

Thermal Environment

Core Body of Knowledge for the
Generalist OHS Professional

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26

WORK SAFETY



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The Manager, OHS Body of Knowledge

Australian Institute of Health & Safety, 3.02 /20 Bruce St, Kensington, Victoria, 3031

Manager@ohsbok.org.au

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Bibliography

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Author

Dr Ross Di Corleto, Principal Advisor, Industrial Hygiene, Rio Tinto.

Peer reviewers

Dr David Bromwich, Adjunct Associate Professor, Griffith University

Peter Knott, Senior Occupational Hygienist, 3M Australia Pty Limited

Second Edition published in 2019

The chapter has been updated with current referencing and to reflect recent research.

Author

Dr Ross Di Corleto, Principal Consultant - Monitor Consulting Services

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Author

Dr Ross Di Corleto, Principal Consultant - Monitor Consulting Services

Peer reviewer

Adj Prof. Dino L Pisaniello FAIOH FAIHS FRACI

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Thermal Environment

Dr Ross Di Corleto PhD, MSc, Grad Dip Occ Hyg, BAppSc, FAIHS, ChOHSP, FAIOH, COH

Director, Monitor Consulting Services

Email: rdicorleto@monitorcs.com.au

Ross Di Corleto has been involved in occupational health and safety and occupational hygiene for over 35 years with experience in the power industry, mining and refining, both nationally and internationally.

He is a Past President of the Australian Institute of Occupational Hygienists and an Adjunct Associate Professor at the University of Queensland University and Edith Cowan University.

Ross' areas of particular interest include heat stress and the thermal environment. He has a Master of Science by research in heat stress and a PhD in occupational health and has authored a number of papers, book chapters and guides on the topic. He has been involved in development and presentation of undergraduate and post graduate modules in occupational health and lectured at a number of Australian Universities.

Thermal Environment

Abstract

The complex range of hazards associated with the thermal environment is widely acknowledged as a serious Occupational Health and Safety (OHS) issue. Exposure to extreme heat or cold can result in illness, injury and, in extreme cases, death. While high-risk situations will require specialist occupational hygiene advice, the generalist OHS professional should have an understanding of the impact of hot and cold environments, risk assessment methods and the regulatory framework as a basis for advising on, implementing, and monitoring controls. This chapter presents fundamental information about potential health and injury effects, assessment and control methods and, given the relevance of heat exposure to Australian working conditions, outlines a three-tiered approach to the assessment of heat exposure.

Keywords

thermal environment, heat, cold, hypothermia, hyperthermia, risk assessment, hydration, thermal Indices, acclimatisation, thermal controls, heat illness

Contextual reading

Readers should refer to 1 *Preliminaries* for a full list of chapters and authors and a synopsis of the OHS Body of Knowledge. Chapter 2, *Introduction* describes the background and development process while Chapter 3, *The OHS Professional* provides a context by describing the role and professional environment.

Terminology

Depending on the jurisdiction and the organisation, Australian terminology refers to 'Occupational Health and Safety' (OHS), 'Occupational Safety and Health (OSH) or 'Work Health and Safety' (WHS). In line with international practice this publication uses OHS with the exception of specific reference to the Work Health and Safety (WHS) Act and related legislation.

Jurisdictional application

This chapter includes a short section referring to the Australian model work health and safety legislation. This is in line with the Australian national application of the *OHS Body of Knowledge*. Readers working in other legal jurisdictions should consider these references as examples and refer to the relevant legislation in their jurisdiction of operation.

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1 Introduction

The management of thermal exposures has long been an issue for the Occupational Health and Safety (OHS) professional. The exposure of workers to extreme heat or cold can result in serious illnesses and injuries, and even death. Risk management is complicated by not only the vagaries of the environment, but also by the variability of the human body and the task being undertaken. This complexity cannot always be eliminated and often requires specialist expertise; thus the generalist OHS professional should have access to specialist occupational hygiene advice in high-risk situations. Nevertheless, there is a role for the generalist OHS professional to utilise some readily available tools and a systematic assessment process to identify the key issues and implement effective controls.

Consequently, this chapter focuses on the health and injury effects associated with exposure to the extremes of the thermal environment, risk assessment, the identification and application of controls to protect workers from exposure to the effects of heat and cold.¹ It does not provide information relating to management of thermal comfort.² Furthermore, while this chapter provides some information relevant to working in cold environments, it is predominantly concerned with exposure to heat as this is most relevant for the Australian climate. Heat stress, a prominent industry concern, impacts directly on the individual and is an indirect contributor to many incidents, including traumatic injury, in Australian workplaces. This chapter presents a systematic three-tiered approach to risk assessment in hot environments.

1.1 Definitions

Heat stress occurs “when a person’s environment (air temperature, radiant temperature, humidity and air velocity), clothing and activity interact to produce a tendency for internal body temperature to rise” (Parsons, 2011). *Cold stress* has been defined as “a thermal load on the body under which greater than normal heat losses are anticipated and compensatory thermoregulatory actions are required to maintain the body thermally neutral” (Holmer, 1998). The US Center for Disease Control and Prevention explained:

Workers who are exposed to extreme heat or work in hot environments may be at risk of **heat stress**. Exposure to extreme heat can result in occupational illnesses and injuries. Heat stress can result in heat stroke, heat exhaustion, heat cramps, or heat rashes. Heat can also increase the risk of injuries in workers as it may result in sweaty palms, fogged-up safety glasses, and dizziness...Workers at risk of heat stress include outdoor workers and workers in hot environments such as firefighters, bakery workers, farmers, construction workers, miners, boiler room workers, factory workers, and others. (CDC, 2011a)

¹ This chapter assumes that the reader is familiar with ‘thermal science,’ including convection, radiation and conduction, and basic physiology as described in *OHS BoK 14 Foundation Science*.

² For more information on thermal comfort, see ANSI/ASHRAE (2023).

Workers who are exposed to extreme cold or work in cold environments may be at risk of the physiological effects of **cold stress**. Extreme cold weather is a dangerous situation that can bring on health emergencies in susceptible people, such as those without shelter, outdoor workers, and those who work in an area that is poorly insulated or without heat...Prolonged exposure to cold will eventually use up your body's stored energy. The result is hypothermia, or abnormally low body temperature. A body temperature that is too low affects the brain, making the victim unable to think clearly or move well. (CDC, 2011b)

In addition, the following which includes CCOHS (2025) definitions are relevant to a discussion on thermal environment:

Acclimatization – Physiological changes which occur in response to several days of heat exposure and make the body accustomed to a hot environment.

Convection – Process of heat exchange between the body and the surrounding air or fluid as a result of bulk flow of that air or fluid.

Dehydration – Loss or deficiency of water in body tissues caused by sweating, vomiting or diarrhoea. Symptoms include excessive thirst, nausea, and exhaustion.

Heat cramps – Painful and often incapacitating cramps in muscles. Heat cramps are caused by depletion of salt in the body as a result of heavy sweating.

Heat exhaustion – Weakness, lassitude, dizziness, visual disturbance, feeling of intense thirst and heat, nausea, vomiting, palpitations, tingling and numbness of extremities after exposure to a hot environment.

Heat rash (prickly heat or millaria) – An itchy rash of small raised red spots on the face, neck, back, chest and thighs caused by a hot and moist environment.

Heat strain – Physiological and behavioural responses of the body as a result of heat exposure.

Heat stroke – Acute illness caused by overexposure to heat. Symptoms are dry, hot skin, high body temperature (usually over 40°C) and mental dysfunction.

Heat syncope – Temporary loss of consciousness [fainting] induced by insufficient flow of blood to the brain. Recovery is normally prompt and without any long-term ill effects.

Metabolic rate – Rate of energy (heat) production of the body which varies with the level of activity.

Nausea – The feeling that one is about to vomit as experienced in seasickness.

Radiation (heat) – Transfer of heat between hot and cold bodies without contact between them.

Relative humidity – The ratio of the water vapour content of air to the maximum possible water vapour content of air at the same temperature and air pressure.

Dry bulb temperature - The normal air temperature measured by a standard thermometer shielded from direct sun and radiant heat (i.e., the "air" temperature).

Wet bulb temperature - The temperature measured by a thermometer with a wet wick over the bulb, reflecting the cooling effect of evaporation (so it indicates how much the air can cool a person through sweating).

Globe temperature - The temperature measured inside a black globe thermometer, representing the combined effects of radiant heat (e.g., sun/hot surfaces) and air movement, as well as air temperature.

2 Historical context

Goldman (2001, p. 4) revealed that the effects of hot environments were documented in the earliest writing; by 3000 BC, the Romans, Egyptians and Greeks had linked the appearance of Sirius, the dog star, with “ushering in the ‘dog days’ of summer...[and] bringing on fever in men and madness in dogs.” There are also references to early controls; for example:

The Roman legionary used an early form of auxiliary cooling, inserting rushes into his head gear and keeping them wet with water...[and used] auxiliaries to carry as much of the legionnaires’ load, and do as much of the engineering digging as possible, thus sparing the fighting edge of the legion (Goldman, 2001, p. 5).

In 1774 Sir Charles Blagden (Blagden, 1775), discussed a number of experiments undertaken in a heated room in which he commented on “the wonderful power with which the animal body is endued, of resisting heat vastly greater than its own temperature”.

In the early 1900s a number of authors wrote on the effects of heat and humidity on workers (Moss et al., 1923; Young et al., 1920; Vernon et al., 1932). 1925 saw the development of the effective temperature index (Houghton & Yaglou, 1924), a key milestone in the assessment of thermal comfort, then in 1957 an investigation into casualties during training in the US Navy led to the development of the now well-known wet bulb globe temperature index (WBGT) (Yaglou & Minard, 1957). Hunt (2011) in describing the mining industry’s long-term struggle with heat stress, cited a 1930 incident rate of fatality from heat stroke in South African mines of 1.5 per thousand workers.

Similarly, there is very early evidence of the health effects of cold environments. Patton (2001) chronicled the effects of cold stress on warfare, commencing with an account of the Battle of Cunaxa near Babylon in the winter of 401–400 BC when 6,000 of Athenian Xenophon’s 10,000 men died from cold exposure and frostbite. The statistics remained large-scale through the centuries. For example, there were more than 15,000 cold injuries during the American Civil War (1861–1865); in World War I the British army sustained 115,000 cold and frostbite injuries, and 2000 Russians died from frostbite and cold exposure during two nights in 1916; and in World War II cold injuries numbered in the millions (Patton, 2001). The magnitude of cold-stress-related morbidity and mortality during World War II stimulated significant programs of research “to solve the problems of the etiology and treatment of frostbite, trench foot and hypothermia” (Patton, 2001, p. 335) that have resulted in “rapid rewarming in the field” (p. 342) as well as physical and psychological preparation for the elements.

Whilst there have been significant advances made in the control and management of both hot and cold environments since these early days there continues to be an issue with the occurrence of thermally related injuries and illnesses in current times.

A recent paper described the impact of hot and cold conditions on workplace injuries (Borg et al, 2025).

3 Extent of the problem

Australian workers' compensation claims data (SWA, 2025) combines the agencies of injury 'heat, electricity and other environmental factors' and so provides little indication of the extent of the problems associated with working in hot or cold thermal environments, consequently this impact is often underestimated. The human body's complex response to hot or cold environments includes subtleties of physiological/pathological change that are unlikely to be reflected in workers' compensation data. Indeed, due to under-reporting, misdiagnosis and lack of public awareness of the many ways it can contribute to death, illness or injury, cold stress has been identified as "possibly one of the most underrated killers in modern medicine" (Lloyd, 1986, p. 3).

The Occupational Health and Safety Council of Ontario (OHSCO, 2009, p. 3) indicated that heat stress is likely to be a concern in all workplaces where 'yes' is the answer to one or more of the following questions:

- Has anyone been affected by heat in your workplace?
- Are fans needed to keep workers cool?
- Is work done in direct sunlight?
- Are there heat-producing processes or equipment in the workplace?
- Do workers wear extra clothing/protective equipment that can make them hot (e.g. overalls, respirators, hard hats, etc.)?
- Have workers ever expressed concern about heat in the workplace?

Shearing is an extreme example of a heat-affected occupation; it was often undertaken in uninsulated corrugated iron sheds and shearers are susceptible to heat rash, heat exhaustion and heat stroke (Gun et al., 1995). Also, despite improvements in working conditions, workers in the mining industry remain particularly vulnerable to heat stress (Hunt et al., 2013). In a study of heat exhaustion in a deep underground mine in Australia, Donoghue, Sinclair and Bates (2000) found that while the average annual incidence was relatively low (43 cases per million worker-hours underground; a total of 106 cases), it was much higher during summer (e.g. 147 cases per million worker-hours underground in the month of February). Similarly, construction and agricultural sectors are also exposed to work environments as are commercial industries such as bakeries and laundries. In these environments the thermal conditions can pose a significant short and long term risk of thermal illnesses.

4 Understanding the impact of hot environments

Understanding the impact of working in hot environments requires some knowledge of the physiological responses of the body and the nature of the relevant acute and chronic health effects. This knowledge provides a basis for risk assessment, which is presented as a three- tiered approach that considers the complexity of the situation, the level of risk and the availability of expert advice. A brief summary of the legislative requirements and standards sets the context for discussion of relevant controls.

4.1 Physiological response³

4.1.1 Thermal Balance (Homeostasis)

Homeostasis is “the maintenance of a constant internal environment within the body”; it includes not only control of the body temperature but also control of the water balance of the blood, the blood sugar level and the blood urea level (Givens & Reiss, 2002, p. 56).

The human body operates within a very narrow core temperature band. While there are core body temperature changes naturally over the day (diurnal variations), normal internal core body temperature usually ranges from 36.8°C to 37.2°C. Heat stress affects the body’s ability to stay in balance. To keep body temperature stable, any heat gained from the environment or from physical work must be offset by the same amount of heat lost from the body. If the body cannot lose heat at the same rate it is gained, heat builds up and the person experiences heat stress. The same works in reverse for cold stress.

