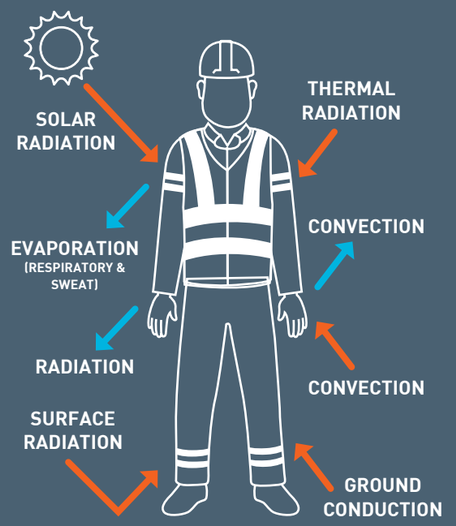
Heat stress in mining

Heat stress can cause a person's core body temperature to rise. Heat stressors include a worker's clothing, work activity and environment (air temperature, radiant temperature, humidity and air velocity). The body's response to heat stress is heat strain.

Physics of heat transfer

- **Conduction** – transfer of heat between two materials, from high to low heat energy areas, for example when you sit on a hot metal chair.
- **Convection** – this is the process of losing heat through the movement of air (or water molecules) across the skin, for example the use of a fan to cool off the body.
- **Radiation** – this is the process of heat transfer over distance between surfaces (particularly at the infrared wavelength), for example the feeling of the sunshine on your arm vs simply the air temperature in the shade.
- **Evaporation** – this is the process of a liquid taking energy from its surroundings to evaporate, like a boiling kettle. The sweat or water on your skin uses energy from your skin to evaporate, and by taking the energy from your skin it cools the skin down.[1]



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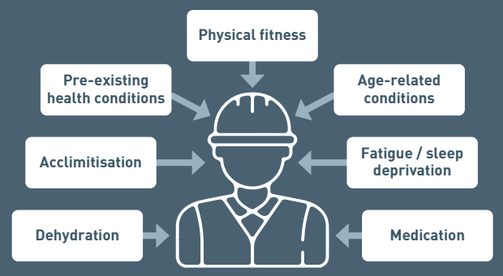
Individual and pre-disposing factors

Individual responses to heat exposure will vary significantly between different operators performing the same work due to individual and pre-disposing factors. These factors must be considered when assessing heat exposure risks and during the development and implementation of controls.

These include, but are not limited to, the following:

- dehydration
- acclimatisation
- pre-existing health conditions
- physical fitness
- age-related conditions
- fatigue/sleep deprivation
- medication

Dehydration is probably an individual's greatest risk.[2]



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Heat strain and related illnesses

Heat oedema – mild form of heat illness resulting in pooling of fluid in legs, brought about by temporary expansion of the surface blood vessels (vasodilatation), so that body fluids move into the hands or legs by gravity.

Heat rash – caused by a blockage and inflammation of sweat ducts in heat and high humidity, from increased sweating. It is characterised by raised lumps that may be intensely itchy, or which can burst, causing a stinging sensation.

Heat fatigue – additional blood is diverted to skin as result of peripheral vasodilatation, reducing output to the brain and internal organs, and resulting in fatigue and reduction in strength.

Heat cramps – painful involuntary muscle spasms from electrolyte dilution, arising from hard work in hot environments, heavy sweating and excessive water intake.

Heat syncope – dizziness or fainting brought about by lowered blood pressure arising from vasodilatation, and pooling of body fluids into legs and resultant lack of blood flow to brain.

Heat exhaustion – mild form of shock with symptoms including extreme weakness or fatigue, uncoordinated action giddiness, nausea, headache and a weak rapid pulse.

Heat stroke – is the most serious of the heat-related illnesses. It occurs when the body can no longer cool itself and the body's thermoregulatory system has failed to prevent core body temperatures rising to critical levels above 40°C. This can be fatal. Symptoms include:

- lack of sweating and hot dry skin
- confusion
- irrational behavior
- loss of consciousness
- convulsions

Heat stroke may result in permanent damage to the brain and other vital organs. If you think someone has severe heat exhaustion, or heat stroke, you must call an ambulance immediately and perform first aid until an ambulance arrives.

Regulatory standards

- Regulation 635 of the Work Health and Safety (Mines) Regulations 2022 outlines that mine operators must manage risks to health and safety associated with extremes of temperature and moisture content of the air.
- Regulation 41A outlines that work practices are arranged so that workers are protected from extremes of heat and cold, and that so far as is reasonably practicable, heating and cooling are provided to enable workers to work in a comfortable environment.
- Schedule 26 cl4 outlines that a Mine Air Quality Officer is tasked with advising senior management of steps to be taken to reduce the exposure of workers to heat or humidity.

Risk assessment

Once a heat stress hazard has been identified, a PCBU must ensure that practices are arranged so that workers are protected from extremes of heat and cold (r41A). The heat stress risk assessment must be conducted by a person or group that is competent to conduct the assessment (r617). The risk assessment must include all operational activities, areas or phases of operations and address all aspects of the hazard (e.g. likelihood, consequence, different ways the hazard may arise, or different impacts it may have in different circumstances). The outcomes of the health risk assessment should be further documented in the site Health Management Plan (HMP) (r675EA).

There are three primary methods for completing a thermal stress risk assessment, using the:

- Basic Thermal Risk Assessment
- TWL (thermal work limit); or the
- WBGT (wet bulb, globe temperature)

The TWL is the more comprehensive tool, taking into account more parameters such as air flow and clothing. It measures the maximum amount of energy your body can give out (per square meter of skin) into the environment so that your core temperature does not rise.

