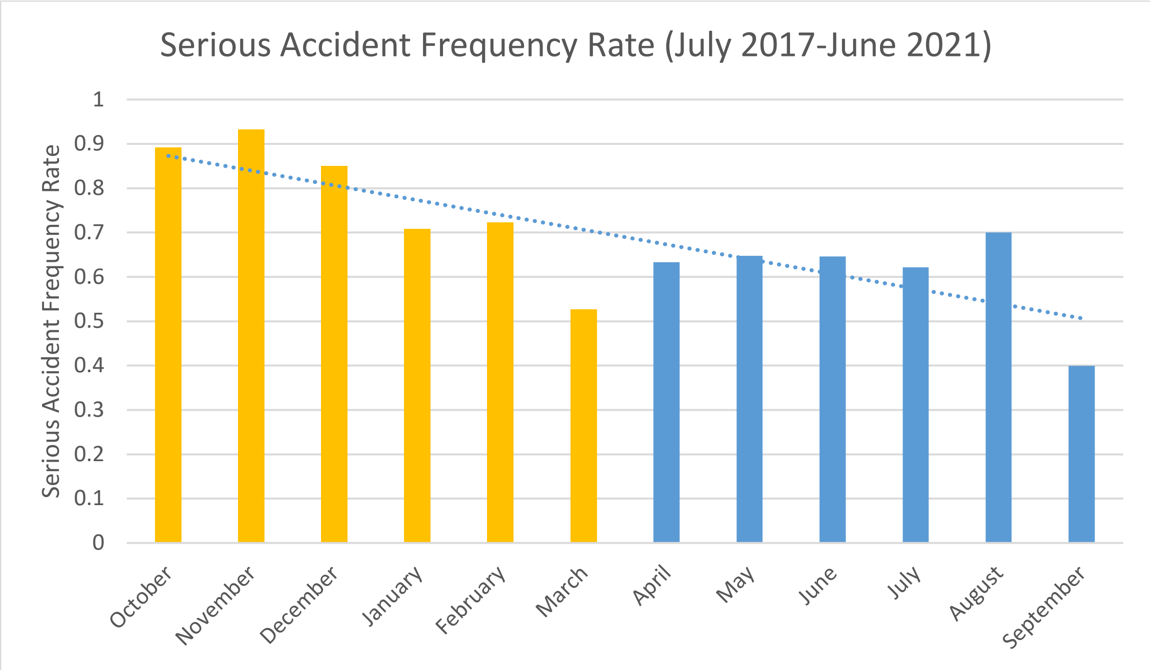


Figure 3 – Serious accident frequency rate for Queensland surface mining operations

The management of heat exposure should be a structured and systematic approach that considers the impacts of:

- environmental conditions
- physically demanding work
- process generated heat
- clothing and PPE
- health and individual factors.

The management of heat stress is a shared responsibility between management and CMWs.

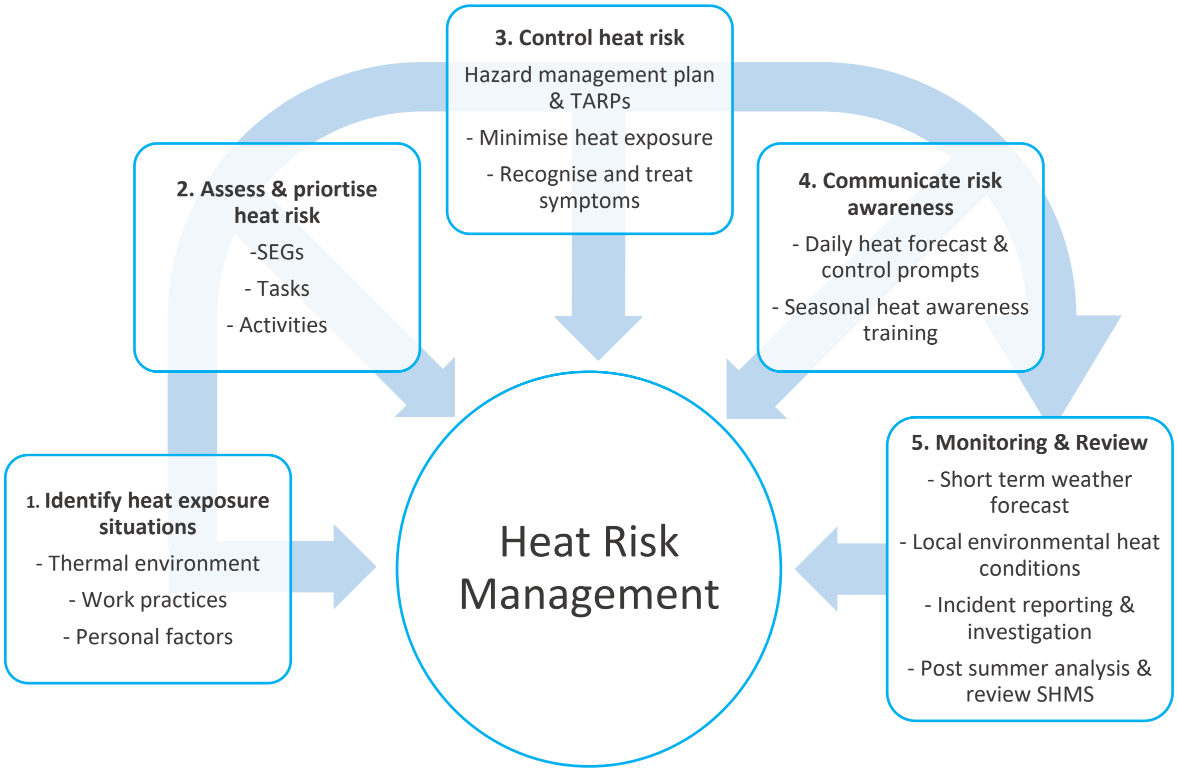


Figure 4 - Basic requirements for an effective Heat Management Plan

3.1 General principles of heat exposure management

Adverse effects from heat exposure come from the body's thermo-regulatory response to heat exposure and inability to maintain a constant core body temperature.

3.1.1 Thermoregulation

Thermoregulation is a continuous and automatic process performed by the body to ensure core body temperature is controlled within a very narrow range of temperature (~37°+/- 1°C) and is essential for maintaining normal body functions and wellbeing. This temperature equilibrium requires a constant exchange of heat between the body and the external environment. If this control is lost and the core temperature begins to rise, various physiological responses occur which can lead to adverse health and safety effects.

Irrespective of the external environmental conditions, the primary heat load on the body is generated by physical work. Since body heat is produced in proportion to the intensity of physical work, higher intensity results in greater body heat production. Most of this excess body heat needs to be dissipated to the environment to prevent its storage. The body automatically activates the primary heat loss mechanisms of increased skin blood flow and sweating. Elevated skin blood flow increases skin temperature and heat loss via radiation and air flow across the skin (convection), while sweating dissipates heat via evaporation. This concept is depicted in figure 5.

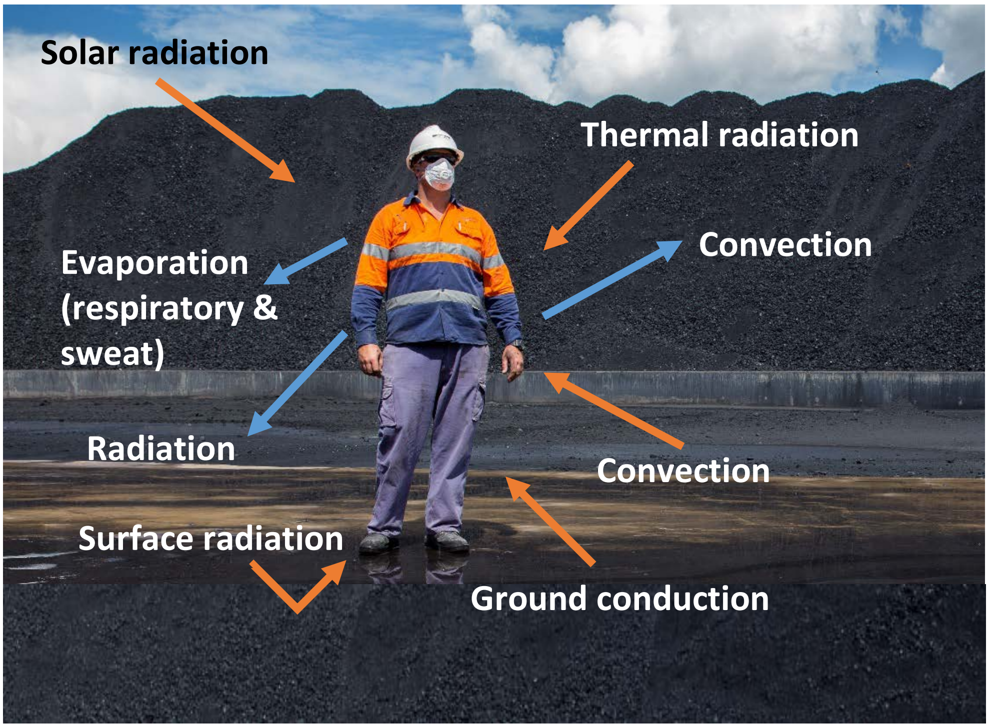
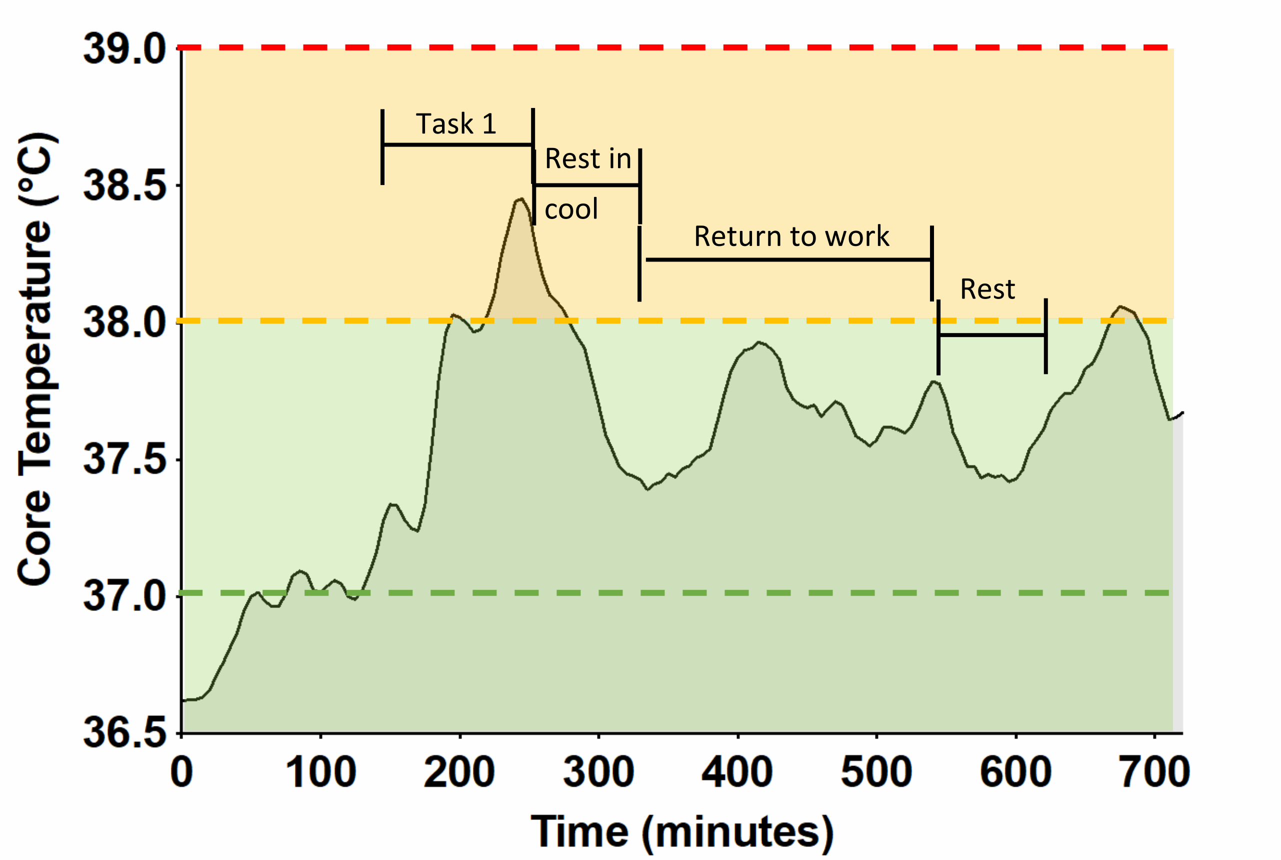


Figure 5 – Factors of thermoregulation

The efficiency of these mechanisms is determined by environmental conditions, with higher temperatures limiting heat loss by radiation and convection, and when combined with high relative humidity, limiting evaporation of sweat. The amount and rate of heat exchange is governed by a range of factors including:

- Environmental conditions (ambient temperature, relative humidity, radiant heat, wind speed)
- Metabolic workload (physical activity performed by of the coal mine worker, higher work rates produces more body heat)
- Personal and pre-disposing factors (physical fitness, acclimatisation, hydration, use of cooling, clothing)

Figure 6 shows the core temperature measured on a maintenance worker at a Queensland open cut coal mine. This figure shows core temperature fluctuations during a routine shift showing the real-time impacts of thermoregulation and demonstrates the rise and fall of core temperature as a direct result of applying work rest regimes.