This is often expressed in a simplified heat balance equation:

$$S = M \pm C \pm R \pm K - E$$

where:

S = net heat accumulation by the body

M = metabolic heat output

C = convective heat input or loss (can be positive or negative)

R = radiant heat input or loss (can be positive or negative)

K = conductive input or loss (can be positive or negative)

E = evaporative cooling by sweating (can only be negative).

³ See also *OHS BOK 7 The Human as a Biological System*.

The body's heat balance process is often likened to a car engine: the organs and muscles are the engine that generates heat; the blood is the coolant that takes the heat from the core to the skin, which is the radiator; and the hypothalamus in the brain is the body's thermostat.

Consider the following example:

A person working in an air-conditioned workshop starts to generate heat. The core temperature begins to rise and the hypothalamus (the thermostat) signals increased heart rate and dilation (widening) of blood vessels at the outer parts of the body i.e., skin, arms, legs, (periphery) so that a greater volume of blood is distributed to the surface of the skin. Once the blood reaches the skin (often making the person appear 'flushed'), the heat is transferred to the cool environment. Moving air helps carry heat away from the body, (convection), and the blood temperature lowers and is returned to the core where the core temperature drops. This is a simple, but effective process for cooling the body. However, if the outside temperature is elevated, the process of heat transfer to the external environment is not as efficient. In this case, the body begins to sweat, and as the sweat evaporates the skin is cooled, which in turn cools the blood and hence lowers the core temperature. In principle, this is similar to the canvas water bag on the front of a ute or the old bush fridge in a canvas bag.

Sweat that drips off has no cooling effect and sweat that soaks a shirt has a much-reduced cooling effect.

Hence the most effective means of regulating temperature is via this evaporation of sweat, which may account for up to 98% of the cooling process (Werner et al., 1993). If fluid is not replaced, the individual can experience reduced capacity for physical work, fatigue and psychological changes:

- Dehydration of 1 to 2% of body weight results in a 6 to 7% reduction in physical work rate.
- Dehydration of 3 to 4% of body weight results in a 22% to 50% reduction in work rate, for "moderate" and "hot" environments, respectively.
- Mental performance (mental function, visuomotor skills and arithmetic tests) begins to decrease at 2% change in total body weight by dehydration (Brake, 2001, Casa et al 2000, Hunt, Stewart & Parker 2009). A fluid loss of 5% or more is considered severe dehydration.

4.1.2 Acclimatisation

Heat acclimatisation is a complex physiological process that occurs over time as the body adjusts to the thermal environment. Being heat-acclimatised means the body has adapted to working in hot conditions. After repeated exposure to heat, the body becomes better at releasing heat, allowing a person to work harder or longer without overheating (Amorim & Moseley, 2010). The acclimatisation process results in greater efficiency of the body to control its internal temperature. Benefits of heat acclimatisation documented by Bricknell (1996) have been summarised as:

- More finely tuned sweating reflexes, with earlier increased sweat production rate at lower electrolyte concentrations

- Lower core and skin temperatures than at the beginning of exposure
- Increase in plasma volume of up to 16% over the first 3-5 days
- Earlier initiation of vasodilation of the blood vessels in the skin (Pryor et al., 2018)
- More stable and better regulated blood pressure with lower pulse rates, and
- Improved productivity and safety (Di Corleto, Coles & Firth, 2003).

Each physiological change associated with acclimatisation (e.g. cardiovascular stability, fluid and electrolyte balances, sweat rates and temperature responses) has its own rate of change during this process. It is as a result of the combination of exercise/work and heat usually >30°C (>86°F) over several repeated or extended exposures. When these two are not combined acclimatisation will occur more slowly. In general, much of the acclimatisation process occurs in the first four to seven days but not all of the above benefits are achieved at the same time (Pryor et al., 2018). The majority of benefits will usually be achieved within two weeks.

1. Early stage (first few days): The body adjusts quickly by improving heart and blood circulation. Heart rate drops, and blood volume increases within about 3–5 days, especially in fit individuals, helping the body cope better with heat (Pryor et al 2018).
2. Middle stage (about 1–2 weeks): Body temperature becomes more stable and cooling improves. Most people reach around 70–80% of full heat adaptation within 7–10 days, although some guidance suggests it can take up to 14 days (Pandolf, 1978; Brake and Bates 2001) .
3. Later stage (after 2 weeks): The body becomes more efficient at saving water and salts. Sweat and urine contain less salt, and heat tolerance is close to maximum, with nearly full adaptation reached by about 3 weeks.

A summary of these benefits is summarized in table 1.

Table 1 Heat acclimatisation benefits (Di Corleto et al, 2025. P. 63) .

Someone with heat acclimatisation exposed to environmental and activity related heat stress has:
<ul style="list-style-type: none"> • Increased sweat production rate at lower electrolyte concentrations (Armstrong <i>et al</i>, 2007), • Change in sweat composition (Taylor, 2006), • Reduction in the sweating threshold (i.e. earlier onset of sweating) (Nadel <i>et al</i>, 1974), • Increase in sweating efficiency (Shvartz <i>et al</i>, 1974), • Increase in plasma volume up to 16% over the first 3 to 5 days (Senay <i>et al</i>, 1976),

- Lower rectal and skin temperatures than at the beginning of exposure (Shvartz *et al*, 1974),
- Decreased resting core temperature (Buono *et al*, 1998),
- More stable and better regulated blood pressure with lower pulse rates and greater stroke volume (Pryor *et al*, 2018),
- Reduction in resting heart rate in the heat (Yamazaki & Hamasaki, 2003),
- Earlier initiation of vasodilation (widening) of the blood vessels in the skin (Pryor *et al*, 2018), and
- Improved productivity and safety (Di Corleto *et al* 2025. p.49).

While the general consensus is that heat acclimatisation is gained faster than it is lost, less is known about the time required to lose acclimatisation. Heat acclimatisation can be lost if a person stops working in hot conditions. Brake, Donoghue and Bates (1998) suggested that loss of acclimatisation occurs over 7 to 21 days. Other research suggests that about one day of heat adaptation is lost for every two days away from heat exposure (Pryor *et al.*, 2018). When returning to hot work, this adaptation can often be regained within 2–3 days. Re-acclimatisation is usually faster than the first time because the body keeps some heat adaptations through a process called “thermal memory” (Heathcote *et al.*, 2019). Physically fit individuals tend to retain heat adaptations better than others (NIOSH, 2016).

An acclimatisation period is recommended for any new workers to site or workers returning from extended leave (i.e. >14 days) in a more temperate climate (Brake, Donoghue & Bates, 1998). There is limited information relating to acclimatisation protocols in the literature. The most commonly used approach is that suggested by NIOSH (2016) to help new workers to adjust to the heat gradually over a period of 7 to 14 days.

1. For new workers, start with no more than 20% of the normal work time in hot conditions on the first day. This can be increased by up to 20% each day after that.
2. For workers who have done the work before in the same climate conditions begin with reduced time in the heat and build up over four days:
 - 50% of usual work time in heat on Day 1
 - 60% on Day 2
 - 80% on Day 3
 - 100% on Day 4.

It should be noted that individuals differ in their ability to acclimatise to heat. Workers who are less physically fit usually need about 50% more time to fully adapt to working in the heat than fitter workers.

4.1.3 Hydration and fluid requirements

Hydration status is a key factor in the ability of the human body to function efficiently in a hot thermal climate. The total body water mass is approximately 60% (Parsons, 2003); this level constantly varies when work is undertaken in hot environments. Fluids are lost via several routes, including sweating, evaporation from the respiratory tract, and excretion. Rehydration of lost fluids is integral to effective management of work in these adverse conditions.

Ensuring that employees maintain a sufficient water intake to counter losses associated with sweat evaporation in hot environments has always been an issue.

Consistently, research has shown that relying purely on the thirst mechanism to maintain fluid volumes is ineffective and often results in 'involuntary dehydration' (Greenleaf, 1982; Sawka, 1988). Many studies have been conducted to identify an ideal replacement fluid that is palatable and provides a rapid rate of absorption into the body (see, for example, Murray, 2005).

Fluid absorption depends on several factors, including stomach emptying rate, drink composition and individual medical history. Under ideal conditions, fluid absorption is limited to about 1.2 litres per hour (Nielsen, 1987), which may be less than sweat losses during heavy work in hot environments. Drinks with high concentrations of carbohydrates, electrolytes, sweeteners or preservatives slow stomach emptying, especially when glucose exceeds 2.5%. This property, known as osmolality, delays fluid movement to the small intestine where absorption occurs and may cause stomach discomfort. Carbohydrate concentrations below about 7% are associated with fewer symptoms. Milk, meal replacement drinks, smoothies and liquid sports meals leave the stomach more slowly due to their protein and fat content. They may cause a feeling of fullness and reduce overall fluid intake during hot work.

Some medical procedures, such as bariatric surgery, can reduce a person's ability to absorb fluids effectively. This must be considered when assessing hydration needs in the workplace.

Palatability should not be underestimated; colour, odour, temperature and taste are critical to palatability and intake (Greenleaf, 1992). Fluid requirements can vary depending on the individual and situation. As a general rule of thumb, the United States National Athletics Trainers Association recommends maintaining hydration such that there is less than 2% body mass loss (McDermott et al 2017)

Taken in frequent small amounts, water is the simplest and most readily absorbed fluid: "Research has established that fluid requirements during work in the heat that lasts less than 90 minutes can be met by drinking adequate amounts of plain water" (Nevola, 1998; Nevola, Staerck & Harrison, 2005). Particularly in the case of an acclimatised individual, the salt levels lost are usually replaced by the salt content of the average diet.

For hot-environment work of 90-240 minutes duration, consideration should be given to the inclusion of fluid that contains some form of carbohydrate additive of less than 7% concentration. For work periods exceeding 240 minutes, fluids should also be supplemented with electrolytes, including sodium (~20-30 mmol/L) and trace

potassium (~5 mmol/L) to replace those lost in sweat.

There are numerous commercial electrolyte-replacement drinks available with varying levels of sodium, potassium, carbohydrates and other additives. Their suitability should be assessed in light of the requirements of the specific situation.

Alcohol should be avoided; as it can have a diuretic effect (increased urine production) and hence increase fluid loss, leading to dehydration and hindering rehydration before and after work (e.g. Brake, Donoghue & Bates, 1998; OHSCO, 2009; SDA, 2009.)

Caffeine is quickly absorbed by the body, with blood levels usually peaking within about 20 minutes after drinking caffeinated beverages or eating certain foods. Early concerns suggested that caffeine could have a mild diuretic effect in some people, especially when consumed at rest. This raised concerns that it might increase fluid loss and contribute to dehydration or interfere with rehydration before and after work or exercise.

Studies (Armstrong et al 2007; Roti et al 2006) show that this is not always the case during physical work or exercise. Research indicates that moderate, regular caffeine intake does not significantly affect fluid or electrolyte balance during exercise, nor does it reduce the ability to work or exercise in hot conditions. In these situations, low level caffeinated drinks can contribute to total fluid intake. However, they should not be relied on as the only source of fluid replacement.

Water intoxication (hyponatraemia)

Hyponatraemia occurs when blood sodium levels become diluted, usually due to heavy sweating combined with replacement using only plain water. Early symptoms are like heat stress and may include nausea, lethargy, confusion, muscle weakness and headaches.

If sodium levels continue to fall, seizures, coma and, in rare cases, death may occur. This condition is uncommon, and the levels of water required to be consumed to induce such an illness are extreme. It is unlikely when a balanced diet is maintained. In situations involving heavy and prolonged sweating, appropriate electrolyte replacement drinks should be provided.

Medication can also impact on the body's ability to manage heat stress and should be taken into consideration. Some medications and drugs can reduce your body's ability to cope with heat when working in hot conditions. This can increase the risk of heat exhaustion or heat stroke, even if the temperature does not feel extreme. For example, diuretics will impact on the fluid balance whilst antihistamines may inhibit the sweating process, and some anti-inflammatories may interfere with thermoregulation. A more detailed description is presented in Appendix 2.

Some drugs:

- Reduce sweating, so heat cannot escape

- Reduce blood flow to the skin, trapping heat in the body
- Increase body heat production or cause agitation
- Interfere with the brain's temperature control centre

This means the body may overheat faster and with fewer warning signs.

4.2 Acute health effects

Initial symptoms of heat strain – deterioration of concentration and fine motor skills and, in some cases, exhaustion – may start to manifest within a rise in core body temperature of 2°C. Heat stroke can begin when core body temperature reaches 40°C with death possible from 42°C (Leithead & Lind 1964). Indeed, the World Health Organization (WHO, 2025) recommended that a core temperature of 38°C not be exceeded during heavy labour. Heat illnesses can range from prickly heat, heat cramps, heat syncope (fainting) and dehydration to the more serious heat exhaustion and heat stroke. There is large variability in the response of individuals to hot conditions. Some individuals may be seriously affected by a body temperature of less than 39°C, whereas there have been documented instances of body temperatures exceeding 40°C without significant impairment of function (Hanson et al., 2000).

4.3 Chronic health effects

Heat stress is commonly associated with short-term illness such as heat exhaustion and heat stroke. However, heat exposure affects are not only acute but can also have long term impacts on health. Evidence shows that ongoing heat exposure may also contribute to long-term illness and increased mortality, even when acute heat illness is not reported (Buralli et al., 2024). Workers performing intense physical labour in hot conditions, especially with inadequate hydration, may be at increased risk of chronic kidney disease (Courville et al., 2022; Buralli et al., 2024). The increasing incidence of chronic kidney disease at almost epidemic levels in the hot coastal communities of Central America (Peraza et al., 2012; Roncal-Jiminez et al., 2014; Bodin et al., 2016) are being linked to recurrent dehydration. This repeated or chronic dehydration increases kidney stress and may also increase the risk of chronic kidney disease and kidney stones, particularly uric acid stones (Courville et al., 2022).