Heat stress risk assessment tools

There are a range of different heat stress risk assessment tools that can be used as tools for evaluating the risk to workers from working in heat. Heat Stress risk assessment tools are based on modelling and can be used as qualitative indicators of exposure risk. The AIOH Guide to Managing Heat Stress[3] has been developed for use in the Australian environment, and is a useful tool to evaluate potential heat stress scenarios. The AIOH guide uses a 3 stage approach.

Stage 1 is a basic thermal risk assessment primarily designed as a qualitative risk assessment without requiring specific technical skills. 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 as an excel based calculator named Basic Thermal Risk Assessment which is freely available on the AIOH website.

Stage 1 can use the basic thermal risk assessment, TWL or WBGT tools, with the controls being based upon the numerical outcome of the assessment. One of the controls would be to determine the level of continuous workload an individual can undertake without raising their core temperature.

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

It is recommended that a competent occupational hygienist assesses thermal stress in the workplace.

Risk	TWL	Effective continuous work limit to prevent a person's core temperature from rising
Critical	<116	No safe sustainable continuous workload (environment will cause core temperature to rise with even light workload)
High	116-140	Light workload only (environment can only receive <140 W per m^2 of skin)
Moderate High	141-180	Moderate workload (environment can only receive 141-180 W per m^2 of skin)
Moderate Low	181-220	Moderately heavy workload (environment can only receive 181-220 W per m^2 of skin)
Low	>220	No workload limit for self-paced (environment can receive any amount of energy from the skin)

Reference: Bates, Lindars & Hawkins (2008)[4]

Resources and further information

1 Resources Safety and Health Queensland, Guidance Note QGN32 Managing Exposure to Heat in Surface Coal Mines and Surface Areas of Underground Coal Mines, January 2022
2 NIOSH (National Institute for Occupational Safety and Health), Criteria for a Recommended Standard Occupational Exposure to Heat and Hot Environments
3 AIOH, A Guide to Managing Heat Stress: Developed for Use in the Australian Environment
4 Bates, G., Lindars, E., & Hawkins, B. (2008). Thermal stress – risk assessment and management tools. AIOH 25th Conference Proceedings
5 DMIRS, Management and Prevention of Heat Stress, Guideline
6 Safe Work Australia, Managing the risks of working in heat, Guidance material

HIERARCHY OF CONTROL FOR HEAT STRESS

1	ELIMINATION	Cancelling work tasks or waiting for hot conditions to pass. Consider whether it is possible to use automated equipment or processes to access hot locations.
2	SUBSTITUTION	Consider swapping physical work for work that can be done by a machine. Have workers do the work in a cooler environment.
3	ISOLATION	Isolation involves physically separating the source of harm from people by distance or by using barriers. Isolate hot machinery or surfaces by using shields, barriers and guards.
4	ENGINEERING CONTROLS	Set up shade tents, use air conditioning, insulate buildings and clad sources or radiant heat, ensure adequate air flow with fans, remove heat or steam with LEV.
5	ADMINISTRATIVE CONTROLS	Safe working procedures and method statements, scheduling more physically demanding activities to be completed in the cooler parts of the day, supervision and buddy system, training.
6	PPE	Loose fitting lightweight clothing, wearable personal cooling systems such as water-cooled garments, air-cooled garments, cooling vests and wetted garments.

Hydration

When working in heat, dehydration is a major risk. Dark or reduced urine output can indicate dehydration. Operators must ensure workers have access to cool drinking water and encourage workers to stay hydrated. Remember that thirst is satisfied before fluid loss is replaced.[5]

Hydration can be tested by using a refractometer to measure the specific gravity of urine. Urine colour charts are another useful way to monitor hydration. It is important to drink plenty of water each day to stay healthy.

1 to 3: Hydrated
Pale, odourless and plentiful urine is often an indication that you are well hydrated.
Keep drinking at the same rate.

4 to 6: Mildly dehydrated
Slightly darker yellow urine can indicated that you need to drink more water.
Drink a glass of water now.

7 to 8: Dehydrated
Even darker yellow urine is often an indication that you are dehydrated.
Drink 2-3 glasses of water now.

At high workloads and /or high thermal stress, sweat rates may exceed 1.2 L/hr. Increasing fluid intake above 600mL per half hour level is not practical because fluid absorption is restricted when volumes >600mL are drunk at one time. In addition, gastric discomfort is a problem. As such, successful re-hydration is a result of drinking little and often.

Training

Workers must be trained to be able to carry out their work safely. For example, workers must be trained to:

- identify and report hazards associated with heat and heat-related illness
- understand how to prevent heat-related illness
- recognise symptoms and signs of heat-related illness in themselves and others
- call for assistance if necessary
- look out for each other's wellbeing
- drink sufficient water to stay hydrated
- modify work intensity and take more regular breaks when working in heat
- recognise the dangers of diuretic drinks
- be aware of individual risk factors
- understand acclimatisation, and recognise the potential dangers associated with the use of alcohol and/or drugs when working in heat.

Health monitoring

- Health monitoring may be required — determination of general fitness, presence of medical conditions and use of medications that may predispose employee to heat strain.
- Persons at risk of heat stress can be monitored at workplace for signs of heat illness and to ensure work-rest and hydration regimes are followed.
- An acclimatization program should be implemented that ensures workers are acclimatized through progressive exposure to the hot workplace; workers should also be encouraged to increase their physical fitness.[6]