Core Temp Legend	
— — — (green)	Normal
— — — (orange)	Recommended limit (Body under stress)
— — — (red)	Upper workplace limit of thermoregulation

Figure 6 – Core temperature over a shift

3.1.2 Health effects

Occupational exposure to heat can result in a range of adverse health and safety effects including impaired performance, injuries, illness, disease, and death. Heat-related symptoms are broadly classified on the basis of frequency and severity into chronic low-grade cases and isolated high-grade cases. Chronic low-grade cases include fatigue, irritability, headaches, cramp and rashes, have been reported for QLD field electrician (9). Isolated high-grade cases include symptoms of the heat-related illnesses of heat exhaustion and heat stroke.

The impact of workplace heat exposure is not just limited to heat stress symptoms or heat-related illness, as workplace accidents / injuries peak during the hottest months (10) and more specifically, during heatwaves (11). Heatwave periods also elevate the risk of occupational heat-related illness by approximately four to seven times higher than that of non-heatwave periods.

The impact of heat extends beyond the work shift, with workers reporting impaired sleep, decreased appetite and strained family relationships following sustained periods of exposure to work in heat conditions (12).

Further details regarding heat effects from heat related illness including symptom recognition and treatment of effected CMW's has been provided in section 7.1 and 7.2.

3.1.3 Controls

The control strategies employed to reduce heat exposure risks are primarily directed at the factors which affect thermoregulation and the rate of heat exchange between the body and the environment (refer to section 3.1.1 above). These include:

- Engineering controls to either modify the thermal environment where CMWs work or reducing the physical exertion and workload requirements of manual tasks.
- Administrative controls which minimise the duration of exposure to heat while performing work through task rotation, work rest cycles and scheduling work to cooler periods.
- Personal protective equipment selection to optimise heat exchange or wearing specialised cooling garments or vests.
- Health assessment and ongoing surveillance to identify and manage individual CMWs with pre-disposing risk factors including acclimatisation, fitness for work, and medical conditions.

4 Hazard identification

All coal mines must develop a system to manage the risk of heat exposure which includes identifying areas, tasks and similar exposure groups where CMWs may be exposed to high heat conditions and / or perform physically demanding work.

The system should consider the following primary risk factors to CMWs when identifying hazards:

- environmental factors
- work process factors
- individual and pre-disposing factors.

4.1 Environmental factors

Several environmental factors can influence the heat load on the body and should be considered when assessing the risk. These include:

- air temperature (dry bulb)
- humidity (wet bulb and dry bulb temperature)
- air flow / movement (from natural or forced ventilation)
- direct sun exposure (radiant heat)
- radiated heat from hot surfaces (plant, equipment or ground).

Basic information regarding ambient environmental conditions can be easily sourced for initial risk assessment from the Australian Bureau of Meteorology (BOM) website or 'off-the-shelf' weather station units.

Environmental conditions can vary across a mine site depending on the specific work location, and may be affected by:

- local topography and depth in-pit, including excavations and stockpile material
- surface type (black coal vs overburden)

- working in open areas without shelter from direct sunlight
- plant structures including confined or partially enclosed spaces (e.g. reclaim tunnels, CHPP infrastructure)
- proximity to radiant heat sources (e.g. machinery, laboratory ovens, spontaneous combustion / reactive ground).

Where heat conditions are significantly affected by local environmental features, adjustments should be considered and applied when the ambient conditions have been obtained from distant weather station data and may not be representative. Any adjustments made where there is a potentially high exposure risk, should be verified by local measurement.

4.2 Work process factors (physical tasks and activities)

The type of work being performed by CMWs influences how they may become exposed to heat. Influences include:

- Location of CMW in relation to ambient heat (e.g. outdoor, in shade or direct sun, or in proximity to hot surfaces);
- Duration of exposure to heat (e.g. task scheduled to occur at midday or early morning, task role change)
- Work process generated heat (e.g. hot works including welding)
- Intensity of work and self-generated heat through physical exertion of the task (e.g. manual handling, shovelling spillage clean-up)
- Selection of personal protective clothing (e.g. disposable coveralls)

Some examples of workgroups and / or tasks that may present an elevated risk on a surface coal mine have been included in Table 1.

Table 1 – Common surface coal mine tasks

Outdoor work in direct sun	• Blast crew • Pump crew • Field maintenance • Exploration and gas drainage drillers
Work process generated heat	• Boilermakers (welding, gouging, lancing) • Workshop maintenance (hot engines, pre-heat fittings) • Laboratory (sample ovens) • Working in and around water / humidity (hosing / cleaning hot plant)
Physically demanding work	• CHPP operators (ascending-descending stairs, unblocking chutes, cleaning) • Civil projects (manual handling portable plant, equipment and tools, concreting) • Emergency response team (manual handling portable equipment)

Confined and partially enclosed spaces	• Plant shutdowns and overhauls (dragline revolving frame) • Painting and blasting (enclosed booths) • Working in mobile equipment or control room cabins with ineffective ventilation systems
Protective clothing	• Boilermakers (heavy protective aprons, gloves and head shields) • Industrial cleaners (disposable coveralls) • Abrasive blasting and cleaning (high pressure protective clothing and head covering) • Electrical HV work (arc flash protective clothing) • Emergency response team (wearing additional PPE / BA and clothing)

The larger proportion of CMWs in surface coal mines operate mobile plant and are positioned inside air-conditioned cabins for a significant part of their shift. This group is considered low risk for heat exposure unless these controls fail. These CMWs are typically only exposed to ambient heat conditions intermittently for short durations when exiting vehicles for meal breaks, swapping machines, or during unplanned maintenance or repairs. These CMWs and others exposed to similar conditions such as operational supervisors, may not be acclimatised to working in heat and will be at elevated risk if their job changes and they are suddenly required to work outdoors for extended periods.

This could also apply to itinerant workers who attend the mine site for intermittent periods and may not be exposed to working in the heat for sufficient enough periods to become acclimatised.

4.3 Individual and pre-disposing factors

Individual responses to heat exposure will vary significantly between different CMWs performing the same work, due to individual and pre-disposing factors. These factors should be considered when assessing heat exposure risks and during the development and implementation of controls. These include, but are not limited to, the following:

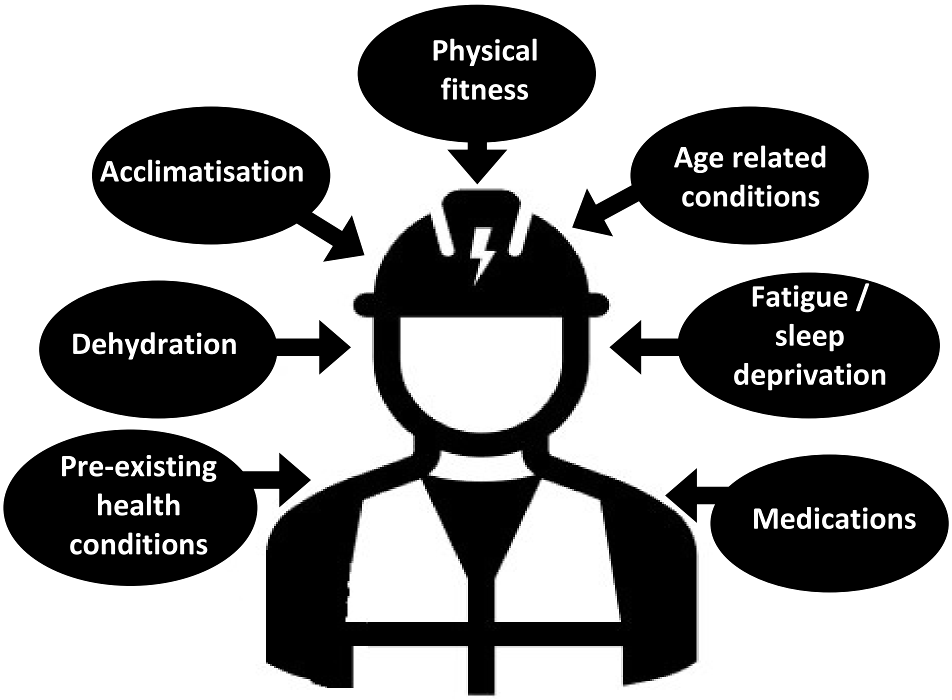


Figure 7 – Individual and pre-disposing factors

In addition to these factors, the bravado of a team member or a "don't want to be seen as a weak link" attitude can lead to workers concealing early signs and symptoms of heat illness, overexposure and over exertion when performing physical tasks.

Where individual risks are flagged to elevate the risk, control strategies need to consider further reducing exposure by modifying the work environment and practices (refer to section 6).

5 Risk assessment

There are a range of different heat stress indices and criteria in published literature which can be used as tools for evaluating the risk to workers from working in heat. These tools typically apply a set of criteria which take into account the environmental heat conditions, rate of metabolic work being performed and acclimatisation status of the worker. Typical recommendations include a suitable exposure duration limit to maintain thermoregulation and prevent an unsatisfactory rise in core body temperature.

5.1 Assessment methods and criteria

Some of the tools and criteria available have been listed below. Available methods are based on modelling and should only be used as qualitative indicators of exposure risk. It is important to note that the published tools are generic by design and have not been derived specifically for application in surface coal mining in Queensland, although provide options for consideration. There are limitations with each methodology and these should be considered during selection.

***AIOH Guide to managing heat stress** – this method uses a three-stage approach:*

Level 1 'basic thermal risk assessment'; primarily designed as a qualitative risk assessment without requiring specific technical skills (13). The tool acts as a simple ranking system to identify moderate and high risk exposure tasks, with an escalation process requiring further detailed assessment, which is outlined in stages 2 and 3. Electronic versions of this tool are available as a mobile phone application ('Thermal Risk') and on the Queensland Government website ('Heat Stress (Basic) Calculator').

Level 2 recommends application of the Predicted Heat Strain method of assessment (ISO 7933; 2004) and Level 3 recommends using physiological monitoring to evaluate the exposure.

Heat Index (Apparent Temperature)

The Heat Index is a temperature equivalent value, calculated from the ambient temperature and relative humidity to estimate the perceived effects of heat exposure. It does not take into account air velocity or radiant heat - both of which contribute to heat loss and gain by the body.

There are updated versions available that take into account varying environmental conditions such as wind speed (13) (14).

Predicted Heat Strain (PHS)

This is a rational method which uses heat balance equations and mathematical calculations for evaluating and predicting the physiological limits for working in heat and can be applied to real or hypothetical situations. The method calculates thermal balance of the body from environmental factors, metabolic rate and estimated clothing characteristics. Outcomes predict the rate of heat loss to the environment through sweat evaporation, conduction and convection. It determines maximum allowable exposure times to avoid dehydration and limit core temperature rise (15).

The index combines the physics of heat exchange and what is required to maintain heat equilibrium with what is physiologically achievable to prevent core temperatures exceeding threshold limits. It involves complex equations and requires the use of computational tools to perform calculations. Software programs are available to calculate predicted heat strain and free versions are available on the internet (16).

Thermal Work Limit (TWL)

Developed by Brake and Bates and based on underground metalliferous mining conditions, this method defines the maximum sustainable metabolic rate that hydrated, acclimatised individuals can sustain in a specific thermal environment, in order to maintain a safe core body temperature (<38.2^{o}C) and sweat rate (<1.2 kg/hr) (17). The criteria takes into account environmental parameters and clothing factors to predict a maximum metabolic work rate that can be continuously sustained, for the conditions being assessed. The calculated limit is classified into separate risk categories with comments and controls provided for each category. There are commercially available portable instruments which can be positioned in the workplace to monitor thermal conditions and calculate the TWL.