In addition, some, liver, heart, digestive system, central nervous system, skin conditions and alterations in gestation length have been linked to long-term heat exposure (see, for example, Porter, Thomas & Whitman, 1999) and the evidence to support these links is becoming more evident (Liu et al, 2022).

4.4 Other hazards

Because heat stress can contribute to fatigue, its control is of particular importance in tasks of a critical safety nature (see, for example, WorkSafe Victoria, 2017b). Furthermore, higher summer temperatures may be partially responsible for increased accident and injury incidence among workers in the mining and munitions industries and physically active individuals (Chrenko, 1974; Knapik et al., 2002).

More recently, there has been discussion about a condition known as a “heat hangover.” This term describes moderate negative physical and perceptual effects that can occur after excessive heat exposure (Brearley, 2016). The symptoms are similar to those of an alcohol hangover. Heat hangovers may develop after repeated exposure to moderate or high heat over long periods. Common symptoms include fatigue, irritability, headaches, nausea, reduced appetite, and general lethargy, often appearing toward the end of a shift or after work. Importantly, these effects can occur without extremely high core body temperatures.

Thermal stress increases fatigue, reduces concentration, and slows reaction times, increasing injury risk (Leithead & Lind, 1964; Ramsey et al., 1983; Hancock, 1986). Studies have linked workers exposure to an increased risk of accidents and injuries within the workplace. These include injuries ranging from superficial injuries through to fractures and amputations (Xiang et al., 2014; Martinez- Solanas et al., 2018; Tawatsupa et al., 2013; Varghese et al., 2019).

A number of studies have found that working in elevated temperatures can result in significant productivity losses (Kjellstrom et al., 2009; Sahu et al., 2013; Flouris et al., 2018). Productivity losses have been estimated at 2% per degree Celsius above 25°C WBGT (Seppanen et al., 2003). In an Australian study reviewing estimates of self-reported absenteeism and reductions in work performance as a result of heat, there was a projected annual economic burden cost of approximately US\$6.2 billion (Zander et al., 2015).

4.5 Risk assessment and assessing the thermal environment

Two categories with six basic factors can be used to define an individual’s thermal environment.

Environmental factors:

- Air temperature
- Radiant temperature
- Air velocity
- Humidity

Personal

factors:

- Clothing insulation
- Metabolic heat.

These factors are considered in a three-tiered approach to assessment of heat exposure that has been designed to be applicable to a range of scenarios where the level applied is dependent on the severity and complexity of the situation (Di Corleto, 1998). The risk- assessment tiers require increasing levels of technical expertise. Whilst a Level 1 assessment could be undertaken by a variety of

individuals with minimal or no technical skills, a Level 2 assessment requires a higher level of skill such as that of an OHS professional and in some cases specialist skills. A Level 3 assessment should be restricted to those with specialist knowledge and skills such as occupational physicians, experienced occupational hygienists or physiologists.

4.5.1 Level 1: Basic assessment of heat stress

The first, or basic, level of thermal risk assessment as detailed in the Australian Institute of Occupational Hygienists heat stress guide (Di Corleto, Firth & Gopoldasani, 2025) is a qualitative assessment that does not require specific technical skills in its application or interpretation. It was developed for use by frontline workers to assist them to better understand the mechanisms and impacts of thermal assessments.

This example of a Level 1 assessment involves a series of questions relating to parameters that will impact the individual's heat stress; responses are assigned a numerical value and weighted according to potential impact on the thermal load. The final numerical value is compared to a predetermined scale that rates the overall heat stress potential.⁴ By asking the assessor to rate specific parameters impacting on thermal stress it focuses on the many aspects of the work environment that need to be considered (i.e. not just a single dry bulb air temperature). It also readily provides ideas for improved controls. Undertaken as part of a walk-through survey with the worker, it can be a useful and powerful tool in training and education. In the original version of the Basic Thermal Assessment developed by the author there was no actual measurement required; use of the Wet Bulb Globe Thermometer (WBGT) temperature in the equation was added to supplement the subjective and qualitative nature of the assessment with some quantification. This was later replaced with the Apparent Temperature for greater simplicity and ease of use. Appendix 1 outlines the AIOH Thermal Risk Assessment Guide suitable for use at Level 1.

Other approaches may include checklists, discussions with workers, STOP reviews and safe work procedures. Various basic risk-assessment programs have been developed that include additional parameters such as heat strain tables and trigger action response plans (Di Corleto, 2023), urine specific gravity, hydration levels and decision matrices (Bates, Lindars & Hawkins, 2008). More recently we have seen the introduction of phone/tablet apps such as the 'Thermal Risk'⁵ app based on the AIOH basic thermal risk assessment (Di Corleto, Firth & Gopoldasani 2025) which can be downloaded onto a mobile phone or tablet for use in the field. It requires the user to answer a series of questions and to enter air temperature and humidity as input. The app can also provide an initial idea on potential issues and controls.

The WBGT index – with its simple calculation and quick result – was developed for ease of use in an industrial/military setting; it provides a compromise between a precise index and the need for a fast assessment. Therefore, it is best used as a first

⁴ See Appendix 1: Basic Thermal Risk Assessment.

⁵ See: <https://play.google.com/store/apps/details?id=com.Gopoldasani.thermalrisk> Or <https://apps.apple.com/au/app/thermal-risk/id867920824>

level assessment tool to determine whether a problem exists by identifying whether reference values are exceeded. If this occurs, the more advanced Predicted Heat Strain (PHS) or Thermal Work Limit (TWL) should be used to provide a more accurate estimation of heat stress (Bethea et al., 2002; ACGIH 2025).

Widely used by the UK and European mining industry and by some underground mines in Australia, Basic Effective Temperature (BET) is a subjective thermal or empirically based index that combines dry bulb temperature, aspirated (psychometric) wet bulb temperature and air velocity, and is read from specially constructed nomograms. A code of practice for working in hot and humid conditions in coalmines has been developed, wherein BET limits are provided (Hanson & Graveling, 1997). It should be noted that the effective temperature on which this is based was originally developed as a thermal comfort index.

4.5.2 Level 2: Thermal assessment using a heat stress index

Level 2 assessment takes a more quantitative approach requiring the measurement of several environmental and personal parameters, such as dry bulb and globe temperatures, relative humidity and air velocity, and estimation of metabolic workload and clothing insulation. These parameters are used in conjunction with a heat stress index to determine allowable exposure times. Predicted Heat Strain (PHS) or Thermal Work Limit (TWL) – the so-called ‘rational indices’ – are normally based on the human heat balance equation (see Parsons, 2003) and attempt to model various important physiological parameters that indicate heat strain. The PHS and TWL indices are intended to predict the risk of heat disorders from climate conditions (ISO 7933, 2023) and average metabolic work rate (ISO, 2021), using predicted responses of the body such as sweating and elevated core temperature. To extend the usefulness of the indices, the thermal characteristics (i.e. insulation effect) of a variety of protective clothing combinations have been included in the calculation (Barker, Kini & Bernard, 1999). The indices assume that light clothing is worn (e.g. cotton clothing or cotton/polyester blends) that the body responds similarly for all persons working under the same conditions.

When using the WBGT, TWL or PHS indices as limiting values, the limits are only appropriate for workers who:

- Have been screened for intolerance to heat, are in good health and are fit for the activity being considered
- Have been properly instructed in the details of their work tasks and the potential effects and signs and symptoms of heat stress
- Are able to self pace their work
- Are under some degree of supervision (minimally a buddy system)
- Are not wearing clothing that restricts sweat evaporation or heat loss.

These indices should only be used as guidelines and not as safe/unsafe limits as no single index can accurately account for all the variables associated with heat stress assessment. Different thermal indices are suitable for different thermal and work conditions, and all have some limitations in terms of their ability to predict human

response to the environment. The generalist OHS professional should be aware of these indices, their application and limitations and when specialist advice may be required as part of the assessment.

4.5.3 Level 3: Physiological monitoring

Where allowable exposure time determined by use of a rational heat stress index (e.g. PHS or TWL) is less than 30 minutes or there is a high level of personal protective equipment (PPE), there should be some form of physiological monitoring (ISO 12894, 2001; Di Corleto, 1998). PPE clothing inhibits evaporation by producing a humid microclimate and diminishes the cooling effect of the evaporation that does take place (Nunnely, 1989).

Physiological monitoring is based on an individual's reactions to the thermal stress to which they are being exposed. These direct measurements take into account the variables (e.g. age, fitness) for which assumptions are made in the Level 2 assessment that utilises indices. Physiological assessment provides a more accurate result and a greater level of confidence as to the impact on the individual regardless of the conditions and, importantly, includes the impact of PPE.

Physiological monitoring can be as simple as assessing the hydration status via urine colour/specific gravity or saliva osmolality through to the use of real-time monitoring instrumentation. The comprehensiveness of the approach being determined by the complexity of the scenario.

Both the American Conference of Industrial Hygienists (ACGIH, 2025) and the International Organization for Standardization (ISO 9886, 2004) have published physiological limits. The ACGIH (2025) stipulated that exposure to environmentally or activity-induced heat stress must be discontinued in the following circumstances:

- Sustained (several minutes) heart rate in excess of 180 beats per minute (BPM) minus the individual's age in years (e.g. $180 - \text{age}$), for individuals with assessed normal cardiac performance; or
- Measured body core temperature increases by more than 1°C from pre-job temperature if the pre-job temperature is less than 37.5°C (99.5°C); or
- A worker's recovery heart rate at one minute after a peak work effort is greater than 120 bpm.
- Exposure should stop with signs or symptoms of heat exhaustion or heat stroke or with a request to stop regardless of what physiological monitoring may indicate.

The ACGIHs overriding advice is to never ignore any signs or symptoms that may be apparent in relation to heat related exposures. ISO 9886:2004 Ergonomics – Evaluation of Thermal Strain by Physiological Measurements (ISO, 2004) suggested that exposure to environmentally or activity-induced heat stress must also be discontinued when 'Heart Rate Limit = $185 - 0.65A$ ' (where A = age in years) is reached. As individual variability can range up to 20 bpm from this average, this level could present a risk for some individuals. Where there is uncertainty, the sustained heart rate over a work period should not exceed a lower limit of HRL, sustained = 180

– age. No matter which limiting values are used, interpretation requires discussion with the workers affected and may require assessment by a specialist occupational hygienist especially where there are extended shifts.

4.5.3.1 Wearable Physiological Monitoring

Many types of personal monitoring devices are now available, with new models released each year. As computer-based learning systems continue to improve, these devices are becoming more accurate at predicting how the body responds to different environmental and work conditions (Notley et al., 2018).

These monitors are often worn like a smartwatch. They can track key physiological measures such as estimated core body temperature, heart rate, and sweating. Information is displayed on the device or a receiver and may trigger alerts, such as a vibration or sound to prompt rest. The data can also be stored and presented as graphs for review by an occupational health professional. Used appropriately, these systems can help monitor worker heat strain in hot environments.

Core body temperature is one of the most commonly monitored indicators. It may be measured directly using ingestible telemetry pills (e.g. Coretemp® or Equivital®) or estimated using skin-mounted sensors (e.g. Kenzen® or Calera Core®). Skin sensors do not measure true core temperature; instead, they estimate it from skin temperature using mathematical models. Some systems also measure sweat rate and sweat composition to assess heat strain and provide hydration prompts (e.g. Epicore®) (Stewart et al., 2023).

When used correctly, these tools can offer clear benefits. However, they also have limitations and potential drawbacks. Careful selection and correct use are essential, particularly for users without specialist training in heat stress or human physiology. Inappropriate device choice or incorrect use can lead to inaccurate data and may increase risk to the wearer.

Table 2 Benefits and limitations of physiological monitors.

Benefits	Limitations
<ul style="list-style-type: none"> • Can provide an accurate measure of core temperature and heart rate of the individual in high-risk scenarios. • It allows real-time monitoring of an individual's response to heat stress and hence when controls are needed. • Provides more relevant information when impermeable clothing is worn. • Can be used to identify early warning signs of heat strain for timely action. 	<ul style="list-style-type: none"> • Responses to heat stress vary among individuals, so interpreting the data requires expertise. • Data quality is dependent on correct use and maintenance of equipment. • Can be ignored when production/peer pressure exists. • Wearers ignore other signs and symptoms based on the monitor information. • Ineffective if an organisation does not have the correct management systems and culture.

- | | |
|--|---|
| <ul style="list-style-type: none"> • Can incorporate several physiological parameters at the one time for assessment. | <ul style="list-style-type: none"> • There may be issues with data privacy laws in some jurisdictions. |
|--|---|

Personal monitoring devices should not be used as stand-alone controls. They must form part of a broader, well-designed heat stress management program. The program should include:

- Training for the worker and supervision so they understand what the technology is telling them.
- Clear and effective policies/procedures which detail what actions to take when alerted to issues.
- Access to resources to assist with interpretation of results.

The appropriate resources, systems and culture must be in place. Too often the presence of production and/or peer pressure can result in alarms and indicators being ignored resulting in potential harm to the individual. These additional resources are important to the success of such a program. Purchase of these instruments alone does not ensure that the individual is protected. If used correctly these can be very helpful tools. They can be utilised to identify when and where a control is needed or whether those controls are having any impact. In some situations, they can reflect the impacts on the worker resulting from other influences such as medications or illnesses.

Before purchasing or deploying such equipment, it is strongly recommended that advice be sought from a health and safety professional with demonstrated expertise in heat stress management.

4.5.3.2 Hydration Assessment

Dehydration is one of several factors that can contribute to serious heat-related illness, so assessing hydration status can be a useful risk management tool. A range of dehydration testing methods are available; however, these include:

- Urine specific gravity
- Urine Colour
- Saliva Osmolality
- Body mass loss

However, none can be considered a true gold standard for use in field conditions. Each method has its own strengths and limitations. Pre-shift testing can provide helpful information about a worker's starting hydration status and whether pre-hydration may be needed. Mid-shift and post-shift testing can then be used to understand the effects of the work and environmental conditions experienced during the shift.

Urine specific gravity

Hydration status can be assessed by measuring urine specific gravity (USG), which

is “the mass of a urine sample compared with the mass of an equal volume of water” (Armstrong, 2003, p. 224). The US National Athletic Trainers’ Association (NATA) recommended that: “Fluid replacement should approximate sweat and urine losses, and at least maintain hydration at less than 2% body weight reduction” (Casa et al., 2000). Also, NATA stated that a USG of greater than 1.020 would reflect dehydration as indicated in Table 1.

Table 3 National Athletic Trainers Association index of hydration status (adapted from Casa et al., 2000)

	Body Weight Loss (%)	Urine Specific Gravity
Well hydrated	<1	<1.010
Minimal dehydration	1 - 3	1.010 – 1.020
Significant dehydration	3 - 5	1.021 – 1.030
Severe dehydration	> 5	> 1.030

Early research indicated that a USG of 1.020 was the most appropriate limit value indicating dehydration (Sawka et al., 2007; Chevront & Sawka, 2005). At this value, a body weight loss of 3% fluid or more would be expected. Generally, a loss of 2–3% body fluid is regarded as the level at which there is an increased perceived effort, increased risk of heat illness, and reduced physical and cognitive performance (Hunt, Stewart & Parker, 2009).

There is a lot of information available in the literature relating to the criteria to be used in the assessment and management of the results obtained. Its main limitation is in relation to “lag” issues, so is best suited to pre-shift sampling. It is important to note that spot samples can result in false negatives and positives (Chevront et al 2015). Particularly if taken when there have been acute changes in water within the body, i.e., high sweating or large intake of water and can be quite inaccurate. The more accurate and widespread testing method involves use of a refractometer, either electronic or optical hand-held. After some preliminary training test strips can be utilised by workers to self-test at camps or in the field. Training is important as reagent strips can be easily misused due to the wide variety of manufacturers, each containing a specific set of instructions for use and result reading (Trabelsi et al. 2018).

Urine production and colour

Urine colour has been examined in several studies as an indicator of hydration status (Armstrong et al., 1998; Shirreffs, 2000) and has been shown to be a simple and practical way to monitor hydration. As dehydration increases, urine output generally decreases. Urine colour also becomes darker as it becomes more concentrated, ranging from dark yellow in cases of significant dehydration to a pale straw colour when adequately hydrated. It should be recognised that urine colour can be influenced by factors such as illness, medications (see [Appendix 2](#)), vitamin supplements and food colouring (i.e., red dragon fruit, beetroot). Despite these limitations, urine colour still remains a popular

and useful screening tool. It requires minimal equipment and training, and its simplicity makes it well suited for use in field settings.

Saliva testing

A more recent introduction into this area is the determination of hydration via saliva testing. Whilst the methodology is not new, the ability to use it in the field due to the development of more portable instrumentation has only come about in recent times. This method measures hydration status based on saliva osmolality (i.e. the number of soluble particles per kg of saliva). It is measured in milliosmoles (mOsm).

It has been used more often in recent years because it is quick and non-invasive. Whilst effective, the results can be affected by factors such as recent food or water intake and normal differences between individuals. Another limitation is the need for access to a dedicated testing device; Due to the relative newness of this approach there is currently limited peer-reviewed evidence supporting its routine use in field settings although it may still be considered useful as part of a broader approach.

Body mass change

Monitoring body mass change is a simple and practical method that requires minimal equipment, typically a set of scales. It is relatively accurate and has been widely used to rapidly assess short-term hydration status. For best accuracy, individuals need to know their normal body weight, and tracking food and fluid intake can be helpful. Despite this, the method is often viewed as inconvenient and has not been widely adopted in field conditions.

Where a shift is expected to involve a high risk of heat exposure, a practical approach is to conduct hydration checks before the shift begins. This may involve urine specific gravity or body weight measurements, followed by worker self-checks using urine colour or saliva testing, supported by appropriate training.

Regardless of the method used, hydration assessments should be recognised as lagging indicators. They must always be used alongside engineering controls or higher-level administrative controls and should never be relied upon as the sole measure of risk. Even the most accurate testing has limited value if the results are not acted on through appropriate control measures. If there is any uncertainty or concern about an individual's hydration status, a further assessment should be carried out by a suitably trained person at the site first-aid or medical facility.

4.6 Legislation and standards

Historically in Australia, the various legislative frameworks, federal and state, have not specifically regulated exposure levels for heat stress. For example, The national model *Work Health and Safety Regulations* (WHSR) (SWA, 2019) require that “a person conducting a business or undertaking (PCBU) must, so far as is reasonably practicable, ensure that:

...workers exposed to extremes of heat or cold at the workplace are able to carry out work without risk to health and safety” [WHSR s 40 (f)].

Jurisdictions such as NSW, Queensland, Western Australia and South Australia publish information bulletins, guidance publications and newsletters on working in heat and managing heat risk under their WHS obligations (e.g., Risk management, heat illness prevention).

In New South Wales, the Occupational Health and Safety Regulation 2011 (Government of NSW, 2017) require the general duty that “workers carrying out work in extremes of heat or cold are able to carry out work without risk to health and safety”.

The Australian Capital Territories (ACT) in November 2025 introduced the Work Health and Safety (Managing the Risks Associated with Extreme Temperatures Code of Practice). This code applies to all workplaces in ACT.

It explains health effects of both heat (e.g., heat stress, heat-related illness) and cold (e.g., hypothermia, frostbite), including symptoms and workplace impacts. It also provides some information relating to the general risk management process as it applies to exposure of workers in hot and cold environments and some practical tools.

There is no nationally mandated “stop work” temperature in the WHS laws or regulations in Australia. Setting a single temperature limit for safe work is not realistic because thermal stress is influenced by several factors working together. Heat risk cannot be judged by air temperature alone. Instead, it depends on the interaction between:

1. The environment,
2. the task being performed, and
3. the individual worker.

Environmental conditions play a major role. Factors such as air temperature, humidity, air movement, and radiant heat from the sun or hot surfaces all affect how the body gains and loses heat. Clothing and the level of personal protective equipment (PPE) worn can further increase heat strain by trapping heat and limiting sweat evaporation.

The nature of the task is equally important. Different jobs place different physical demands on the body. Light tasks, such as writing or monitoring work, generate little internal heat. In contrast, heavy tasks such as digging, lifting, or using a jackhammer produce much higher levels of metabolic heat, increasing the risk of heat stress even in the same environment.

Individual characteristics must also be considered. Workers who are well acclimatised to hot conditions generally tolerate heat better than those who are not. Health and fitness, hydration status, age, and the use of medications or drugs can all affect how the body responds to heat.

Because these factors vary widely, a flexible, risk-based approach is needed rather than a single temperature limit. Queensland is unique in Australia in legislating numeric heat-stress exposure thresholds for mining workers.

In Queensland the *Mining and Quarrying Safety and Health Regulation 2017 s 143* (Queensland Government, 2017a) refers to specific values:

- 1) The site senior executive must ensure the mine has a system for managing the risk to persons from heat in places at the mine where the wet bulb temperature exceeds 27°C.
- 2) The system must provide for setting maximum wet and dry bulb temperature limits for the persons' exposure having regard to subsection (3) and any criteria stated in a guideline for managing heat.

- 3) The site senior executive must ensure a person is not exposed to a wet bulb temperature exceeding 34°C at the mine unless the person is
 - a) engaged in work to reduce the temperature... or
 - b) a mines rescue member carrying out training or emergency response under procedures documented in the system; or
 - c) being evacuated in an emergency.

Furthermore, under the equivalent Queensland coal mining regulation (Queensland Government, 2017b, regs 369-370), Division 2: Heat Stress Management, (Clause 369) also stipulates

- 1) "...must provide for ensuring the health of persons in places at the mine in which-
 - a) The wet bulb temperature exceeds 27°C

Furthermore, in Part 3) it goes on to say:

- 3) A person must not work in a place at the mine where the effective temperature exceeds 29.4°C.....

While Western Australia includes a limited numeric wet-bulb value tied to ventilation requirements, no other state or territory prescribes temperature-based exposure limits in mining regulation. The Australian Institute of Occupational Hygienists' guide to managing heat stress (Di Corleto, Firth & Gopaldasani, 2025) does not refer to specific environmental exposure temperature limits. And in fact, cautions the use of such an approach. *"Managing heat stress effectively requires recognising that no single "silver bullet" or universal stop-work temperature can protect all workers under all conditions."* (Di Corleto, Firth & Gopaldasani. 2025. Page 22)

4.7 Controls

Various factors must be addressed in managing and minimising the risk associated with working in hot environments; no one control will be effective. A range of controls is given below.

Elimination/substitution

Work should be scheduled to avoid the hottest part of the day. Where possible, consideration should be given in long term planning of scheduled maintenances during the cooler months. With advances in modern technology the use of remotely operated equipment may be an option.

Engineering

- **Air circulation** should be sufficient to allow evaporation of sweat (the body's principal cooling mechanism). In high humidity more air needs to be moved, hence higher air velocity is required. This can be facilitated by fans. Caution should be exercised when increasing air movement in temperatures above approximately 40 - 45°C as at these temperatures the increased heat load may exceed the benefit obtained from sweat evaporation. In such cases, cooled air from 'chiller' units should be utilised where possible.
- There are a number of other practical approaches for controlling heat in buildings and work environments by utilizing different modes of ventilation. Three main design approaches are described: passive ventilation, mechanical ventilation, and air-conditioning. The choice of approach

depends on the size, layout, and location of the structure.

- **Passive or natural ventilation** relies on building design to allow hot air to escape and cooler air to enter thus dissipating heat from the structure. Techniques such as cross-flow ventilation use wind and pressure differences created by high- and low-level openings, roof vents, and turbine ventilators. These features promote air movement through a chimney effect, reducing heat build-up without mechanical assistance. An example is provided in figure 1.

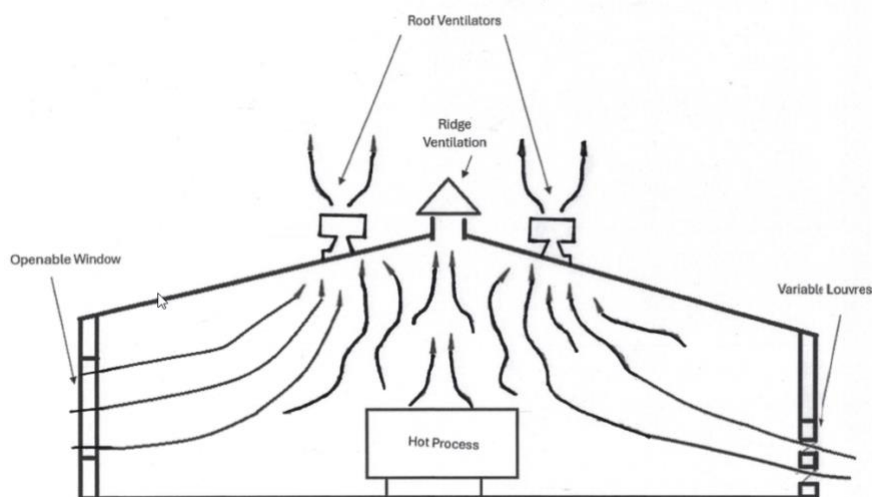


Figure 1 Example of building ventilation to remove process heat (source: Di Corleto, Firth & Gopaldasani 2025)

- **Mechanical ventilation** is commonly used where natural airflow is insufficient. Fans and ducted systems can remove heat and humidity and increase air movement around workers. Thermal de-stratification fans may also be used to mix warm and cool air layers, creating a more even temperature throughout large spaces.
- **Evaporative cooling systems** can be effective in dry environments but are less suitable in humid or tropical conditions. Their use also requires regular maintenance to control microbial growth.
- **Air-conditioning** is effective for enclosed or localised spaces but is often impractical for large industrial areas or remote outdoor work. Local cooling, such as air-conditioned vehicles or temporary enclosures, can provide effective recovery areas and help reduce core body temperature.
- There are some situations where process equipment is the key source of the heat such as pipes and metal encased vessels. In these cases, foil-faced insulation blankets can be used. These are flexible, non-bio-persistent materials, such as rockwool mats, with an aluminium foil layer on one side. The foil surface reflects radiant heat, which improves the overall insulation performance of the system. The foil layer can also act as a vapour barrier, helping to limit moisture build-up within the insulation. This reduces the risk of corrosion under insulation. Foil-faced blankets can

also be used to create temporary reflective shields in work areas located near radiant heat sources.

- Fixing steam leaks and keeping things well-maintained can make buildings cooler and reduce humidity. Reflective or light-coloured external cladding and roofing can reduce internal temperatures
- Where solar radiation is the key source then the use of simple shade structures can be used to reduce the temperature. They are often a simple and cost-effective approach. These structures may be solid roof structures or include the use of different grades of shade cloth. The latter can be useful where the impact on air flow may be a concern. Portable shade structures which are easy to transport and erect can be obtained from camping supply shops. Retractable shade structures can also be incorporated into mobile equipment to provide protection from the sun.