Wet Bulb Globe Temperature (WBGT)

WBGT is a temperature-based index which predict the effects on core body temperature by estimating the environmental contribution to heat stress, including the influence of air temperature, radiant heat and humidity. It involves specialised monitoring equipment to measure the dry bulb, wet bulb and globe temperature in-situ. ACGIH have developed Threshold Limit Values (TLVs) with recommended work-rest intervals for acclimatised an unacclimatised workers. It takes into account clothing adjustment factors and metabolic work rates to ensure core body temperature does not exceed safe limits (18). A number of other recognised methodologies also use WBGT in determining exposure limits including AIHA, OSHA, ISO (19) and NIOSH. Portable instruments are commercially available to measure, display and record WBGT levels in the workplace.

NIOSH - Recommended Exposure Limits (RELs) for acclimatised workers and Recommended Action Levels (RALs) for non-acclimatised workers

NIOSH RELs were developed to protect most acclimatised workers while being exposed to environmental and metabolic heat from developing adverse heat-related health effects (14). NIOSH RALs are developed to protect unacclimatised workers. RALs & RELS are developed for the level of physical activity required while wearing conventional one-layer work clothing ensembles. The NIOSH RELs and RALs apply WBGT–based limits for workers and are similar to those of other national and international standards.

Effective Temperature

This is a subjective and empirically based temperature index, combining dry bulb temperature, aspirated wet bulb temperature and air velocity which is read from specially constructed nomograms (20). Measurements of dry bulb and wet bulb temperature are typically made with a handheld 'sling psychrometer' and values used with a psychometric chart to determine the effective temperature. This method is still used as a regulatory tool in the Queensland underground coal mining industry (21).

Physiological monitoring

Physiological monitoring assesses workers individual responses to working in thermal conditions. It may include assessment of core body temperature (net product of heat production and heat loss), heart rate (indicative of work rate and heat induced cardiovascular strain), sweat rate and dehydration (representative of fluid balance). Core body temperature is the most accurate measure of heat exposure risk, but it is difficult to accurately assess in the field due to invasive procedures and technological limitations.

Direct core temperature measurement using gastrointestinal temperature assessment can be performed using ingestible tablets and provides the most accurate assessment. Direct core temperature measurements are not practical for monitoring routine work in heat on a daily basis, but can be used for investigative purposes. There are a range of alternatives to measure thermal strain and further guidance can be obtained from ISO 9886 – Ergonomics – Evaluation of thermal strain by physiological measurements (22). However, oral, axillary, tympanic, temporal, forehead temperatures and heart rate monitoring are not valid surrogates of core body temperature in field conditions (23). Situations where physiological monitoring could be considered include:

- during extreme environmental conditions
- working in encapsulating suits
- where individual factors such as fitness and acclimatisation status are unknown or significantly impact the workers ability to thermo-regulate normally (heat-intolerant).

Customised mine based risk assessment

Several Queensland coal mines have developed their own customised risk assessment methods to manage heat exposure, by adopting elements from the published assessment methods listed above and adapting these to mine specific exposure conditions. A summary of these two approaches have been provided as examples in Appendix 2 and 3, for practical guidance. These methods consider factors including environmental conditions, estimated workload, clothing and some individual factors. Results from the assessment are used to guide the sequential application of control actions, which have been listed in Trigger Action Response Plans (TARPs).

- Baseline Heat Exposure Assessment (Appendix 2 – Example 1)
- Shift-based Heat Management Tool (Appendix 3 – Example 2)

The customised methods should be considered for use in practical applications, in conjunction with the empirically derived assessment methods and criteria, from which they have been derived.

5.2 Assessment of thermal environment

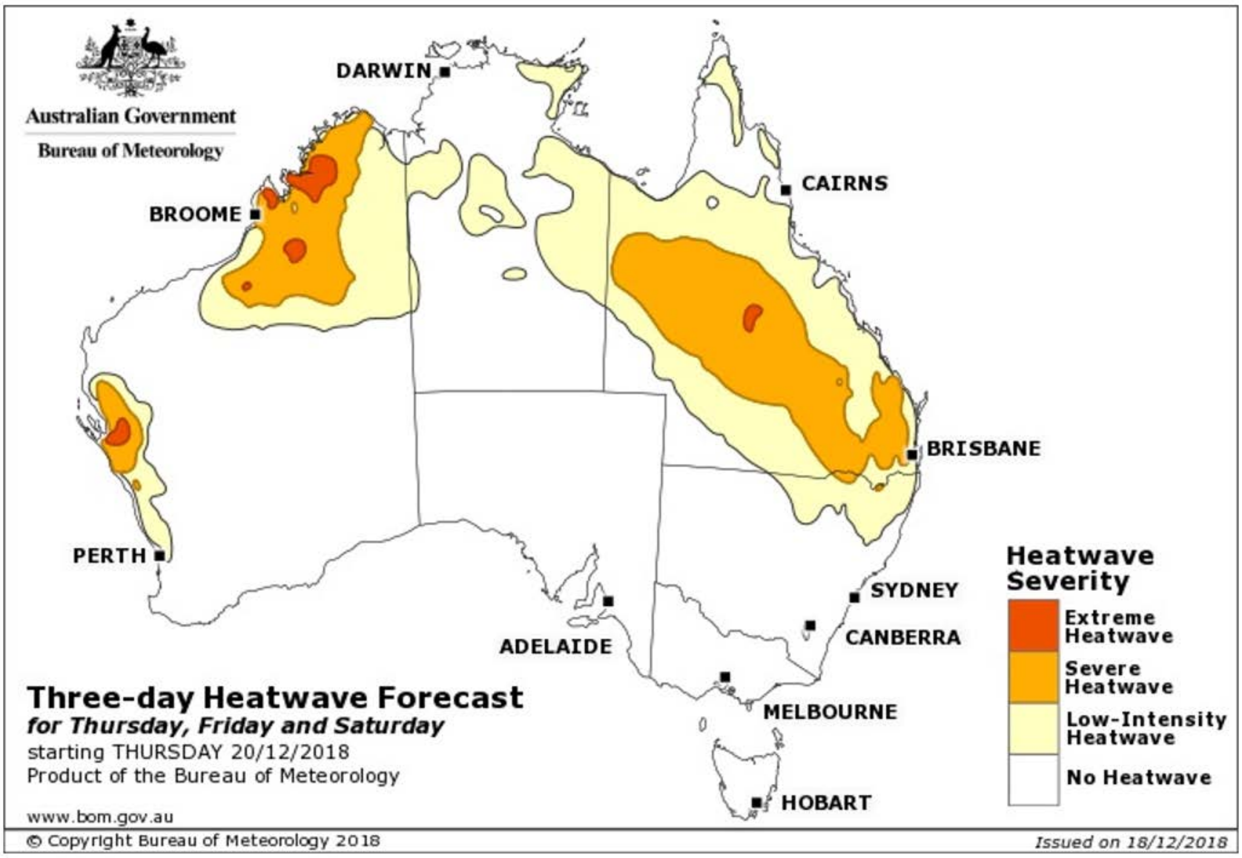
The chosen assessment criteria will require capture of environmental data which may include:

- Air Temperature (dry bulb)
- Humidity (dry bulb, wet bulb)
- Radiant temperature (globe)
- Wind speed

There are many tools available that report information - from simple weather monitoring stations or the national Bureau of Meteorology (BOM). The BOM data provided by local stations provides a reliable indication of ambient heat conditions including temperature, humidity and wind speed, to inform an initial assessment of environmental heat exposure risk.

While data collected from BOM and other weather stations provides information about ambient conditions, it may not accurately reflect thermal conditions at particular positions within the workplace. Alternatively, more accurate location or task specific data can be collected using portable monitoring devices. There are a range of commercially available devices, including direct reading instruments (with and without digital display), data recording and logging, and data transfer options. To ensure accurate data is collected, the equipment should be maintained and calibrated as per the manufacturer's specifications.

The BOM service also provides forecast advanced warning for predicted heat wave events, which provides a useful trigger to prompt heat awareness communication to workers and activate escalated exposure controls on the mine site. The BOM defines a heat wave as 3 or more days where maximum and minimum temperatures are unusually high for the location. It should be noted that the heat wave forecast does not include changes in humidity.



BOM Heatwave Legend	
	Low Intensity – most people can cope
	Severe – challenging for vulnerable people, such as the elderly
	Extreme – Dangerous for anyone who does not take protective action

Figure 8 – Example BOM heat wave assessment

5.3 Assessment of work activity / task / clothing

The internal heat load generated from performing physical work can be assessed and ranked in order of severity, according to the estimated metabolic rate associated with the task or activity. Correct assessment of work rate is of equal importance to environmental assessment in evaluating heat stress. A summary of the estimated metabolic rates for typical tasks performed on coal mine sites has been provided in the table below.

Table 2 – Estimated metabolic rates (derived from ISO 7243 (19)**)**

Class	Metabolic Work Rate (Watts)	Examples
Resting	115 (100-125)	Resting; sitting stationary in a chair; no physical activity
Low	180 (125-235)	Walking on flat surface, work area inspections (single level), arm and leg work driving a vehicle. Using lightweight handheld tools
Moderate	300 (235-360)	Sustain hand and arm work (hammering, pneumatic tools), intermittent handling of heavy material, pushing or pulling light loads
High	415 (360-465)	Intense activity such as shovelling, using a sledgehammer, digging with a crowbar, pushing or pulling heavy loads
Very High	520 (>465)	High intense activity at a fast to maximum pace. Running on a level surface, climbing stairs, ramp or ladder

The typical clothing worn by CMWs includes full length cotton drill or denim trousers, long sleeve cotton drill shirts, hard hat, socks and steel cap boots. This clothing has primarily been chosen to act as a barrier to protect CMWs from physical hazards and solar UV. Additional items of PPE including gloves, respirators, disposable overalls, fire retardant clothing and chemical protective overalls may be worn for specific tasks. Any clothing will act as a barrier to heat transfer and the greater the surface area covered, the greater the affect. The insulating effect of fabric will reduce heat gain from hot environments; although this benefit is outweighed by the increased resistance to sweat evaporation off the skin, which is the main cooling mechanism in hot humid environments.

Resistance to evaporation is reduced by air circulation around and through clothing. This may be enhanced by loosely woven (or perforated) fabrics with construction that is loosely fitted, with openings that allow air under clothing with body movement (24). For a given clothing ensemble and fabric type, minor changes to the structural design of clothing is likely to have limited impact on reducing evaporative resistance. Selecting lighter fabric materials with lower 'GSM' density and suitable SPF rating UV protection, may facilitate increased air movement through the fabric and improve evaporation.

Full-length chemical protective coveralls, vapour barrier garments and other types of impermeable clothing do not facilitate evaporative cooling and the duration of wear time should be strictly controlled.

The impact of clothing on impeding the body's capacity to dissipate heat while working in hot conditions must be taken into account when assessing exposure risks.

There are a range of protective clothing ensembles including air, water and ice cooled garments which are commercially available and reported to provide supplementary body cooling. In general, cooling garments are most effective when worn during work to blunt the rise in core temperature, rather than to expedite body cooling during rest periods.

Further information on the thermal properties of clothing can be found in the reference material provided (24) (14).

5.4 Assessment of an individual

Incident investigations have indicated that heat exhaustion events in mining occur in elevated ambient heat conditions and are often triggered by a compromised state of wellbeing on the day of the event. This may be due to temporary illness, lack of sleep, fatigue, or recovery from previous alcohol consumption.

Individual assessment, while likely the most important, is difficult to control as it requires CMWs to self-report any potential underlying health conditions that may impact their ability to thermoregulate. These conditions may also impact heat tolerance in the short term (daily) or long term and should be reassessed regularly. An example of a 'symptoms self-assessment' tool, which can be used by individual CMWs on a daily basis when working in heat, has been attached in Appendix 4. The responses on the form should be used to inform and enable the supervisor to monitor changes in the workers' wellbeing during the shift and respond in a timely manner.

6 Controls and hierarchy

Control measures should be introduced to those SEGs, work areas and activities assessed with increased risk of heat exposure at the mine site. Control measures should follow the hierarchy of control and incorporate strategies that target reducing heat exposure from the thermal environment, task / work activity and minimise impacts from individual factors.

The role of supervisors is critical to ensuring effective implementation of heat controls. This requires ongoing assessment of the thermal work environment, monitoring the wellbeing of individual CMWs and responding in a timely manner as specified in the TARP.

A catalogue of practical controls utilised in surface coal mines is included as a photo library in Appendix 5. The following sections provide suggested controls that should be considered.

6.1 Thermal environment

- Install forced ventilation or portable air-conditioning systems to increase air movement in the work area for body cooling
- Erect permanent or temporary portable shade to the work location to shield radiant heat from sun
- Locate permanent or portable air-conditioned cool rooms in the work area
- Apply insulation to shield radiant heat sources
- Select safety clothing to optimise heat exchange through lower insulation (reduced layers and thickness) and increased permeability (open weave fabric with perforations)

- Consider the wearing of specialised personal cooling garments / vests. In general, cooling garments are most effective when worn during hot work to blunt the rise of core temperature rather than expedite body cooling during rest periods. These may be useful in extreme heat conditions, or when wearing full length protective clothing including coveralls. Limitations associated with the efficacy of cooling garments in managing core temperature should be considered prior to their use (13).
- Suitable amenities including toilets and the provision of potable water should be provided in close proximity to the work area to encourage hydration during the shift.