Administrative controls

- Ready access to cool palatable drinking water is a basic necessity.
- A clean cool area for employees to rest and recuperate may be important. Whilst resting in the work environment can provide some relief for the worker, the level of recovery is much quicker and more efficient in an air-conditioned environment. These need not be elaborate structures; basic inexpensive portable enclosed structures with an air conditioner, water supply and seating have been found to be successful in a variety of environments. For field teams with high mobility, even a simple shade structure readily available from hardware stores or large umbrellas can provide relief from solar radiation.
- Work-rest regimes are sometimes necessary where engineering controls are insufficient to protect the individual. Heat stress indices, such as WBGT, PHS or TWL (section 4.5), assist in determining duration of work and rest periods.
- Mechanising tasks to reduce the metabolic workload.
- Allow unacclimatised personnel time to acclimatise with light tasks allocated for the first few days in a job
- Training workers to identify symptoms and the potential onset of heat-related illness as part of the 'buddy system.' Training content should include:
 - Mechanisms of heat exposure.
 - Potential heat exposure situations.
 - Identifying causal factors.
 - Importance of correct hydration.
 - Effects of using alcohol and drugs in hot environments.
 - Early identifying of symptoms of heat illness.
 - Controls and the prevention of heat illness.
 - First aid treatment of heat related illnesses.

- Self-determination of work pace and management policy .

Personal protective equipment

- Ice cooling garments remove body heat by placing frozen packs close to the skin, which cools the blood near the surface and helps reduce core temperature. These systems are low cost and allow good mobility, but users often report discomfort from cold contact. There is also concern that the coldness of these packs may cause blood vessels to contract thus reducing blood flow and limit cooling effectiveness. Newer garments use organic phase-change liquids that freeze at higher temperatures, improving comfort and ease of preparation. These garments can provide short-term relief in hot environments but are less effective than liquid-circulating systems. It should be noted that these vests have variable acceptance by workers as some find them cumbersome and uncomfortable.
- Vortex tube air cooling may be used in some situations, particularly when a cooling source is required when supplied air respirators are used. Cooled air can be supplied through breathing helmets, such as those used by abrasive blasters or spray painters, or through personal cooling equipment such as vests, chaps, or gloves. Air supplied to these systems must meet breathing-air quality requirements. A key limitation is the need for a continuous airline connection. Care is also required to prevent hoses contacting hot surfaces, which can damage the hose and heat the air. Some sites lack suitable breathable air supplies, requiring oil-free compressors. Despite these limits, circulating air systems are effective and less costly than water-based systems.
- Clothing appropriate for the environment and task. For example, light and vented to allow air flow or in cases where radiant heat is an issue, with the use of a slightly heavier and/or reflective material to provide some insulation. The type of reflective clothing should match the task and the direction of radiant heat. For example, an apron may be adequate when heat exposure is mainly from the front, while a full suit may be needed when heat surrounds the worker. Full suits can reduce sweat evaporation, so the reduction in radiant heat must outweigh the loss of cooling. Reflective clothing should be worn loose, with minimal underlayers, to allow airflow. Cooling vests may extend work time, but combined PPE can restrict movement and should be trialed before purchase.

5 Understanding the impact of cold environments

While not as common as exposure to high temperatures in industrial situations in Australia, exposure to low temperatures does occur and can result in significant injury and illness if not properly addressed. Cold exposure can occur in cold-storage areas associated with the freezing of food products, in meat-processing plants, in low-temperature exterior climates (particularly in the elevated mountain regions in winter) and in extreme scenarios in other countries and Polar regions. For example, the coldest wind chill recorded in Canada was on January 13 1975 at Kugaaruk, Nunavut, where the air temperature was -51°C with 56 km/hr winds, producing a wind chill of -78 (Environment Canada, 2019). Cold stress refers to endurance of low-temperature conditions sufficient in duration and intensity to result in an alteration or adaptation of internal systems (Reed et al., 2013). The exposure may be general, affecting the whole body, or localised involving only extremities or the face.

It is important to ensure that the core body temperature does not drop below 36°C at which point shivering becomes uncontrollable, vasoconstriction occurs and the heart rate can decrease. In severe cases, prolonged low body temperatures can result in death. Three key components play major roles in the impact of cold environments on the individual:

- Low temperature
- Wind speed
- Wetness.

The varying combination of these factors can determine the severity of cold stress for the work environment (Figure 2).

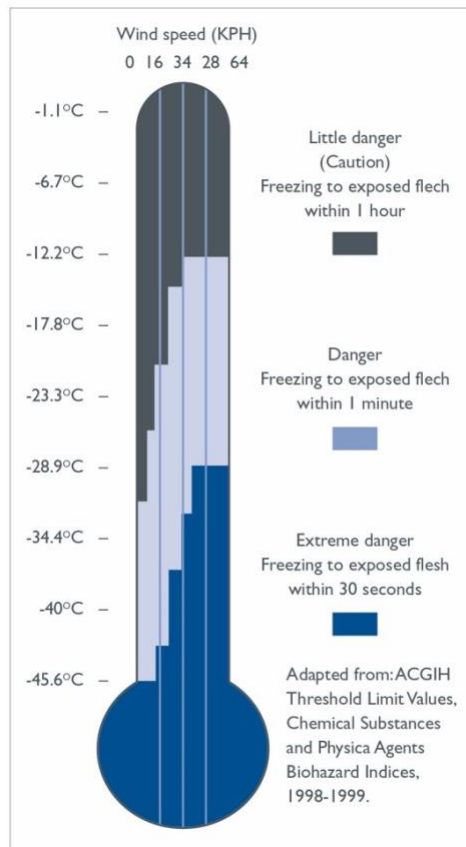


Figure 2. Combined effect of temperature and wind speed on cold stress
(adapted from OSHA, 1998)

5.1 Health effects

The impact of exposure to cold environment can range from local damage to body parts (e.g. hands, face or feet) to general hypothermia from exposure to cold air and/or immersion risks in cold water.

Cold-Related Illnesses

Cold-related illnesses occur when the body is exposed to cold, wet, or freezing conditions for long periods. These injuries range from mild skin irritation to severe tissue damage and can affect the hands, feet, face, and other exposed areas.

Chilblains

Chilblains are a mild cold injury caused by repeated exposure to cold and damp conditions, usually at temperatures between 0°C and 16°C. They mainly affect the fingers, toes, ears, and nose. Symptoms include redness, swelling, itching, tingling, and pain, which may appear hours after exposure and last for several days. In severe cases, skin ulcers can form. Chilblains can often recur in people who are susceptible. Keeping the affected areas warm and dry helps prevent them, while treatment includes gentle re-warming, elevation to reduce swelling, and pain relief if

needed. (Work Safe Alberta, 2012)

Immersion Foot and Trench Foot

Immersion foot occurs when feet are exposed to wet, cold conditions above freezing for days or weeks, sometimes at temperatures up to 10°C. It is usually classified into one of three forms, mild, medium and severe (Burton & Edholm 1955; Kravets et al 2022). The main damage is to nerves and muscles. Symptoms include numbness, tingling, pain, swelling, skin colour changes from red to blue or purple, and blistering. In severe cases, tissue death and gangrene may occur.

Trench foot is a type of immersion foot caused by prolonged exposure to cold, damp environments without freezing. It commonly develops when wet socks or footwear are worn for long periods. Symptoms include inflammation, redness, itching, severe pain, numbness, blistering, and eventual tissue breakdown. Prevention includes well-fitting, water-resistant footwear and keeping feet dry. Early treatment involves elevation and keeping the feet warm and dry. (Work Safe Alberta, 2012; Ipieca & IOGP, 2025)

Fingertip Fissures

Prolonged or repeated exposure to cold, especially in dry conditions, can cause deep and painful cracks in the skin of the fingertips. These fissures can limit hand use. Prevention includes keeping hands warm and using moisturising creams. Treatment may involve medical skin adhesives to seal the cracks. (Ipieca & IOGP, 2025)

Frostnip

Frostnip is the mildest form of freezing injury. It affects exposed areas such as the ears, nose, cheeks, fingers, and toes. The outer layers of skin freeze, causing stinging or prickling pain, numbness, and whitening of the skin, while deeper tissue remains unaffected. Frostnip can recur in vulnerable individuals. Prevention includes protective clothing and monitoring for early signs. First aid involves rapid re-warming in shelter and protection from further cold exposure.

Frostbite

Frostbite is a serious injury caused by freezing of both superficial and deeper tissues. It occurs when tissue temperature falls below 0°C or when blood flow is reduced in cold conditions. Commonly affected areas include fingers, toes, ears, nose, and cheeks. Mild cases may involve redness, swelling, and pain, while severe cases can cause blistering, loss of sensation, tissue death, and gangrene. Frostbitten tissue is highly prone to infection and may suffer permanent damage.

Table 4 Wind Chill Calculation Chart (Source: Ipieca & IOGP, 2025, p. 20)

(T air = air temperature in °C, V_{10} = observed wind speed at 10 m elevation, in km/h)

T Air V_{10}	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	-58
10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63
15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66
20	1	-5	-12	-18	-24	-30	-37	-43	-49	-56	-62	-68
25	1	-6	-12	-19	-25	-32	-38	-44	-51	-57	-64	-70
30	0	-6	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72
35	0	-7	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73
40	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74
45	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75
50	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63	-69	-76
55	-2	-8	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77
60	-2	-9	-16	-23	-30	-36	-43	-50	-57	-64	-71	-78
65	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
70	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-80
75	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
80	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

Frostbite guide:
Low risk of frostbite for most people
Increasing risk of frostbite for most people in 10-30 minutes of exposure
High risk for most people in 5-10 minutes of exposure
High risk for most people in 2-5 minutes of exposure
High risk for most people in 2 minutes or less

Hypothermia is a condition that results when the body's core temperature falls below 35°C. Warning signs can include nausea, fatigue, irritability or euphoria. An affected person may not fully realise the danger of the situation because the progressive cooling of the body can cause mental confusion and impaired judgement. If untreated, hypothermia may result in death (Weinberg, 1993).

Alcohol should be avoided as it can give a false feeling of warmth and increase drowsiness. It reduces a person's ability to cope with extreme climates by disrupting the hormones that control body fluids and by directly affecting blood vessels (IOGP & Ipieca, 2025). It can lower blood sugar levels, which may lead to rapid body cooling, especially in a person who is tired or exhausted (BOHS, 1996).

Table 5 Progression of the body's response to hypothermia. (Adapted from: Lott et al 2021; Ipieca & IOGP, 2025)

Stage of Hypothermia	Body Temperature (Core)	Impact on the Body
Normal	37°C	Normal body temperature
Initial stage	36°C	Judgement may be affected
1 (mild)	35°C	May cause uncontrollable shivering and chattering teeth. A person may feel very tired or sleepy and have a fast but weak pulse. Blood pressure may be high, the skin may look pale, and reactions can become slow. People may also appear withdrawn or apathetic and feel an increased need to urinate.
2 (moderate)	32°C	Marked by reduced or stopped shivering, confusion, and slurred speech. The skin may appear bluish, blood pressure may drop, and reflexes can be lost. Memory problems may occur, and the heart rhythm can become abnormal.
3 (severe)	28°C	Occurs when shivering stops and the heart rate, breathing rate, and blood pressure fall. A person may experience hallucinations and have no reflexes. Urine output becomes very low, fluid can build up in the lungs, and the pupils may appear large. Loss of consciousness may occur, with a risk of coma or death.
4 (very severe)	<24°C	There are no detectable vital signs, including breathing or a heartbeat.

Acclimatisation

Cold acclimatisation is not as well understood and appears to be less important than heat acclimatisation. Unlike heat acclimatisation, cold acclimatisation is limited, inconsistent, and cannot be relied upon to protect workers from cold stress or cold injury. Only a small number of studies have measured its effects (Blondin et al., 2017; Davis, 1961). People mainly cope with cold through learned behaviours, such as using clothing and shelter to stay warm. Clear evidence of whole-body physiological acclimatisation to cold is limited and remains uncertain. However, research has shown that repeated cold water immersion over several days can reduce shivering intensity, suggesting some level of acclimatisation may occur (Blondin et al., 2019).

There is also evidence of local acclimatisation in the hands and fingers. People who regularly expose their hands to cold, such as fishermen and Inuit populations, often maintain higher hand temperatures. This may be due to reduced blood vessel constriction and increased cold-induced blood flow to the skin. It is important to note that This is **local**, not whole-body, and does **not protect against hypothermia**.

Similar cold-adaptive traits have been observed in Korean female breath-hold divers, known as *haenyeo*, who historically tolerated cold water while wearing thin cotton suits. Their tolerance to cold has decreased since the introduction of wetsuits, suggesting reduced ongoing cold adaptation (Lee et al., 2017).

5.2 Legislation and standards

As with hot environments, the national model regulations (WHSR) (SWA, 2019) (s 40 (f)) require that “a person conducting a business or undertaking (PCBU) must, so far as is reasonably practicable, ensure that: ...workers exposed to extremes of heat or cold at the workplace are able to carry out work without risk to health and safety”.

Apart from that there is limited reference to work in cold environments in the regulatory space. Safe Work Australia provide a short piece in their Model Code of Practice *Managing the work environment and facilities* (SWA, 2024) which is also replicated by the NSW Government Code of Practice (WorkCover NSW, 2019) of the same name.

The different state OHS regulators provide relevant codes and guidelines; for example, WorkSafe Victoria (2017b) produced a handbook targeting cold storage facilities and a number of industry-specific guides and fact sheets provide practical and useful information.

As mentioned earlier, the Australian Capital Territories (ACT) in November 2025 introduced the Work Health and Safety (Managing the Risks Associated with Extreme Temperatures Code of Practice). This code includes a section on cold exposure and applies to all workplaces in ACT.

Occupational Exposure Limits and guidelines are based on an 8-hour work shift followed by 16 hours away from exposure. These limits may not apply to longer workdays, so care is needed when assessing extended shifts. More detailed guidance is available in publications from the American Conference of Governmental Industrial Hygienists (ACGIH) 2025 TLVs and BEIs.