6.2 Task / work activity (work rest cycle, task rotation, scheduling)

- Organise work so that high workload tasks are conducted during cooler periods of the day or overnight when environmental conditions are more favourable (e.g. heavy hot work on dragline buckets / jewellery scheduled for early morning)
- Consider work that is 'paced' or 'self-paced'. 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 task that is not self-paced needs special attention. Paced work can include persons working in teams or to deadlines. (e.g. concreting, scheduled shutdown maintenance, shot firing)
- Use a task rotation or 'buddy' system to reduce exposure duration (e.g. hot work in poorly ventilated spaces, unscheduled maintenance in machine 'hell hole')
- Schedule work / rest regimes to incorporate cooling and recovery periods between successive heat exposures. Rest periods should be a minimum of 15 minutes in shaded <u>and</u> cooled areas to have a greater impact on reducing core body temperature (14)
- Decrease the work rate, in terms of metabolic heat production, using labour saving (mechanical aids) devices, adopt less physical work methods and reduce the amount of "overhead" work e.g., crane / loaders / bobcats / EWP.

6.3 Individual factors

- Acclimatisation is compromised after absence from work in heat for a week or more. This may result in a significant loss of benefits from heat acclimatisation and may lead to an increased likelihood of acute dehydration, illness, or fatigue. Acclimatisation can be regained in 2 to 3 days after returning to work in heat (14). This is influenced by a range of factors and needs to be assessed on a site and individual basis. Where a loss of acclimatisation is found, consideration should be given to adjusting work requirements for CMWs in the first days back at work. A formal acclimatisation protocol may be required for some tasks. An example of how this is applied at one Queensland mine is provided in Appendix 6
- 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
- Pre-existing health conditions which may place the CMW at increased risk to heat exposure should be reported and assessed on a case-by-case basis by the appointed medical advisor (AMA). These may include previous incident of heat related illness,

cardiovascular conditions, skin conditions and pregnancy

- Ensuring access and provision of competent medical professionals to identify and assess pre-disposing conditions and susceptibility to health-related illness treatment of CMWs
- Maintaining a healthy diet and consuming food prior to attending work, as this provides energy and is a major source of electrolytes. Adequate dietary intake should preclude the need for replacement electrolyte supplements to be added to water during the shift
- If consuming alcohol, ensure intake is within national guidelines and avoiding drinking alcohol 8-12 hours before the start of the shift
- Hydration – the consumption of sufficient cool, potable water readily accessible to the work area is the preferred method of hydration
    - Small quantities of water at frequent intervals (15-20 mins) is recommended for practical fluid replacement rather than the intake of large amounts per hour (14)
    - Consumption of energy drinks should be limited or taken in moderation, as excessive consumption can result in a salt, particularly potassium, imbalance. Excessive consumption of drinks containing caffeine including tea, coffee, energy drinks and cola may have a diuretic effect in some individuals and should also be taken in moderation (13)
    - Pre and post shift hydration testing can be used where a high risk is identified. A response plan should be activated when testing indicates dehydration is occurring. Hydration testing could be a valuable tool to assess a worker's ability to return to work following a heat related incident.
    - Including crushed ice in drinks used for hydration purposes is an effective strategy for maintaining reduced core body temperature
    - Urine colour charts in bathrooms can assist workers with self-assessment of hydration status. An example of this has been provided in Appendix 5.

6.4 Trigger Action Response Plans (TARPs)

TARPS may be developed to communicate to stakeholders when heat exposures have increased and require the staged controls to prevent an unacceptable level of exposure to CMWs at the mine.

The site's SHMS should clearly indicate the trigger levels, including how they are to be determined and what actions should be taken to implement heat exposure controls.

A TARP should be considered to identify the actions required to be taken by persons with relevant accountability for managing the risks from exposure to heat.

The TARPs should include:

- key triggers that indicate when additional controls are required
- an escalation process to ensure any increase in the level of risk is considered with appropriate actions to mitigate the effects of the exposure
- clear definitions, responsibilities and names / positions of those required to implement

these actions.

The trigger metrics could include:

- Environmental temperature, humidity and airflow (refer section 5.2)
- Physical work rates (refer section 5.3)
- Acclimatisation status (refer section 5.4)

The control measures should be designed to limit exposure to CMWs and may include:

- engineering controls
- awareness communication
- task rotation
- work / rest regimes
- restrictions applied to unacclimatised persons
- hydration protocols
- additional monitoring
- the relocation of persons

Examples of TARPs applied to manage heat in coal mines have been included in Appendix 2 & 3.

6.5 Health / medical surveillance

Individuals with pre-disposing health conditions which contribute to heat intolerance should be identified within the Coal Mine Workers' Health Scheme at pre-employment and periodic reviews. Where a CMW is potentially exposed to hot/humid conditions, the employer must identify this under section 1 of the approved Health Assessment Form as required by section 46A of the CMSHR.

In addition, where in the course of employment at a mine there is an appreciable increase in risk relating to heat exposure, a notice must be given to the CMW's employer under section 49 of the CMSHR. This could result from changes such as:

- a change in the worker's role or workplace resulting in an appreciable increase in exposure to heat
- a heat related incident on-site
- engagement by supervisors or the site health and safety team with their workforce that identifies possible heat intolerance due to a change in their physiological condition, or medication.

A copy of this notice must also be given to the employer's appointed medical adviser (AMA) to consider the worker's frequency of health assessment.

Health surveillance programs should be based on published guidelines for medical evaluations which have been specifically developed for workers exposed to hot environments. The program should include as a minimum: an assessment of the individual's tolerance to work in heat, predisposing medical conditions, use of medications and exposure history, including previous incidents of heat illness (14) (24).

Following the event of a heat related exposure which has resulted in medical treatment, the worker may have developed an intolerance to working in heat. Their return to work plan should take this into consideration.

Where a risk assessment has determined that a SEG may involve exposure to higher than normal thermal environments for the majority of a shift cycle, and on an ongoing basis, the assessment should include provisions to address heat intolerance.

7 Emergency response and treatment of heat related illness

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

- access to emergency first aid treatment facilities onsite to assist in 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.

7.1 Signs, symptoms and treatment of heat affected CMWs

Early recognition of symptoms with appropriate first aid treatment is vitally important in reducing the effects of heat strained individuals. The below figure shows the progression of heat related effects.

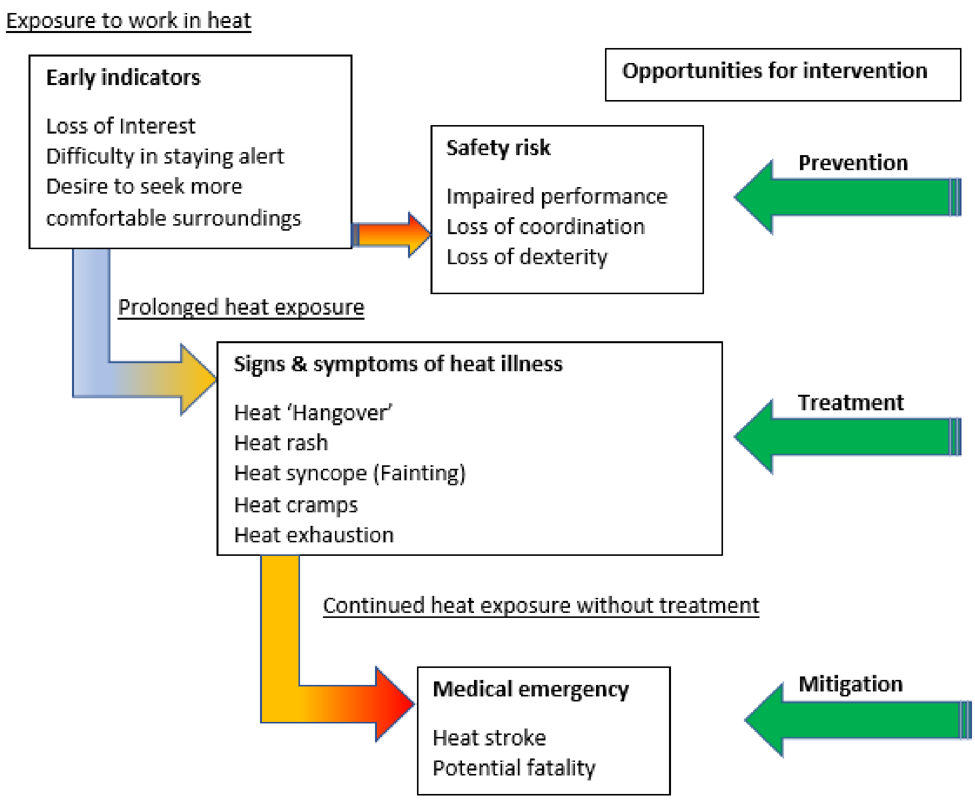


Figure 9 – Progression of heat related effects

Prolonged and uncontrolled exposure to heat can manifest into a range of heat related illnesses. Recognition and responding to the early signs and symptoms can provide an opportunity to prevent or reduce the severity of heat illness. These have been summarised in table 3 below.

Table 3 – Signs, symptoms and treatment of heat illnesses

Signs & symptoms	Treatment
Heat rash • Clusters of red spots / bumps usually on neck and upper chest (prickling sensation)	• Move to cooler place • Keep the affected area dry and clean • Avoid using ointments and creams • Apply cold compress
Heat syncope • Fainting due to inadequate blood flow to the brain	• Lie patient on their back in a cool area with airflow • Elevate patients' legs
Heat cramps • Painful muscle pains and spasms, usually in abdomen arms or legs	• Rest in cool shaded place • Stretch affected muscles • Increase fluid intake with electrolyte supplement and food
Heat exhaustion • Heavy sweating • Cold, pale skin • Fast, strong pulse • Heat cramps • Paleness • Weak, dizzy, nauseous, headache • Nausea and vomiting • Fast, weak pulse • Irritability	• Follow DRSABCD action plan • Rest in cool, shaded place (ideally an air-conditioned room or vehicle) • Maintain airflow over the body • Have cool shower or bath or apply cool wet towels to body • Sip water or suck ice chips with electrolyte supplement • Seek medical attention if symptoms don't improve

7.2 Emergency response for heat affected CMWs

It is important to note that heat stroke is a medical emergency where treatment within the initial 30 minutes is critical. The emergency response plan should include specific response and treatment of suspected heat stoke events due to the potential severity of the condition.

Table 4 – Signs, symptoms and treatment of heat stroke

Signs & symptoms	Treatment
Heat Stroke • High body temperature (>40ºC) • Hot, dry skin • Fast, strong pulse • Slurred speech • Weak, dizzy, nauseous, headache • Irrational and unusual behaviour • Loss of consciousness / cardiac arrest	• Call emergency services • Follow DRSABCD action plan • Move person to cool, shaded place (ideally an air-conditioned room or vehicle) • Immerse in as cold as possible water from the neck down for 15 mins Or if ice water immersion not available do a combination of the following: • Wet person with cold water under shower, hose or with cloths • Spray skin with water and fan continuously • Apply ice packs (groin, armpits, facial cheeks, palms and soles) • Do not give liquids to drink unless fully conscious

The core body temperature of workers suffering heat stroke needs to be lowered as rapidly as possible, leading to the concept of "cool first, transport second" with area under the core temperature curve predicting survivability (25). It is critically important that the first responder starts treatment as soon as possible and does not wait for onsite emergency services to arrive. The difference between the impacts of prompt recognition and or delayed treatment is shown in figure 10.