5.3 Assessment of the Cold Environment

A similar stepped approach to that used for heat stress can be applied when assessing cold environments. However, cold exposure must be considered in terms of its different effects on the body. This includes local effects, such as injury to the hands, feet, and face, as well as whole-body effects, including the risk of hypothermia.

The strategy of a three-stage protocol is readily applied as follows (Di Corleto & Britton, 2024, p. 454):

- **Observation:** basic thermal risk assessment or checklist as per annex A in International ISO 15743:2008. ISO Geneva. Organization for Standardization 2008, *Ergonomics of the Thermal Environment—cold workplaces—risk assessment and management*
- **Analysis:** determination of wind cooling effects or incorporating a cold-stress index such as IREQ (ISO 11079:2007, ISO, Geneva).

- **Expertise:** utilisation of individuals with specific competencies such as occupational health-care professionals and occupational hygienists and specialised monitoring equipment (ISO 15743:2008).

When assessing the impact from a localised consequence, key factors to consider include:

- convective cooling such as wind chill. (wind blows away insulating layers of air near the body),
- conductive cooling (contact with cold objects),
- extremity cooling, and
- airway cooling.

The wind chill index is a key component when assessing exposure to the cold. International limits such as the American conference of Government Industrial Hygienists (ACGIH) threshold limit values (TLV) are often utilised. The US army have developed a risk flow chart for the cold and is illustrated in figure 3.

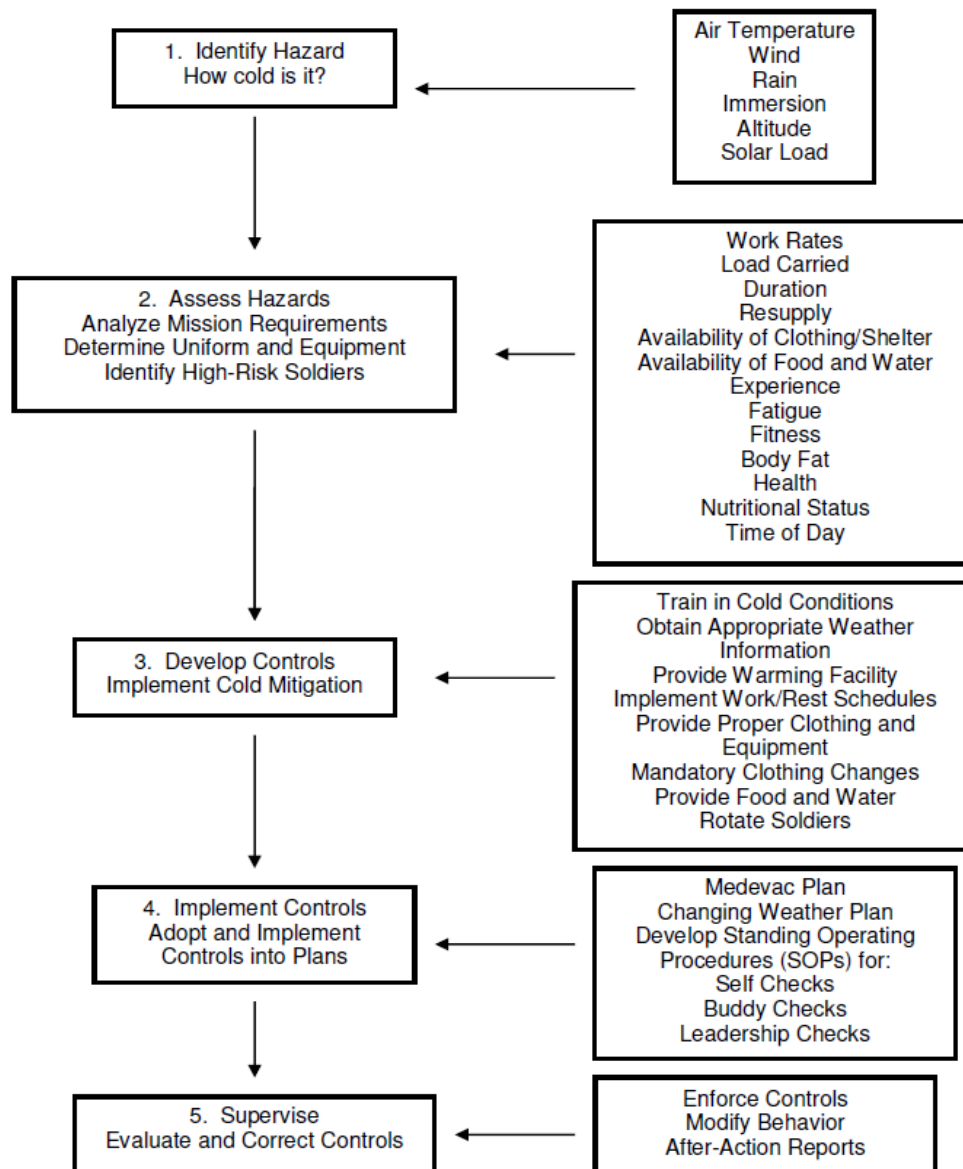


Figure 3 Cold Strain Risk Management Process. (US Department of the Army, 2005)

Additional considerations when assessing for risk to hypothermia include:

- humidity,
- improper clothing,
- nutrition, (extras calories are required while working in extreme cold)
- general state of health.

When assessing the risk of hypothermia from work in the cold environment an approach can be used which uses a thermal index based on heat balance equations. One such index is the Required Clothing Index (IREQ). The method for calculating IREQ is defined using the heat balance equation described in ISO 11079 (2007). IREQ is a way of working out how much clothing insulation a person needs to stay warm in cold conditions. It looks at the balance between the heat your body produces, and the heat lost to the environment through air temperature, wind, moisture, and how hard you are working. In simple terms, IREQ helps answer the question: “Am I wearing enough clothing for this job and these conditions?”

If the clothing worn provides less insulation than the IREQ value, the body will lose heat and the risk of cold stress or hypothermia increases. If the clothing meets or exceeds the IREQ value, body heat can be maintained, and the work can be done more safely. IREQ helps to identify that the clothing is fit for the conditions, not just comfortable at the start of the job.

5.4 Controls

Controls for working in cold climates tend to focus on administrative controls and PPE. Some examples of controls are listed below.

Elimination/substitution

- Warm air jets, radiant heaters and contact warm plates have been used in some situations.
- Where possible tasks should be undertaken in the warmest part of the day.

Engineering

- Tools with metal handles should be covered by thermal insulating material when used in sub-zero climates.
- Where bare hands are required for more than 15 minutes sources of heating should be considered such as:
 - warm air jets
 - contact warm plates, and
 - radiant heaters.
- Where possible the use of metal chairs should be avoided or covered if used.
- Reduce manual handling to minimise sweating

Administrative controls

- Appropriate training of employees in relation to cold exposure.
- Utilise a warm-up schedule. A useful guide is provided by Worksafe Saskatchewan at: [Working-in-Cold-Conditions-Fact-Sheet.pdf](#)
- For work locations such as cold stores or where the temperature is below -12°C constant supervision such as the use of a 'buddy system' should be utilised.
- Work output should be controlled to minimise heavy sweating; where this cannot be avoided, individuals should be encouraged to take rest breaks to allow them to change into dry clothes.

Personal protective equipment and increasing resistance

- Selection of suitable clothing that can be layered to adjust the changing environmental conditions, protection of extremities with windproof hats and gloves.
- Choose clothing that has worked well in the past. If the clothing is new, make sure it has been properly tested. Set the insulation level to suit the weather conditions and the work being done (more information at ISO 11079:2007, Annex B).
- Use layered clothing so it can be adjusted as needed and works more effectively. Make sure zippers and other fasteners still work in snow and strong wind, and can be used easily with cold, stiff fingers.
- Boots should provide good thermal insulation, especially in the soles, and have slip-resistant soles. They should have enough room for toes and thick socks. Socks must be kept dry and changed when needed.
- Face protection should be considered in windy cold conditions.
- Drink warm, sweet beverages preferably caffeine free and avoid alcohol.
- Consume warm, high-calorie foods (e.g. pasta).

6 Contact injuries

Within the occupational environment there are numerous thermal sources (both hot and cold) that can result in discomfort or burns to the skin. For example, the national model regulations (SWA, 2019) specifically refer to:

Guarding and insulation from heat and cold

The person with management or control of plant at a workplace must ensure, so far as is reasonably practicable, that any pipe or other part of the plant associated with heat or cold is guarded or insulated so that the plant is without risks to the health and safety of any person. (WHSR s 209)

Thermal contact injuries may range from superficial burns that do not penetrate the outer layer of skin or epidermis, through partial-thickness burns that penetrate the outer layer but not the inner layer of skin or dermis to full-thickness burns that penetrate the skin and damage the underlying tissue below (Parsons, 2003) (see, for example, Figure 4).

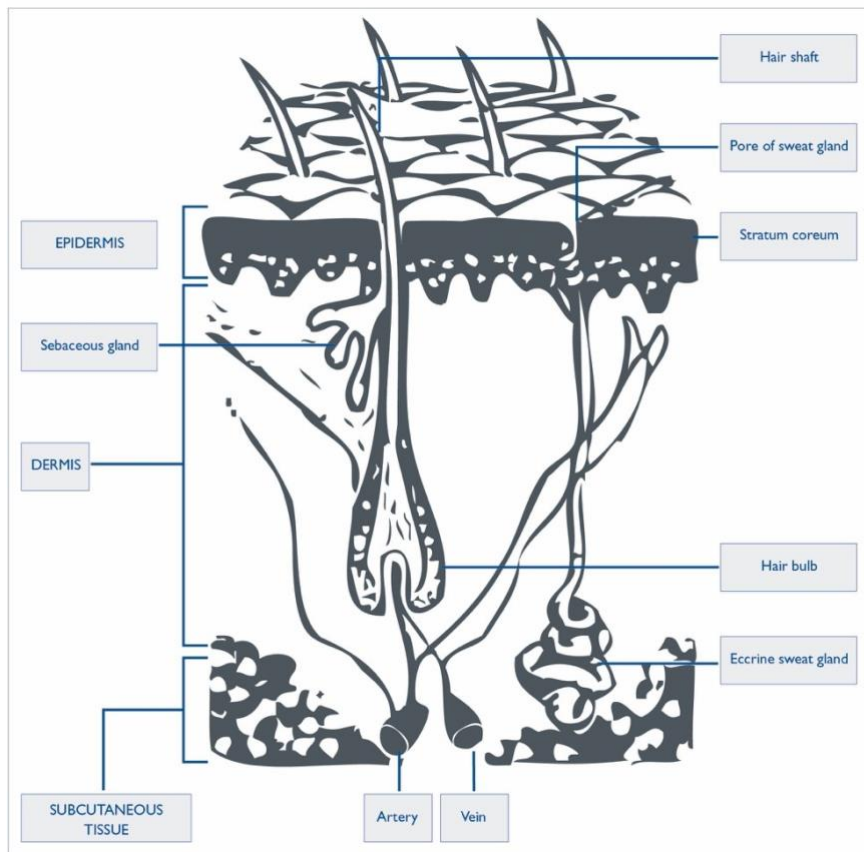


Figure 4. The structure of human skin

While the international standard *ISO 13732-1:2006 Ergonomics of the Thermal Environment – Methods for the Assessment of Human Responses to Contact with Surfaces – Part 1: Hot Surfaces* (ISO, 2006) provides a comprehensive risk-assessment process, a simplified version for contact burns when working with hot machinery is provided below.

1. Through consultation with the operator/s, identify contact points, touchable surfaces and length of contact periods.
2. Use task analysis and observation to determine worker behaviour under normal and extreme use of the machine.
3. Establish conditions that would produce maximum temperatures of touchable parts of the equipment (not normally heated as an integral part of the functioning of the machine).
4. Undertake surface temperature measurements while the machine is operating.
5. Determine the burn threshold value (i.e. the temperature which is the boundary between no burn and a superficial burn). Multiple thresholds may need to be utilised where different materials are involved.
6. Compare the measured results with the burn thresholds.

Also, there is potential for injury resulting from short or prolonged contact with cold surfaces. Curves of surface temperature and exposure time are provided for touching and gripping of cold surfaces for a variety of materials including aluminium, stone,

nylon and steel in Youle and Parsons (2009) and in *ISO 13732-1:2005 Ergonomics of the Thermal Environment – Methods for the Assessment of Human Responses to Contact with Surfaces – Part 3: Cold Surfaces* (ISO, 2005).

7 Implications for OHS practice

In general, much of the assessment and determination of controls in relation to the thermal environment can be undertaken by the generalist OHS professional. Many of these controls are not complicated and are relatively easily implemented, in fact the simpler the better. In some cases there may be required a combination of controls from the different levels of the hierarchy of controls, i.e. engineering and administrative. It is also important to note that one of the key factors associated with the management of the thermal environment is a good understanding of the hazards, the controls available and the symptoms as they present early in the exposure. It is thus imperative that individuals potentially exposed be provided with the appropriate training.

There are some instances where the exposure may not have been adequately characterised, hence making the selection of controls more difficult or the exposures are so extreme that they are not easy to determine. In such situations the utilisation of professionals with experience in the monitoring and assessment of thermal environments such as occupational hygienists or others knowledgeable in the application of physiological monitoring and assessment such as occupational physicians or thermal physiologists should be approached to assist.

8 Summary

After brief consideration of the historical context and the extent of the problems associated with occupational exposure to extreme hot and cold environments, this chapter focused on provision of information about the thermal environment that is likely to be relevant to the generalist OHS professional role. It elucidated the health effects of hot and cold environments, addressed risk assessment and presented control options. Given the relevance of heat exposure to Australian working conditions, this information was supplemented with a three-tiered approach to the assessment of heat exposure. Finally, the implications for OHS practice were considered.