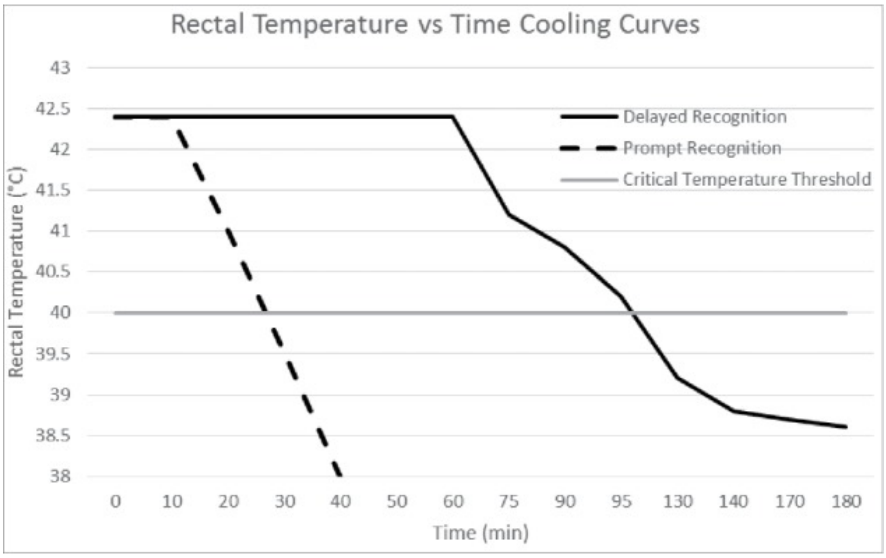


Figure 10 – Core temperature during cooling

Core temperature curves of a person (dashed line) who was promptly recognised and rapidly treated went home the same day. The person who had a delayed diagnosis and treatment eventually died from multiple organ system failure (solid line) (26).

Note: Patients can become hypothermic when cooled too rapidly. If the CMW begins shivering, becomes cool to touch or peripherally shut down, cooling should discontinue.

Further guidance material regarding the recognition and treatment of heat related illnesses is provided from:

- Australian Resuscitation Council ANZCOR Guideline 9.3.4 (September 2020) – Heat Induced Illness (Hyperthermia) (27)
- Queensland Ambulance Service – CPG Hyperthermia (28)
- Safe Work Australia Guidance Material – Managing the Risks of working in heat (29)
- QLD Health – Heat related Illness Fact Sheet (30)

7.3 Queensland Mines Rescue Services

The 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 and may vary from the site-specific procedures.

8 Reporting and investigations

Historically, the reporting and recording of heat related incidences has not been captured effectively within the Queensland Surface Coal Mining sector. The occurrence of heat related illnesses in individual workers represents sentinel health events which indicate that heat control measures may not be adequate. Heat related illnesses can be difficult to diagnose due to the multiple factors that contribute to exposure and other symptoms that mask the role of heat exposure. Therefore, heat exposure should be recognised as a potential contributing factor and included in investigations of all incidents reported when CMW were known to be working in heat conditions.

All events where heat exposure is a contributing factor should be managed in accordance with the Mine's Incident Management Process and recorded / reported as a heat related incident (likely classified as a HPI or LTI). Under the CMSHA, section 17 defines a HPI as *an event, or a series of events, that causes or has the potential to cause a significant adverse effect on the safety or health of a person*.

Where heat related incidents occur onsite and meet the requirements of section 16 of the CMSHR being; *(a) a person suffers an injury— (i) of a severity that requires treatment by a doctor, or a nurse, or a person qualified to give first aid; or (ii) that prevents the person from carrying out the person's normal duties at the mine* it must be reported in the approved form.

Investigation of a potential heat related illness should be undertaken by the mine site operation to identify contributing factors and failed defences. Minimum records in the investigation should include:

- Thermal environment conditions (e.g. temperature, humidity, wind speed)
- Task and intensity of physical work being undertaken (e.g. light, moderate, heavy work load)
- Additional clothing / PPE worn
- Individual predisposing factors, if present (e.g. acclimatisation, hydration, fitness)
- List of controls in place including status (e.g. work as intended, work as done, work as normal)
- Mention if the work was being conducted under a heat TARP and the TARP level
- Conditions listed above in the preceding 7 days leading up to the event that the CMW was exposed to.

Return to work guidelines should be developed for the affected worker in accordance with medical advice to re-establish worker heat tolerance prior to undertaking full duties.

8.1 *Return to work after an event*

Incidents of heat illness, including suspected heat exhaustion and heat stroke, should be managed in accordance with the mine site's Incident Management Process.

Investigation of the heat related illness will be undertaken by the mine site operation. Return to work guidelines should be developed for the affected worker in accordance with medical advice to re-establish worker heat tolerance prior to undertaking full duties. Consideration should be given to:

- Registered medical practitioner assessment
    - Identification of any potential underlying conditions that the CMW may not have been previously aware of
- Impacts of repeated heat conditions that the CMW may have been exposed to
- Rehydration status
- Planned work activities suitable for worker impacted by a heat related illness on return to work.

9 Structured education, training and awareness

The site's SHMS 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 and recorded on the OCE report or other daily communications.

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 before commencing work.

Training refreshers should be conducted yearly prior to the summer season and / or when TARPs trigger the need for additional awareness - for example during heat wave events. Notification of heat wave events is a service with data provided through the Bureau of Meteorology and operates from October to March ('Heatwave Service for Australia').

The following curriculum should be considered as minimum content:

- Risk management processes applied at the mine prior to working in a hot / humid environment
- Individual predisposing risk factors for heat stress; physical fitness, acclimatisation, effects of drugs / medications, alcohol and caffeine
- Knowledge of work practices and controls including site specific procedures e.g. TARPs. This also includes the prompt reporting of the development of signs and symptoms
- Health effects including acute, chronic and safety impacts
- Impact of heat exposure on work performance and also general well-being for everyday life outside of work

- Recognition of signs, symptoms and treatment of heat illness
- First aid treatment and emergency response
- Proper use of personal protective equipment
- Cultural attitudes towards heat exposure which underplay the potential risk to CMWs. E.g. bravado of not wanting to be seen as 'weak' by reporting early signs of heat stress following over exposure and taking a break while others continue to work.

10 SHMS System requirements

10.1 Develop a SHMS that includes effective management and control of heat exposure

The SSE is responsible for the development of a single SHMS for the mine and ensuring the risk to persons from coal mining operations is at an acceptable level. This includes heat exposure. The requirements of the SHMS are detailed in Section 62 of the CMSHA to ensure the risk to coal mine workers' health and safety is at an acceptable level. This includes the requirement to regularly review and continually improve the SHMS to maintain an acceptable level of risk for heat exposure under Section 62(f) of the CMSHA (2).

Specifically, Section 143 of CMSHR requires '*A surface mine's safety and health management system must include a procedure for protecting persons from heat that may lead to heat stress, heat exhaustion or heat stroke'* (3).

10.2 Roles and responsibilities

The roles, responsibilities and competencies of all CMWs who have accountability and responsibility for managing heat exposure on surface mines, must be defined and assigned as per Recognised Standard 22 – Management Structures in Coal Mines. The roles and responsibilities assigned to persons may also include service providers.

Those in the organisation that allocate 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.

10.3 Review

The site's SHMS should 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 should be reviewed at regular intervals and / or following heat related incidents to ensure its continued suitability, adequacy and effectiveness.

10.4 Audit

The site's heat management system should 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 effectively implemented and maintained. The audit should cover any associated risk assessment, procedures, TARPs, training records and heat stress incidences reported and recorded at the mine.

The frequency of the audit program should be based on the risk of the hazard concerned and the results of previous audits. The mine should establish and maintain procedures for the identification, maintenance, and disposition of records.

11 Bibliography

1. Resources Safety & Health Queensland. *Recognised Standard 18 - Management of Heat in Underground Coal Mines.* s.l. : Queensland Government, 2021.

2. Queensland Legislation. *Coal Mining Safety and Health Act 1999.* s.l. : Office of the Parlimentary Counsel, current as of 7 September 2020.

3. Queensland Legislation. *Coal Mining Safety and Health Regulation 2017.* s.l. : Queensland Parlimentary Counsel, Current as at July 2021.

4. WeatherZone. WeatherZone. *Climate averages, extremes and records.* [Online] 22 October 2021. https://www.weatherzone.com.au/climate/stationdrill.jsp.

5. *Preliminary evidence of a heat hangover, a new heat illness classification for occupational settings?* Brearley, M. Townsville : Conference: Science of Sport, Exercise and Physical Activity in the Tropics, 2016.

6. *Are workers at risk of occupational injuries due to heat exposure? A comprehensive literature review.* Varghese, B M, et al. 2018, Safety Science, pp. 110: 380-392.

7. *Characterising the impact of heatwaves on work-related injuries and illnesses in three Australian cities using a standard heatwave definition- Excess Heat Factor (EHF).* Varghese, B M, et al. 2019, Journal of Exposure Scince and Environmental Epidemiology, pp. (29) 821-830.

8. Queensland Government. Qld quarterly mine and quarry safety data. *Qld quarterly mines frequency rates.* [Online] https://www.data.qld.gov.au/dataset/quarterly-mines-and-quarries-safety-statistics-data.

9. *Influence of age, geographical region, and work unit on heat strain symptoms: a cross-sectional survey of electrical utility workers.* Rogerson, Shane, et al. 2020, Journal of Occupational and Environmental Hygiene, pp. (17) 515-522.

10. *Association between high temperature and work-related injuries in Adelaide, South Australia, 2001-2010.* Xiang, J, et al. 2014, Occupational Environmental Medicine, pp. 71(4): 246-252.

11. *Extreme heat and occupational injuries in different climate zones: A systematic review and meta-analysis of epidemiological evidence.* Fatima, S H, et al. 2021, Environmental International.

12. *The impact of perceived heat stress symptoms on work-related tasks and social factors: A cross-sectional survey of Australia's Monsoonal North.* Carter, S, et al. 2020, Applied Ergonomics.

13. Australian Institute of Occupational Hygienists (AIOH). *A Guide to Managing Heat Stress: Developed for Use in the Australian Environment.* Di Corleto, R, Firth, I and Mate, J. Melbourne, VIC, 2013.

14. National Institute for Occupational Safety and Health (NIOSH) . *Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments.* s.l. : Department of Health and Human Services, CDC, 2016.

15. International Organization for Standardization (ISO). *ISO: 7933 Ergonomics of the thermal*

environment - Analytical determination and interpretation of heat stress using calculation of the predicted heat strain. Geneva : ISO, 2004.

16. *A free software to predict heat strain according to the ISO 7933:2018.* FameLab. 2019, Industrial Health, pp. 57(6): 711-720.

17. *Limiting Metabolic Rate (Thermal Work Limit) as an Index of Thermal Stress.* Brake, R and Bates, G P. 2002, Applied Occupational and Environmental Hygiene, pp. 17(3): 176-186.

18. American Conference of Governmental Industrial Hygienists (ACGIH). *Threshold Limit Values for chemical substances and physical agents & Biological Exposure Indices.* Cinncinati, Ohio : ACGIH, 2021.

19. International Organization for Standardization (ISO). *ISO 7243: Ergonomics of the thermal environment — Assessment of heat stress using the WBGT (wet bulb globe temperature) index.* Geneva : ISO, 2017.

20. *Environmental warmth and its measurement.* Bedford, T. 1940, Med Res Council, War Memorandum No. 17 HMSO.

21. Resources Safety and Health Queensland. *Recognised Standard 18 - Management of Heat in Underground Coal Mines.* Brisbane : Resources Safety and Health Queensland, 2021.

22. International Organization for Standardization (ISO). *ISO 9886 - Ergonomics - Evaluation of thermal strain by physiological measurements.* Geneva : ISO, 2004.

23. *Validity of devices that assess body temperature during outdoor exercise in the heat.* Casa, D J, et al. 2007, Journal of Athletic Training, pp. 42(3): 333-342.

24. American Conference of Governmental Industrial Hygienists (ACGIH. *Documentation of the TLV and BEIs for chemical substances and physical agents: Heat Stress and Strain.* Cincinnati, Ohio : ACGIH, 2017.

25. *Exertional heat stroke: new concepts regarding cause and care.* Casa, D J, et al. 2012, Current Sports Medicine Reports, pp. 11(3): 115-123.

26. *Exertional heat stroke and the evolution of field care: A physician's perspective.* Roberts, William O. 2017, Temperature (Austin), pp. 4(2): 101-103.

27. Australian Resuscitation Council. ANZCOR Guideline 9.3.4. *Heat Induced Illness (hyperthermia).* [Online] September 2020. https://resus.org.au/?wpfb_dl=35.

28. Queensland Ambulance Service. Clinical Practice Guideline. *Environmental / Hypothermia.* [Online] February 2021.

29. Safe Work Australia. *Managing the risks of working in heat - Guidance material.* s.l. : Safe Work Australia, 2021.

30. Queensland Health. Heat-related Illness . *Fact Sheet.* [Online] December 2018. https://www.health.qld.gov.au/__data/assets/pdf_file/0022/713416/dm-heat-illnesses.pdf.