Key thinkers

Australian

Professor Ollie Jay: Director of the Heat and Health Research Centre and Thermal Ergonomics Laboratory in the Faculty of Medicine and Health at The University of Sydney.

Dr Matt Brearley: Thermal physiologist at Thermal Hyperformance.

International

Dr Andreas Flouris: Professor of Physiology at the University of Thessaly Department of Exercise Science, Greece.

Dr Ken Parsons: Emeritus professor of Environmental Ergonomics at Loughborough University. UK

Professor George Havenith: Environmental Ergonomics and Physiology, Loughborough University. UK

Professor Douglas Casa: Department of Kinesiology, University of Connecticut. USA

Professor Thomas Bernard: College of Public Health, University of South Florida. USA

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Appendix 1: Basic Thermal Risk Assessment (informative only)

Reproduced from the Australian Institute of Occupational Hygienists' *A guide to managing heat stress: Developed for use in the Australian environment.* (Di Corleto, Firth & Gopoldasani, 2025)

HAZARD TYPE	Assessment Point Value				
	0	1	2	3	
Sun Exposure	Indoors <input type="checkbox"/>	Full Shade <input type="checkbox"/>	Part Shade <input type="checkbox"/>	No Shade <input type="checkbox"/>	
Hot surfaces	Neutral <input type="checkbox"/>	Warm on Contact <input type="checkbox"/>	Hot on contact <input type="checkbox"/>	Burn on contact <input type="checkbox"/>	
Exposure period	< 30 min <input type="checkbox"/>	30 min – 1hour <input type="checkbox"/>	1 hour - 2 hours <input type="checkbox"/>	> 2 hrs <input type="checkbox"/>	
Confined space	No <input type="checkbox"/>			Yes <input type="checkbox"/>	
Task complexity		Simple <input type="checkbox"/>	Moderate <input type="checkbox"/>	Complex <input type="checkbox"/>	
Climbing, up/down stairs or ladders	None <input type="checkbox"/>	Low <input type="checkbox"/>	Moderate <input type="checkbox"/>	Significant <input type="checkbox"/>	
Distance from cool rest area	<10 Metres <input type="checkbox"/>	10 - 50 Metres <input type="checkbox"/>	50-100 Metres <input type="checkbox"/>	>100 Metres <input type="checkbox"/>	
Distance from drinking water	<10 Metres <input type="checkbox"/>	10 - 30 Metres <input type="checkbox"/>	30-50 Metres <input type="checkbox"/>	>50 Metres <input type="checkbox"/>	
Clothing (permeable)		Single layer (light) <input type="checkbox"/>	Single layer (mod) <input type="checkbox"/>	Multiple layer <input type="checkbox"/>	
Understanding of heat strain risk	Training given <input type="checkbox"/>			No training given <input type="checkbox"/>	
Air movement	Strong Wind <input type="checkbox"/>	Moderate Wind <input type="checkbox"/>	Light Wind <input type="checkbox"/>	No Wind <input type="checkbox"/>	
Resp. protection (-ve pressure)	None <input type="checkbox"/>	Disposable Half Face <input type="checkbox"/>	Rubber Half Face <input type="checkbox"/>	Full Face <input type="checkbox"/>	
Acclimatisation	Acclimatised <input type="checkbox"/>			Unacclimatised <input type="checkbox"/>	
SUB-TOTAL A					
		2	4	6	
Metabolic work rate*		Light <input type="checkbox"/>	Moderate <input type="checkbox"/>	Heavy <input type="checkbox"/>	
SUB-TOTAL B					
		1	2	3	4
Apparent Temperature		< 27°C <input type="checkbox"/>	>27°C :S 33°C <input type="checkbox"/>	>33°C :S 41°C <input type="checkbox"/>	> 41°C <input type="checkbox"/>
SUB-TOTAL C					
TOTAL = A plus B Multiplied by C				=	

*Examples of Work Rate.

Light work: Sitting or standing to control machines; hand and arm work assembly or sorting of light materials.

Moderate work: Sustained hand and arm work such as hammering, handling of moderately heavy materials.

Heavy work: Pick and shovel work, continuous axe work, carrying loads up stairs.

Instructions for use of the Basic Thermal Risk Assessment

- Mark each box according to the appropriate conditions.
- When complete add up using the value at the top of the appropriate column for each mark.
- Add the sub totals of Table A & Table B and multiply with the sub-total of Table C for the final result.
- If the total is **less than 28**, the risk due to thermal conditions is low to moderate.
- If the total is **28 to 60**, there is a potential of heat-induced illnesses occurring if the conditions are not addressed. Further analysis of heat stress risk is required.
- If the total **exceeds 60**, the onset of a heat-induced illness is very likely and action to implement controls should be taken as soon as possible.

It is important to note that that this assessment is to be used as a guide only. A number of factors are not included in this assessment, such as employee health condition and the use of high levels of PPE (particularly impermeable suits). In these circumstances experienced personnel should carry out a more extensive assessment.

Appendix 2: The Impact of Medication

Drug / class	Mechanism affecting heat balance	Practical heat-risk implication (what this means at work)
Phenothiazines (antipsychotics / neuroleptics)	Disrupt hypothalamic temperature regulation; anticholinergic effects may reduce sweating	Body temperature control is impaired; worker may overheat without warning, even at moderate heat loads
Butyrophenones (antipsychotics / neuroleptics)	Central interference with thermoregulation; anticholinergic activity may reduce sweating	Reduced ability to regulate body temperature; higher risk of heat illness during hot work
Thioxanthines (antipsychotics / neuroleptics)	Anticholinergic effects → blocked or reduced sweating	Sweating is limited, so heat cannot be released effectively
Belladonna & synthetic alkaloids	Strong anticholinergic action → blocks sweat gland function	Little or no sweating; rapid heat storage and increased risk of heat exhaustion or heat stroke
Antiparkinsonian agents	Anticholinergic activity → reduced sweat production	Reduced evaporative cooling; higher heat strain in hot environments
Tricyclic antidepressants	Anticholinergic effects → impaired sweating	Heat loss is reduced; workers may overheat more quickly
Antihistamines	Anticholinergic properties → reduced sweating	Reduced cooling capacity; greater susceptibility to heat stress, especially in PPE
Epinephrine (sympathomimetic)	Cutaneous vasoconstriction → reduced blood flow to skin	Heat is trapped in the body; cooling is less effective
Ephedrine (sympathomimetic)	Cutaneous vasoconstriction → reduced skin heat loss	Increased risk of elevated core temperature during physical work
Levarterenol / norepinephrine (sympathomimetic)	Peripheral vasoconstriction → limits heat dissipation	Reduced ability to lose heat; greater heat strain
Amphetamines (recreational)	Increase metabolic heat production; cause vasoconstriction; increase activity and agitation	Marked increase in heat production with reduced heat loss; high risk of heat illness
MDMA (ecstasy)	Raises core temperature; vasoconstriction; increased activity and impaired heat perception	Very high risk of heat stroke, especially during physical work or hot conditions
Cocaine	Vasoconstriction; increased metabolic rate and agitation	Heat builds rapidly; severe heat illness possible, even in short exposures

Notes for frontline heat-stress guidance

- These drugs do not cause heat illness on their own, but they reduce the body's ability to cope with heat.
- Workers taking these substances may need lower heat exposure limits, more frequent breaks, hydration monitoring, and closer supervision.

Risk is amplified when combined with high workload, PPE, dehydration, or hot work environments.

Appendix 3: Heat Stress Case Study Scenarios

Utilising a Level 1 Assessment Process

First stage of assessment is to utilise the Basic Thermal Risk Assessment (BTRA).

This assessment can be carried out using:

1. Hardcopy forms (Appendix 1)
2. Excel Spreadsheets: <https://www.aioh.org.au/resources/tools/>
3. Online calculators: <https://onlineservices.oir.qld.gov.au/etools/views/calc/heatStress.xhtml>, or
4. Phone Applications (<https://play.google.com/store/apps/details?id=com.Gopaldasani.thermalrisk>) or (<https://apps.apple.com/au/app/thermal-risk/id867920824>)

For Scenario 1 consider a worker preparing for a concrete pour on a building site of a two-story industrial building. The conditions are as follows:

- Preparing for a concrete pour on first floor of a construction.
- Simple light metabolic task. Should take around 90 minutes.
- There is no shade available as roof cannot be set up until floor is completed.
- Preparing the formwork involves walking along floor checking/adjusting steel reinforcement and form work.
- Also includes walking up and down from ground floor to job (one flight of steps).
- Individual does not carry a drink container with them.
- Closest drinking water and rest area is 60 metres away in crib room.
- Still day with no air movement
- Standard light cotton hi-vis shirt & trousers
- Worker has been trained in heat stress management
- Worker's first day back from a 2-week skiing holiday in Canada
- Air temp is 31°C and Relative Humidity 70%.

For this example, we will use the hardcopy method.

An apparent temperature is utilised in this approach which can be obtained from calculation websites such as the Bureau of Meteorology (BOM) or phone applications. With the temperature and humidity available a simple apparent temperature can be calculated from a table as per below. It is based on the original work of Steadman. This may not be as accurate as one that includes wind speed, but it is suitable for a first level assessment.

Apparent Temperature: Temperature - Humidity scale.

Align dry bulb temperature with corresponding relative humidity to determine apparent temperature in unshaded section of table. Numbers in () refer to skin humidities above 90% and are only approximate.

Dry Bulb Temperature. (°C)	Relative Humidity (%)											
	0	10	20	30	40	50	60	70	80	90	100	
20	16	17	17	18	19	19	20	20	21	21	21	
21	18	18	19	19	20	20	21	21	22	22	23	
22	19	19	20	20	21	21	22	22	23	23	24	
23	20	20	21	22	22	23	23	24	24	24	25	
24	21	22	22	23	23	24	24	25	25	26	26	
25	22	23	24	24	24	25	25	26	27	27	28	
26	24	24	25	25	26	26	27	27	28	29	30	
27	25	25	26	26	27	27	28	29	30	31	33	
28	26	26	27	27	28	29	29	31	32	34	(36)	
29	26	27	27	28	29	30	30	33	35	37	(40)	
30	27	28	28	29	30	31	33	35	37	(40)	(45)	
31	28	29	29	30	31	33	35	37	40	(45)		
32	29	29	30	31	33	35	37	40	44	(51)		
33	29	30	31	33	34	36	39	43	(49)			
34	30	31	32	34	36	38	42	(47)				
35	31	32	33	35	37	40	(45)	(51)				
36	32	33	35	37	39	43	(49)					
37	32	34	36	38	41	46						
38	33	35	37	40	44	(49)						
39	34	36	38	41	46							
40	35	37	40	43	49							
41	35	38	41	45								
42	36	39	42	47								
43	37	40	44	49								
44	38	41	45	52								
45	38	42	47									
46	39	43	49									
47	40	44	51									
48	41	45	53									
49	42	47										
50	42	48										

(Source: Steadman, 1979)

From here it is simply a case of completing the questions in the form as shown below.

Basic Thermal Risk Assessment – Apparent Temperature (informative only)

HAZARD TYPE	Assessment Point Value				
	0	1	2	3	
Sun Exposure	Indoors <input type="checkbox"/>	Full Shade <input type="checkbox"/>	Part Shade <input type="checkbox"/>	No Shade <input checked="" type="checkbox"/>	
Hot surfaces	Neutral <input checked="" type="checkbox"/>	Warm on Contact <input type="checkbox"/>	Hot on contact <input type="checkbox"/>	Burn on contact <input type="checkbox"/>	
Exposure period	< 30 min <input type="checkbox"/>	30 min – 1hour <input type="checkbox"/>	1 hour - 2 hours <input checked="" type="checkbox"/>	> 2 hours <input type="checkbox"/>	
Confined space	No <input checked="" type="checkbox"/>			Yes <input type="checkbox"/>	
Task complexity		Simple <input checked="" type="checkbox"/>	Moderate <input type="checkbox"/>	Complex <input type="checkbox"/>	
Climbing, up/down stairs or ladders	None <input type="checkbox"/>	One Level <input checked="" type="checkbox"/>	Two Levels <input type="checkbox"/>	>Two Levels <input type="checkbox"/>	
Distance from cool rest area	<10 Metres <input type="checkbox"/>	10 - 50 Metres <input type="checkbox"/>	50-100 Metres <input checked="" type="checkbox"/>	>100 Metres <input type="checkbox"/>	
Distance from drinking water	<10 Metres <input type="checkbox"/>	10 - 30 Metres <input type="checkbox"/>	30-50 Metres <input type="checkbox"/>	>50 Metres <input checked="" type="checkbox"/>	
Clothing (permeable)		Single layer (light) <input checked="" type="checkbox"/>	Single layer (mod) <input type="checkbox"/>	Multiple layer <input type="checkbox"/>	
Understanding of heat strain risk	Training given <input checked="" type="checkbox"/>			No training given <input type="checkbox"/>	
Air movement	Strong Wind <input type="checkbox"/>	Moderate Wind <input type="checkbox"/>	Light Wind <input type="checkbox"/>	No Wind <input checked="" type="checkbox"/>	
Resp. protection (-ve pressure)	None <input checked="" type="checkbox"/>	Disposable Half Face <input type="checkbox"/>	Rubber Half Face <input type="checkbox"/>	Full Face <input type="checkbox"/>	
Acclimatisation	Acclimatised <input type="checkbox"/>			Unacclimatised <input checked="" type="checkbox"/>	
SUB-TOTAL A		3	4	12	
				19	
Metabolic work rate*		2	4	6	
SUB-TOTAL B				2	
				2	
Apparent Temperature		1	2	3	4
SUB-TOTAL C				3	3
TOTAL = A plus B		Multiplied by C		=	
19 + 2		x 3		= 63	

*Examples of Work Rate.