31. Weather Intelligence Pty Ltd. Heat X. *Weather Intelligence.* [Online] https://weatherintelligence.global/.

Appendix 1: Drugs implicated in intolerance to heat

Drugs implicated in intolerance to heat (extracted from NIOSH – Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments) (14)

Drug or drug class	Proposed mechanism of action
Anticholinergics (e.g., benzotropine, trihexyphenidyl)	▪ Impaired sweating
Antihistamines	▪ Impaired sweating
Phenothiazines	▪ Impaired sweating, (possibly) disturbed hypothalamic temperature regulation
Tricyclic antidepressants (e.g., imipramine, amitriptyline, protriptyline)	▪ Impaired sweating, increased motor activity and heat production
Amphetamines, cocaine, ecstasy	▪ Increased psychomotor activity, activated vascular endothelium
Analgesics (e.g., acetaminophen, aspirin)	▪ Liver or kidney damage
Ergogenic stimulants (e.g., ephedrine/ephedra)	▪ Increased heat production
Lithium	▪ Nephrogenic diabetes insipidus and water loss
Diuretics	▪ Salt depletion and dehydration
Calcium channel blockers (e.g., amlodipine, verapamil)	▪ Reduced skin blood flow and reduced blood pressure
Ethanol	▪ Diuresis, possible effects on intestinal permeability
Barbiturates	▪ Reduced blood pressure
Antispasmodics	▪ Impaired sweating
Haloperidol	▪ Tachycardia, altered central temperature regulation, and hyponatremia
Laxatives	▪ Dehydration
Beta blockers (atenolol, betaxolol)	▪ Reduced skin blood flow, reduced blood pressure, and impaired sweating
Narcotics	▪ Excessive sweating, salt depletion and dehydration
Levothyroxine	▪ Excessive sweating, salt depletion and dehydration

Adapted from *Heat Stress Control and Heat Casualty Management* [DOD 2003].

Appendix 2: Example 1 baseline heat exposure assessment

Background

The baseline risk of a heat event occurring is assessed by generating a risk profile for each SEG. The risk assessment considers separate activities with similar heat exposure. The approach uses the AIOH Guide Level 1 basic thermal risk assessment to assess individual SEG characteristics and was developed by Weather Intelligence Pty Ltd (31). The risk score calculated then further advises actions to be taken. Provided below is a worked example of the tool for Blast Crew SEG.

Step 1: Complete and calculate scores for sections A and B of the risk assessment for each SEG / sub-SEG/ activity with similar heat exposure. If you could answer the same question with two different answers depending on circumstances, then split the assessment into two SEGs or sub SEGs (e.g. welders with different PPE requirements or field workers acclimatised and non-acclimatised). Ideally a group of workers should undertake sections A and B of the risk assessment for each SEG and be representative of typical work conditions.

Section A: element exposure *(select one answer from each row)*

SEG: *Blast crew*

Sub-group / activity: *loading shot*

Assessment value				
0	**1**	**2**	**3**	**-**
What is your exposure to the sun?				**Value**
☐ N/A	☐ Indoor	☐ Shed	☒ Part Shade / No Shade	3
What is your exposure to the wind?				**Value**
☐ strong wind	☒ moderate wind	☐ light wind	☐ Nil airflow	1
What is your exposure to hot surfaces?				**Value**
☐ Neutral	☐ Warm on Contact	☒ Hot on Contact	☐ Burn on Contact	2
Do you work in confined spaces?				**Value**
☒ No	-	-	☐ Yes	0
Has training been provided on heat management?				**Value**
☒ Training Given			☐ No Training Given	0
What is your exposure period?				**Value**
☐ Less than 30 minutes	☐ 30 – 60 minutes	☐ 1 – 2 hours	☒ More than 2 hours	3
What is the task complexity?				**Value**
☐ Simple	☒ Moderate	☐ Complex	-	1
What level of access are you working on?				**Value**
☒ None	☐ One Level	☐ Two Levels	☐ More than Two Levels	0
What is the distance from cool rest area?				**Value**
☐ Less than 10 metres	☐ 10-50 metres	☐ 50-100 metres	☒ More than 100 metres	3
What is the distance from drinking water?				**Value**
☐ Less than 10 metres	☒ 10-30 metres	☐ 30-50 metres	☐ More than 50 metres	1

Assessment value				
0	**1**	**2**	**3**	**-**
What workwear is worn?				**Value**
☐ Single Layer (Light)	☒ Single Layer (Moderate)	☐ Multi-Layer	☐ Specialist (seek further advice)	1
What type of respirator do you wear?				**Value**
☒ None	☐ Disposable Half Face	☐ Rubber Half Face – Filter	☐ Full Face	0
Are you acclimatised?				**Value**
☒ Acclimatised	-	-	☐ Unacclimatised	0
			Section A Score	15

Section B: Metabolic work rate

What is the level of activity?			
2	**4**	**6**	**Value**
☐ Low	☒ Moderate	☐ High	4
Example: Standing / spotting while maintaining plant or equipment e.g. confined space, traffic control, TLO works, OCE observing	**Example:** Sustained hand and arm work, arm and trunk work, walking around 4.5km/h e.g. servicing equipment, walking conveyors, road train tyre fitting	**Example:** Intense arm / trunk work, carrying heavy material, shovelling, carrying loads upstairs e.g. handling of conveyor components, setting up / managing dragline jewellery, handling of cables	

Step 2: Determine the 'Risk Score' for each apparent temperature category using the scores for section A and B (above) and section C (below), using the formula:

Risk Score = A + B x C

Section C: Environmental temperature data (Apparent Temperature or WBGT category)				
	1	**2**	**3**	**4**
	☐ <27°C	☐ >27°C ≤33°C	☐ >33°C ≤ 41°C	☐ >41°C
Risk Score	19	38	57	76

Low risk = risk score <28 Moderate risk = 28-60 High risk = >60

Step 3: Use the long-term, site specific weather data from BOM and / or local weather station to determine the frequency that each apparent temperature category in Section C, occurs during each month.

Apparent temperature or WBGT				
Month: January	**1**	**2**	**3**	**4**
	☐ <27°C	☐ >27°C ≤33°C	☐ >33°C ≤ 41°C	☐ >41°C
Risk Score	19	38	57	76
Frequency of temp. category	2%	67%	30%	1%

Step 4: Baseline risk profiles are generated by applying step 3 to each SEG. The risk profile should indicate the potential frequency of a heat exposure in any given month. Data can then be displayed to show baseline risk profiles for each SEG / sub-SEG on a monthly basis (examples provided in figures 2-1 to 2-4). Data could be displayed in a variety of ways. By using historical weather, baseline profiling is used to screen and identify high risk SEGs. This can then be used to prioritise resources for controls, training and a 'SEG heat safe plan' developed for each SEG.

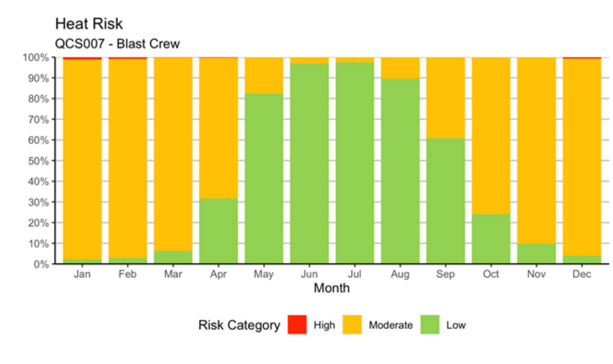


Figure 2-1: Example Baseline Risk Profile for Blast Crew

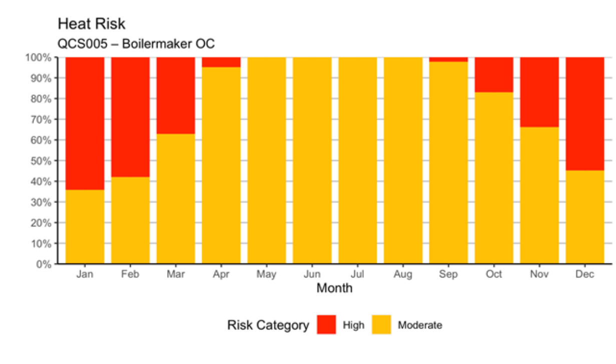


Figure 2-2: Example Baseline Risk Profile for Boilermaker

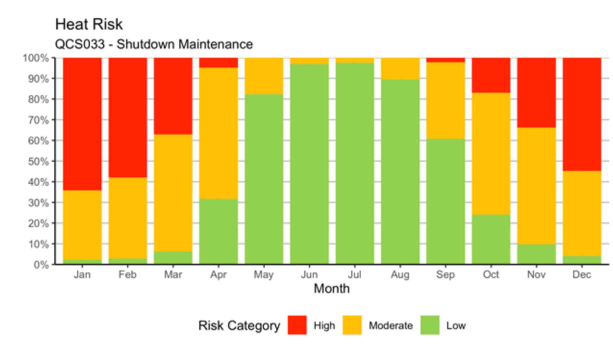


Figure 2-3: Example Baseline Risk Profile for Shutdown maintenance

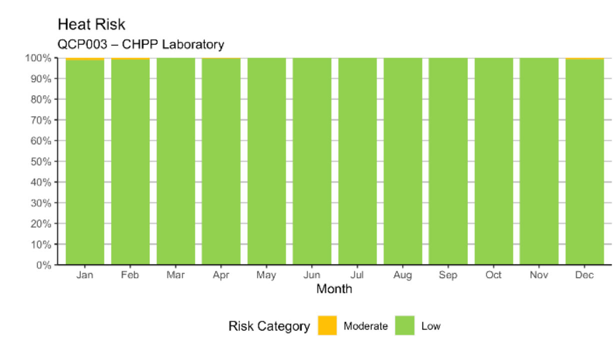
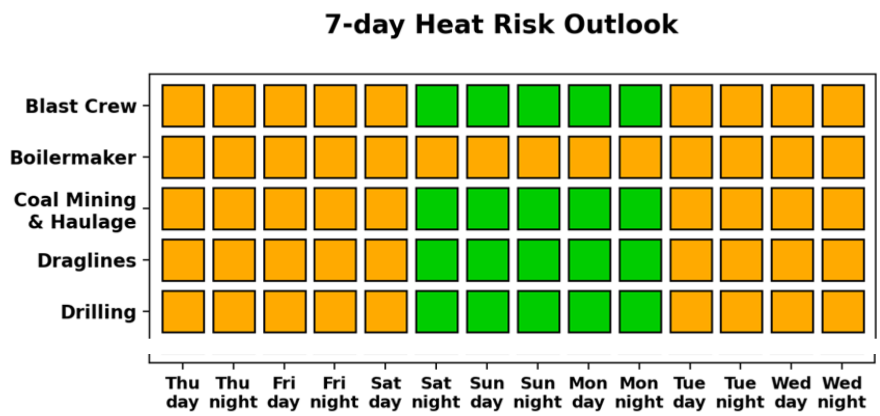


Figure 2-4: Example Baseline Risk Profile for CHPP Laboratory

Step 5: Using daily and / or short-term forecast weather data and the scores from section A and B (Step 1) for each SEG, a heat risk score can be calculated for the activation of TARPs on a daily basis. This daily or short-term forecast weather data can be obtained from site monitoring station or reputable weather services (e.g. BOM). An example of a 7-day outlook for priority SEGs is provided below as part of the daily heat risk profile report. This allows sites to apply a proactive approach and implement controls in advance (31).



Step 6: using the daily heat risk cores determined in step 5, the following TARP can be applied where appropriate.

Status – Normal Level 1 (Green) Heat Risk Score ≤ 28	
Who	**Actions**
Supervisors	• Review daily heat risk profile report • Refer to SEG Heat Safe Plans for basic level of controls
CMWs	• No action required • Refer to SEG Heat Safe Plans for basic level of controls
Status – Moderate Level 2 (Orange) Heat Risk Score > 28 & ≤ 60	
Who	**Actions**
Supervisors	• Apply level 1 actions and refer to SEG Heat Safe Plans for level 2 controls • Provide warning to ensure workers are hydrated and prepared for increased heat risk during pre-start meeting • Ensure heat controls applied and monitoring equipment available if needed • Consider rescheduling work (if additional controls are not available) • Allow 15-minute rest break in each hour or as per heat stress work rest ratio. • Apply 'Symptom Self-Assessment Questionnaire' to monitor all exposed workers throughout shift for symptoms of heat illness and confirm they are eating and drinking regularly • No person is permitted to work outdoor alone for intervals >30 minutes • Un-acclimatised persons must not work alone
CMWs	• Refer to SEG Heat Safe Plans for level 2 controls • Implement additional controls if recommended • Follow supervisors instructions for additional breaks • No person is permitted to work outdoor alone for intervals >30 minutes • Un-acclimatised persons must not work alone • Complete 'Symptom Self-Assessment Questionnaire' and report to supervisor
Status – High Level 3 (RED) Heat Risk Score >60	
Who	**Actions**
Supervisors	• Apply level 2 actions and refer to SEG Heat Safe Plans for level 3 controls • Alert affected workers (include expected time of peak and duration of event) • Hydration - 400 - 600 ml every 30 minutes, carry water on person • Reschedule work (if additional controls are not available) • Reschedule un-acclimatised workers to lower risk work • consider self-paced work and direct monitoring as recommended
CMWs	• Refer to SEG Heat Safe Plans for Level 3 controls • Implement additional controls if recommended • Follow supervisors instructions for additional breaks or rescheduling or work • Un-acclimatised persons must not work in heat conditions

Appendix 3: Example 2 shift-based heat management tool

Step 1: Screening for priority heat SEGs

A risk assessment with a relevant cross section of stakeholders is undertaken using the mine's current SEGs as a screening tool to identify at-risk SEGs to heat exposure. The risk assessment is qualitative and no measurements are taken into consideration at this point. The likelihood and consequence are rated for each SEG based on the company's internal risk matrix to determine the workplace hazard management plan. Figure 3-1 is an example of the risk assessment.

Item #	Process / Activity	Sub Activity	Hazard	Current Controls	C	L	R	New Controls	C	L	R
	CHPP Laboratory	Lab technicians processing samples (sedentary work) and indoors	Extreme temperatures leading to adverse health effects	• Heat management procedure and TARP • Cool crib (aircon supplied) • Work/rest cycles self-managed • Supply of cool drinking water and ice • Readily available electrolyte supplements • Wide sun brims for when working outside • Sunscreen for when working outside • Use of office space with air conditioning	2	2	5L	• Develop and roll out a formal training for heat stress management to CMW's • Develop a hydration education presentation and roll out to CMW's • Communicate and roll out the new Heat TARP to CMW's	2	2	5L
	CHPP Production	Conducting inspections of plant and conveyors, walking up and down stairs. Intermittent hosing	Extreme temperatures leading to adverse health effects	• Heat management procedure and TARP • Cool crib and control rooms (aircon supplied) • Work/rest cycles self-managed • Supply of cool drinking water and ice • Readily available electrolyte supplements • Wide sun brims for hard hats when working outside • Sunscreen for when working outside • Rotate work between work group	2	3	8M	• Develop and roll out a formal training for heat stress management to CMW's • Develop a hydration education presentation and roll out to CMW's • Communicate and roll out the new Heat TARP to CMW's	2	3	8M
	CHPP Maintenance	Performing mechanical repairs on plant. Light to moderate manual handling.	Extreme temperatures leading to adverse health effects	• Heat management procedure and TARP • Cool crib and control rooms (aircon supplied) • Work/rest cycles self-managed • Supply of cool drinking water and ice • Readily available electrolyte supplements	2	3	8M	• Investigate extension of the roof line or install shade sail for the western side of the workshop • Investigate the opportunity to purchase mobile gazebos for the CHPP	2	3	8M

Figure 3-1: Example qualitative risk assessment

Step 2: Establishing TARP triggers and actions for priority SEGs

The risk assessment (step 1) determines the need for a heat TARP for specific SEGs. Environmental temperature and work rate data is then used to determine triggers and actions for a heat TARP. Temperature data can be collected from BOM or onsite weather stations. Site specific data can also be collected using hand-held measurement devices where data is required from specific work/activity locations e.g. reclaim tunnel, confined spaces.

Step 3: Determination of work rate

A list of tasks is generated for each priority SEG identified in step 1 and these are grouped into 'work rate' categories as per below (14).

Work rate	Example
Easy work (normal heart rate) 250 watts	*Using electric tools, walking on flat surfaces, operating equipment, inspection of work, basic fitting, welding and oxy-cutting*
Moderate work (moderate heart rate) 425 watts	*Climbing up & down stairs repetitively, doing polypipe works, carrying equipment 10 to 20kgs*
Hard work (high heart rate) 600 watts	*Using hand tools for long periods (shovels, crow bar, sledge hammer), climbing or carrying heavy equipment over 20kgs uphill*

Step 4: Determine the heat index and heat TARP level

The Apparent Temperature Heat Index is used to determine the heat TARP level, for priority SEGs identified in step 1.

Measurement of dry bulb temperatures and relative humidity collected in step 2 is used to determine the apparent temperature heat index for a given task (Figure 2). For example: at the bottom of the pit where maintenance is conducted a dry bulb measurement of 38 degrees Celsius and a relative humidity of 55 % results in Apparent Heat Index of 53 as plotted below. This triggers an orange level heat TARP.

Environmental Temperature	Relative Humidity															
	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
42C	48	50	52	55	57	59	62	64	66	68	71	73	75	77	80	82
41C	46	48	51	53	55	57	59	61	64	66	68	70	72	74	76	79
40C	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75
39C	43	45	47	49	51	53	55	57	59	61	63	65	66	68	70	72
38C	42	44	45	47	49	51	53	55	56	58	60	62	64	66	67	68
37C	40	42	44	45	47	49	51	52	54	56	58	59	61	63	65	66
36C	39	40	42	44	45	47	49	50	52	54	55	57	59	60	62	63
35C	37	39	40	42	44	45	47	48	50	51	53	54	56	58	59	61
34C	36	37	39	40	42	43	45	46	48	49	51	52	54	55	57	58
33C	34	36	37	39	40	41	43	44	46	47	48	50	51	53	54	55
32C	33	34	36	37	38	40	41	42	44	45	46	48	49	50	52	53
31C	32	33	34	35	37	38	39	40	42	43	44	45	47	48	49	50
30C	30	32	33	34	35	36	37	39	40	41	42	43	45	46	47	48
29C	29	30	31	32	33	35	36	37	38	39	40	41	42	43	45	46
28C	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
27C	27	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
26C	26	26	27	28	29	30	31	32	33	34	34	35	36	37	38	39
25C	25	25	26	27	27	28	29	30	31	32	33	34	34	35	36	37
24C	24	24	24	25	26	27	28	28	29	30	31	32	33	33	34	35
23C	23	23	23	24	25	25	26	27	28	28	29	30	31	32	32	33
22C	22	22	22	22	23	24	25	25	26	27	27	28	29	30	30	31

Figure 3-2: Apparent Temperature Heat Index.

Step 5: Using the heat index value colour banding calculated in Step 4 and the work rate determined in step 3, determine the work / rest ratio and hydration actions to be used in the TARP, by applying the table below.

Table TARP Actions: work/rest ratio and hydration *(* (14)*)*

TARP level (Heat index banding)	Easy work (normal heart rate) 250 watts	Moderate work (moderate heart rate) 425 watts	Hard work (high heart rate) 600 watts
	TARP Actions		
Yellow	No limit on work 2 cups water/hr	50/10 work/rest regime 2.5 cups water/hr	40/20 work/rest regime 2.5 cups water/hr
Orange	No limit on work 2.5 cups water/hr	40/20 work/rest regime 2.5 cups water/hr	30/30 work/rest regime 4 cups water/hr
Red	No limit on work 2.5 cups water/hr	30/30 work/rest regime 2.5 cups water/hr	20/40 work/rest regime 4 cups water/hr

Step 6: Application of a Trigger Action Response Plan (TARP)

The heat TARP has been attached below. This TARP is applied to priority heat SEGs identified at Step 1, with trigger levels and actions required to manage heat exposures, which have been derived from steps 2 to 5 above.

<table>
<tr><th>Person(s) actions</th><th>Normal Status</th><th colspan="3">Level 1 Response</th><th colspan="3">Level 2 Response</th><th colspan="3">Level 3 Response</th></tr>
<tr><td>Environmental trigger conditions</td><td>Apparent Temperature Heat Index = ≤ 34</td><td colspan="3">Apparent Temperature Heat Index = 35 - 45</td><td colspan="3">Apparent Temperature Heat Index = 46 - 53</td><td colspan="3">Apparent Temperature Heat Index = ≥54</td></tr>
<tr><td>Work rate</td><td rowspan="2">Un-restricted self-paced work - low risk</td><td>Easy</td><td>Moderate</td><td>Hard</td><td>Easy</td><td>Moderate</td><td>Hard</td><td>Easy</td><td>Moderate</td><td>Hard</td></tr>
<tr><td>Work / rest ratio</td><td>No limit on work</td><td>50/10</td><td>40/20</td><td>No limit on work</td><td>40/20</td><td>30/30</td><td>No limit on work</td><td>30/30</td><td>20/40</td></tr>
<tr><td>Hydration rate (cups water / hr)</td><td>Remain hydrated and self-manage hydration</td><td>2</td><td>2.5</td><td>2.5</td><td>2.5</td><td>2.5</td><td>4</td><td>2.5</td><td>2.5</td><td>4</td></tr>
<tr><td>Heat wave</td><td colspan="10">NOTE: Heat wave forecast should be considered when assessing TARP trigger conditions where applicable</td></tr>
<tr><td>All personnel</td><td>• Include personal risk assessment
• Ensure you have adequate cool drinking water available and drink regularly
• Consider time of day and weather and be prepared to escalate to Level 1</td><td colspan="3">• All controls from normal status review personal risk assessment - put additional controls in if necessary
• Report any signs of heat stress to the supervisor and others in work group and use ‘symptom self-assessment questionnaire’
• Consider job rotation and working in shaded areas
• Consider time of day and weather and be prepared to escalate to Level 2</td><td colspan="3">• All controls from Level 1
• Notify supervisor, OCE or Health and Safety department of changes to TARP level
• Implement higher level controls including task rotation of jobs, follow working alone procedure, take appropriate corrective action to reduce the effective temperature e.g. fans/shade</td><td colspan="3">• All controls from Level 2
• Withdraw to a place of safety as initial response
• No work to be undertaken until a risk assessment is completed for the task in consultation with your supervisor or team leader.</td></tr>
<tr><td>Appointed supervisor/s and OCE</td><td>• Monitor ambient temperature, humidity and other indicators of heat stress e.g. clothing; PPE
• Ensure general heat stress controls available
• Work scheduling can be planned as needed</td><td colspan="3">• As per normal state
• Implement wok rest regimes as required for Level 1
• Supervisor to discuss thermal stress management at pre-start meetings.
• Ensure un-acclimatised persons are not scheduled to work alone
• Initiate options that will reduce the temperature of the working place (e.g. access to shade options, use of fans), relocation of work if</td><td colspan="3">• As per Level 1
• Notify superintendent/manager of changes to TARP level
• Implement wok rest regimes as required for Level 2
• Review thermal stress controls – Implement task rotation of jobs, follow working alone procedure, take appropriate corrective action to reduce the apparent temperature e.g. check fan/shade effectiveness, review work rest</td><td colspan="3">• As per Level 2
• Withdraw team to a place of safety (Non TARP area) as initial response.
• No work to be undertaken until a risk assessment (JHA) is completed for the task in consultation with your supervisor or team leader.
• Unacclimatised workers to be removed from hot work areas
• Implement wok rest regimes as required for Level 3</td></tr>
</table>

		possible, consider task postponement i.e. work at night, work scheduling and mechanical use to limit physical labour. • Ensure access to adequate hydration sources for team, such as cool water, ice. • Apply 'Symptom Self-Assessment Questionnaire' to monitor all exposed workers throughout shift for symptoms of heat illness and confirm they are eating and drinking regularly.	cycle and thermal work load and increase controls if required. • Ensure all team members are aware of current temperature levels and required controls.	
Health & Safety Manager	• Maintain availability of heat exposure monitoring equipment Ensure competence of people taking measurements	• Be aware of current temperatures and likelihood of escalating trigger levels • Communicate heat related incidents and hazards as they occur	• Notify other at risk SEGs management of heat affected workers	• Notify SSE of changes to TARP response level • Ensure additional heat index measurements are taken and advice given • Participate in risk assessments • Liaise with medics and health specialist about resourcing hydration testing

Appendix 4: Example symptoms self-assessment questionnaire

Symptoms questionnaire

Name		Date	

Symptoms	Not At All 0	A Little 1	Somewhat 2	Moderate 3	A Lot 4	Extreme 5
Lightheaded						
Headache						
Dizzy						
Thirsty						
Weakness						
Irritable						
Hard to breathe						
Muscle cramp						
Tiredness						
Nauseous						
Felt Hot						
Trouble concentrating						
'Goosebumps' or chills						
Management Guide	All symptoms 0 or 1 **Proceed**		Some symptoms 2 or 3 **Monitor symptoms and adjust work rate**		Any symptoms 4 or 5 **Stop and Report to Supervisor**	

Could work at my best	Strongly Agree 0	Agree 1	Somewhat Agree 2	Somewhat Disagree 3	Disagree 4	Strongly Agree 5

Workload	Less Than Normal	Normal	Higher Than Normal

Have you followed the mine's Safety and health management system, to notify the SSE of any medications currently being used that may impair your ability to perform duties in heat? ◻ Yes ◻ No

Appendix 5: Catalogue of practical controls

Figure 5-1 – Portable shade for exploration driller geologist

Figure 5-2 & 5-3 – Portable shade used during ERT training

Figure 5-4 – Portable shade for industrial cleaners wearing coveralls

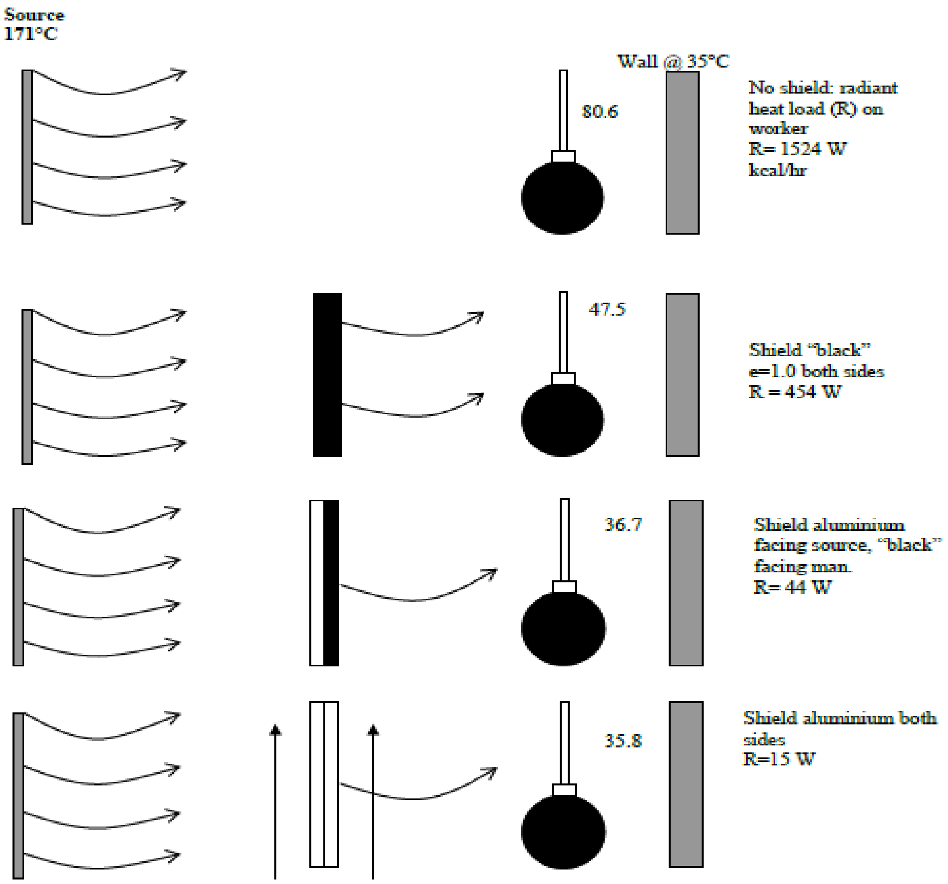


Figure 5-5 – Radiant heat controls from shielding (adapted from AIOH (12))

Figure 5-6 & 5-7 - Portable air-conditioned fan units provide cool air inside workshops

Figure 5-8 – Portable cooling fan directed at exploration drill operator position

Figure 5-9 – Portable air-conditioning unit for dragline shutdowns

Figure 5-10 – Portable air-conditioned crib room & facilities located at worksite

Figure 5-11 – Portable pedestal fan used to cool workers around laboratory ovens

Figure 5-12 – Portable pedestal fan used to cool workers around laboratory ovens

Figure 5-13 – Enclosed air-conditioned cab on roadside skid steer with slasher

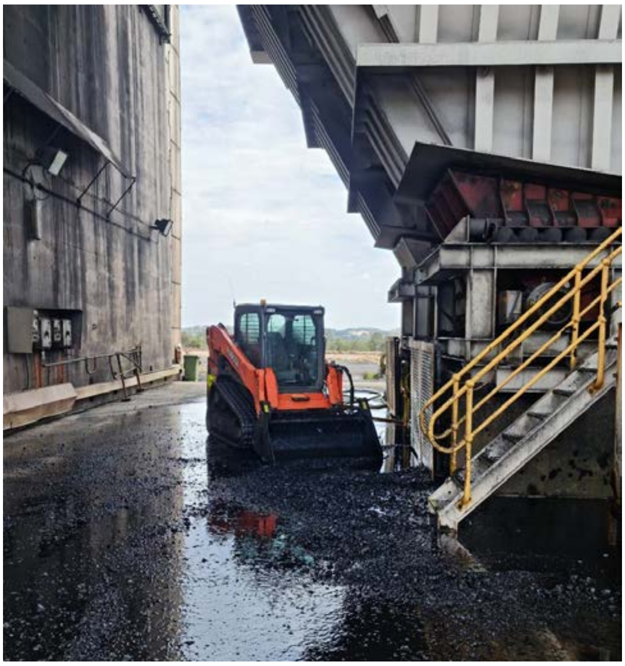


Figure 5-14 – Skid steer used to clean up spillage at CHPP instead of manual shovelling

Figure 5-15 – Protective clothing selected for blast crew including vented shirts, broad brimmed hat with legionnaire style neck covering

Figure 5-16 –Cooling (ice) vest worn outside work shirt for example purposes

Figure 5-17 –Cooling (ice) vest showing insert gel packs

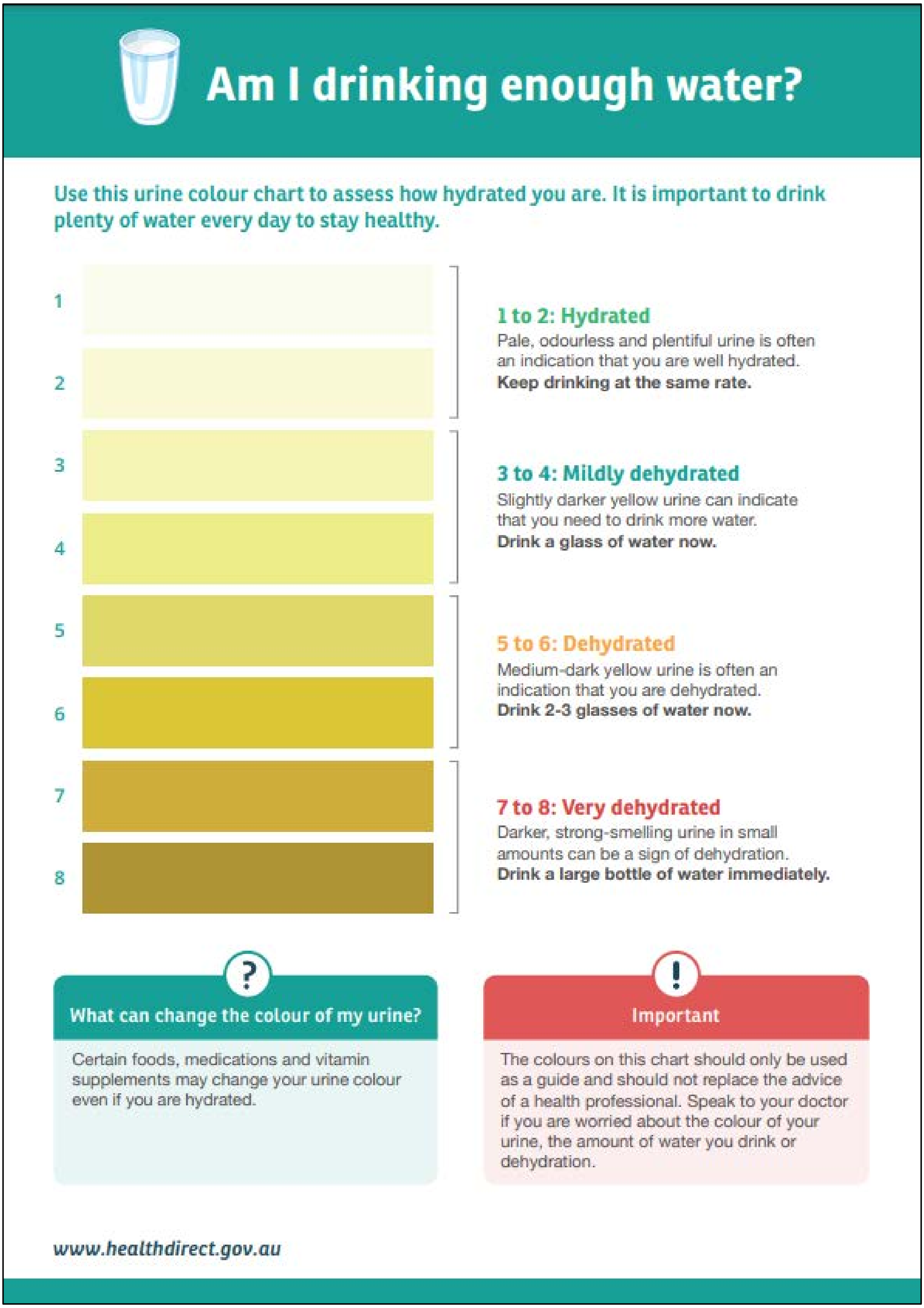


Figure 5-18 – Urine colour chart example

Appendix 6: Heat acclimatisation protocols

Example 1 NIOSH recommendations (14)

Acclimatisation plan

- Gradually increase exposure time in hot environmental conditions over a period of 7 to 14 days.
- For new workers, the schedule should be no more than 20% of the usual duration of work in the hot environment on day 1 and a no more than 20% increase on each additional day.
- For workers who have had previous experience with the job, the acclimatisation regimen should be no more than 50% of the usual duration of work in the hot environment on day 1, 60% on day 2, 80% on day 3, and 100% on day 4.
- The time required for non–physically fit individuals to develop acclimatization is about 50% greater than for the physically fit.
- Heat acclimatisation can be maintained for a few days of non-heat exposure.

Example 2 Customised mine site example

Workers shall notify their supervisor of their heat acclimatisation status when they have experienced a prolonged period away from work or have had absence due to illness.

Supervisors must discuss and review heat stress and acclimatisation concerns and options with new employees or contractors and with workers returning from a prolonged absence.

Supervisors must consider the risk of unacclimatised crew members developing thermal stress symptoms, when allocating daily work assignments and organising rest breaks and task schedules.

Acclimatisation plans must be developed and documented by supervisors in consultation with affected employees and may include, but are not be restricted to:

- Employee self-assessment checklist completed to identify early signs and symptoms of thermal stress at predetermined intervals (not greater than 6hrs). An example of this is provided in Appendix 4.
- Shorter or regulated working hours in hot / humid environments and combined with work in low heat area to enable acclimatisation.
- Rotation of tasks within the crew

Appendix 7: Glossary

Acclimatisation	Gradual physiological adaptation that improves an individual's ability to tolerate heat stress.
Age	Advanced age can result in a reduced physiological capacity and tolerance to perform work in heat.
Dehydration	Loss of body fluid due to sweating can result in dehydration if not replaced. Fluid and electrolyte replacement is affected by dietary intake of solid food and fluids.
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 are not limited to: • AIOH basic thermal risk assessment • Predicted heat strain • Thermal work limit • WBGT • Effective temperature (ET) • Physiological monitoring.
Heat stroke	A life-threatening advanced state of heat illness characterised by a failure of the body's thermo-regulatory system.
Medications	Therapeutic and recreational – many drugs can affect thermo-regulation (Appendix 1 provides further information)
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.
Physical fitness	An individual's physical fitness, irrespective of age, affects their tolerance to work in

	heat.
Pre-existing Health Condition	Specific conditions that have an impact of the individual's thermoregulatory system and heat tolerance and may include previous incident of heat related illness.
Serious Accident	An accident resulting in the death of a person, or a person being admitted to hospital as an inpatient for the injury.
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 8: Abbreviations

ACP	Air Cooling Power
ACGIH	American Conference of Governmental Industrial Hygienists
BET	Basic Effective Temperature
BOM	Bureau of Meteorology
CMSHA	Coal Mining Safety and Health Act 1999
CMSHR	Coal Mining Safety and Health Regulation 2017
CMW	Coal Mine Worker
DB	Dry Bulb
ET	Effective Temperature
GSM	Grams per square meter (fabric)
NET	Normal Effective Temperature
NIOSH	National Institute for Occupational Safety and Health
PHS	Predicted Heat Strain
PPE	Person Protective Equipment
RAL	Recommended Action Level
REL	Recommended Exposure Limit
RSHQ	Resources Safety and Health Queensland
SAFR	Serious Accident Frequency Rate
SEG	Similar Exposure Group
SHMS	Safety and Health Management System
SSE	Site Senior Executive
TARP	Trigger Action Response Plan
TWL	Thermal Work Limit
WB	Wet Bulb
WBGT	Wet Bulb Globe Temperature