Light work: Sitting or standing to control machines; hand and arm work assembly or sorting of light materials.

Moderate work: Sustained hand and arm work such as hammering, handling of moderately heavy materials.

Heavy work: Pick and shovel work, continuous axe work, carrying loads up stairs.

If the total is **28 to 60** there is a potential of heat-induced illnesses occurring if the conditions are not addressed.

If the total exceeds 60 then the onset of a heat-induced illness is very likely and action should be taken as soon as possible to implement controls.

As can be seen the total of **63** indicates that action should be taken as soon as possible to mitigate the risk. One of the benefits of this method is that it allows the user to check the responses to determine where best to apply controls (i.e., columns 2 and 3). Providing a cool rest area closer and ready access to drinking water will help to reduce the risk. Ideally increasing the air flow would also be helpful but in large industrial scenarios this may not be practical. Sometimes provision of strategic located shade, portable fans, misting fans or chillers can also be utilised.

Also be aware that the worker is unacclimatised and in the first few days back the body's coping mechanisms will not be as effective. They are likely to have a reduced sweat rate, with a higher concentration lost in their sweat and cardiovascular performance will not be as effective as when acclimatised.

Utilising a Level 2 Assessment Process.

In some situations, the risk is not always as clear cut as will be demonstrated in the following scenarios. In these circumstances, a more quantitative approach with additional monitoring such as Predicted Heat Strain (PHS) or Thermal Work Limit (TWL) will be required. In this example PHS will be utilised.

Scenario 2a Fruit Picker.

- A newly arrived British backpacker picking fruit in Northern Australia.
- They work for approx. 90 minutes and then stop for a 15-minute break.
- Heat stress training provided is: “*drink water, wear a hat and use sunscreen*”.
- Picker has drink container with her
- Cooled environment is 200 metres away, so break is taken under closest shady tree (<10m)
- Work involves picking fruit from tree that machinery has missed but all at ground level in part shade.
- Mainly hand arm work, moderate intensity.
- Light breeze blowing
- Wearing light summer clothes, Clothing is a light cotton short-sleeve shirt & light trousers with an insulation factor of 0.5 clo
- 1 1/2 hr shift, Ta = 34C; RH= 20%

Monitoring Data

- Dry Bulb = 34°C
- Globe = 35°C
- Rel Humidity = 20%
- Air Velocity = 0.2 m/s
- Metabolic Load⁶ = 145 W/m²
- Posture = Standing
- Clothing⁷ = 0.5 clo
- Unacclimatised worker

⁶ Metabolic Load value available from ISO 8996:2021 or often built into the apps or website calculators as dropdowns.

⁷ Insulation factor value available from ISO 9920:2009 or often built into the apps or website calculators as dropdowns.

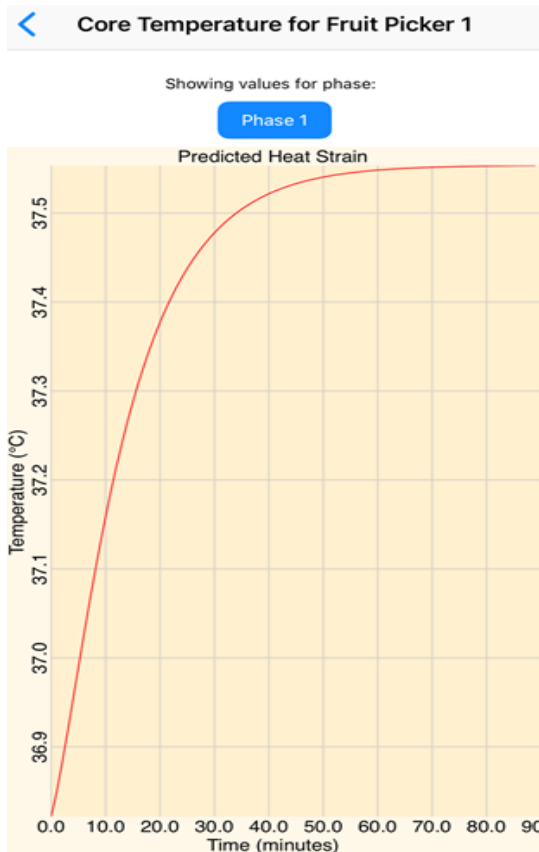


Figure A1 Predicted core temperature of worker picking fruit.

Scenario 2b Fruit Picker.

Based on the data the predicted core temperature does not exceed the World Health Organisation limit of 38°C. So, the conditions are unlikely to cause issues for a fit healthy individual.

While having lunch there is a sudden downpour that lasts for 30 minutes.

- When the pickers return to work the ambient environment has changed.
- Air temperature has dropped to 32°C and relative humidity has increased to 80%

Do we need to do anything?

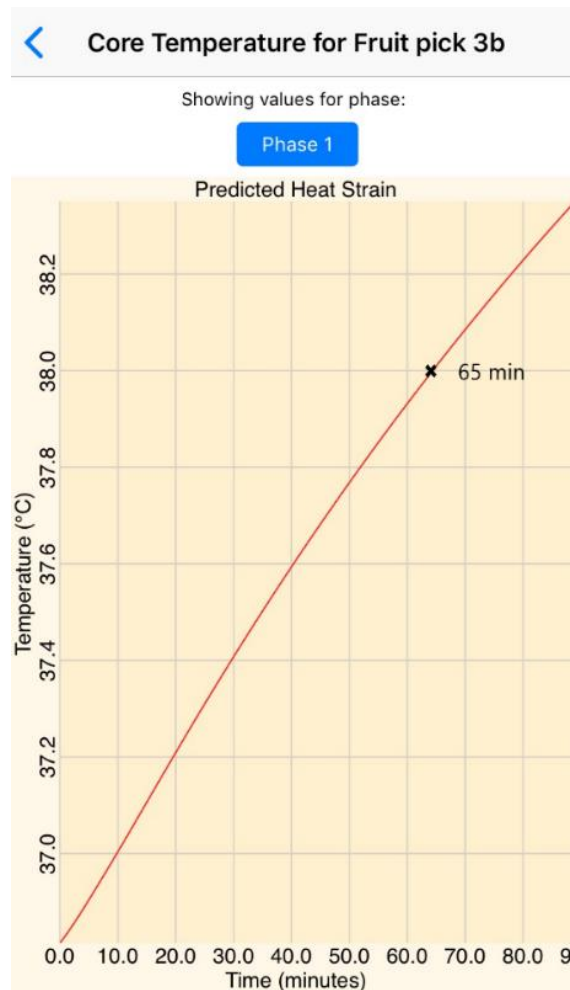


Figure A2 Predicted core temperature of worker picking fruit with increase humidity.

In this case the core temperature is predicted to exceed the limit within 65 minutes so steps will need to be taken to remediate the situation as the risk is not acceptable. This may require the a review of the work/rest.

Scenario 3 Industrial Laundry.

Undertaking an assessment of an industrial laundry building at a site as a result of complaints from the workers.

- The building contains 4 large washing machines and six commercial size driers which vent via low unclad 150mm diameter pipes at the back to the outside
- Multiple basic tasks take approx. 2 hours to complete.
- The workers take their breaks at a small kitchen area 12 metres away, which is not isolated from the work environment.
- The workers are acclimatised and have ready access to drinking water

Some work environment parameters in the vicinity of the driers have been collected/provided.

- Dry Bulb = 38.9°C
- Globe = 49.3°C
- Rel Humidity = 28.6%
- Air Velocity = 0.2 m/s
- Metabolic Load = 175 W/m²
- Posture = Standing
- Clothing is cotton Shirt & Trousers = 0.75 clo

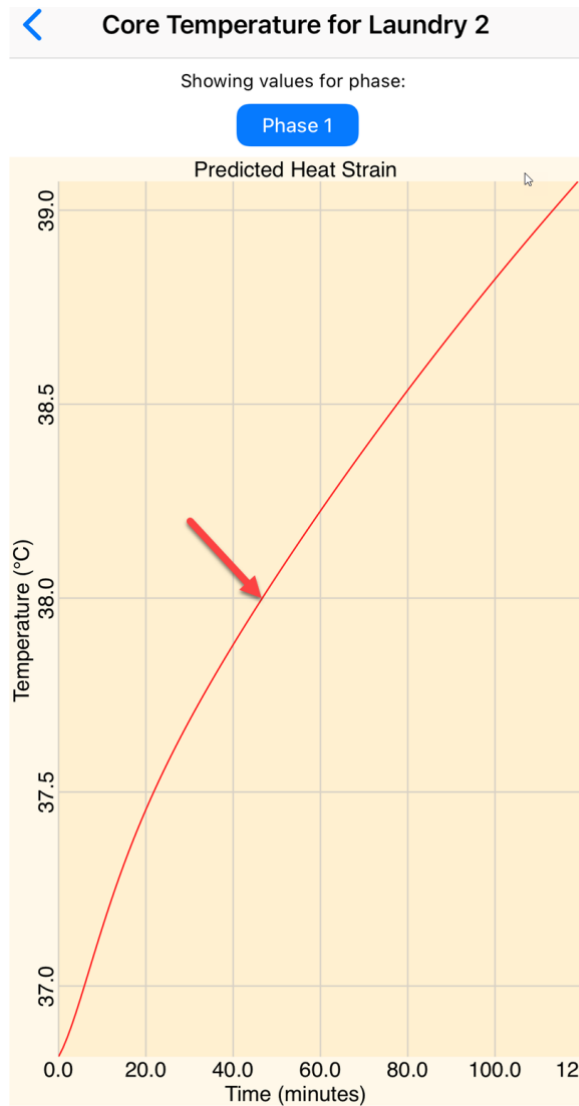


Figure A3 Predicted core temperature of laundry worker under original conditions

The 38 °C limit is reached within approximately 47 minutes hence additional controls are required. By reviewing the work environment and the monitoring results it can be seen that there is greater than 10°C between the globe temperature and the air temperature. This would indicate that the likely impact of radiant heat.

There are four unclad pipes which vent hot air from the driers to the outside and are the likely source. By insulating the pipes this will reduce the radiant heat. Recalculating with the adjusted temperature results in an improvement for the predicted core temperature.

[Back](#) **Laundry 2**

Showing values for phase: **Phase 1**

120.00 minutes

Metabolic Rate: 175 - Arm and trunk work

Acclimatised: Yes

Can Drink Freely: Yes

Posture: Standing

Static Clothing Index: 0.75 - Underpants, shirt, trousers, socks, shoes

Air Temperature: 38.90 °C

Globe Temperature: 40.00 °C

Mean Radiant Temperature: 0.00 °C

Relative Humidity: 28.60 %

Parital Vapour Pressure: 0.00 kPa

Air Velocity: 0.20 m/s

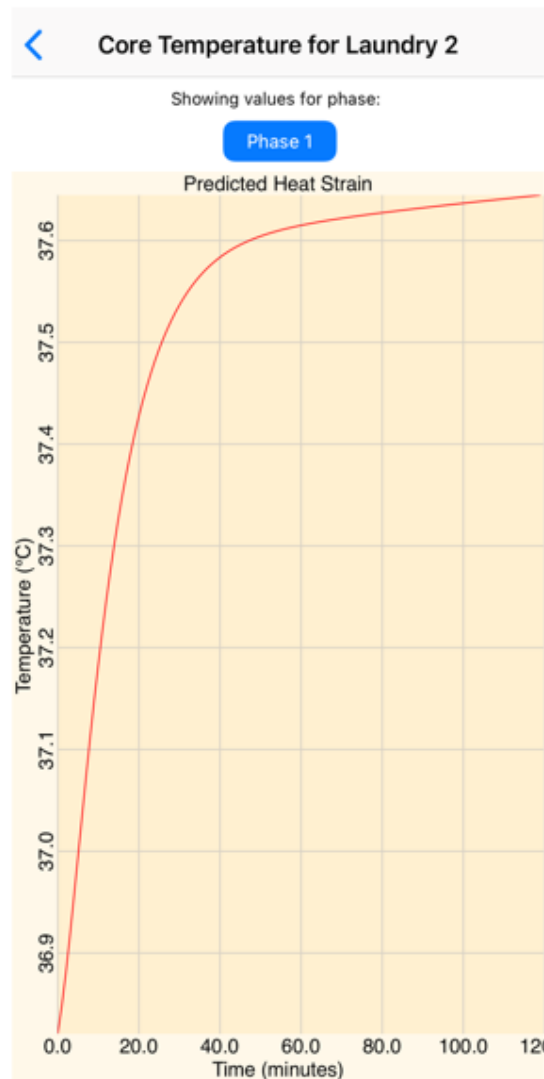


Figure A4 Predicted core temperature of laundry worker after insulation of drier pipework

Another potential issue is the low air flow of 0.2 m/s which would equate to very slight breeze with little or no movement of smoke as it rises. Improving the air velocity will increase the rate of evaporation of sweat which in turn increase the cooling effect on the skin and thus blood vessels.

This could be done in the short term by using fans. A more permanent fix in the long term could be including rooftop ventilators in conjunction with louvres in the lower section of the walls. Combined they will encourage what is known as the “chimney effect” drawing the hot air up through the roof.

De-stratification fans could also be employed.

Recalculating the predicted impact with an increased air velocity shows a significant improvement.

[Back](#) **Laundry 2**

Showing values for phase: **Phase 1** I

120.00 minutes

Metabolic Rate: 175 - Arm and trunk work >

Acclimatised: Yes >

Can Drink Freely: Yes >

Posture: Standing >

Static Clothing Index: 0.75 - Underpants, shirt, trousers, socks, shoes >

Air Temperature: 38.90 °C

Globe Temperature: 49.30 °C

Mean Radiant Temperature: 0.00 °C

Relative Humidity: 28.60 %

Parital Vapour Pressure: 0.00 kPa

Air Velocity: 2.00 m/s

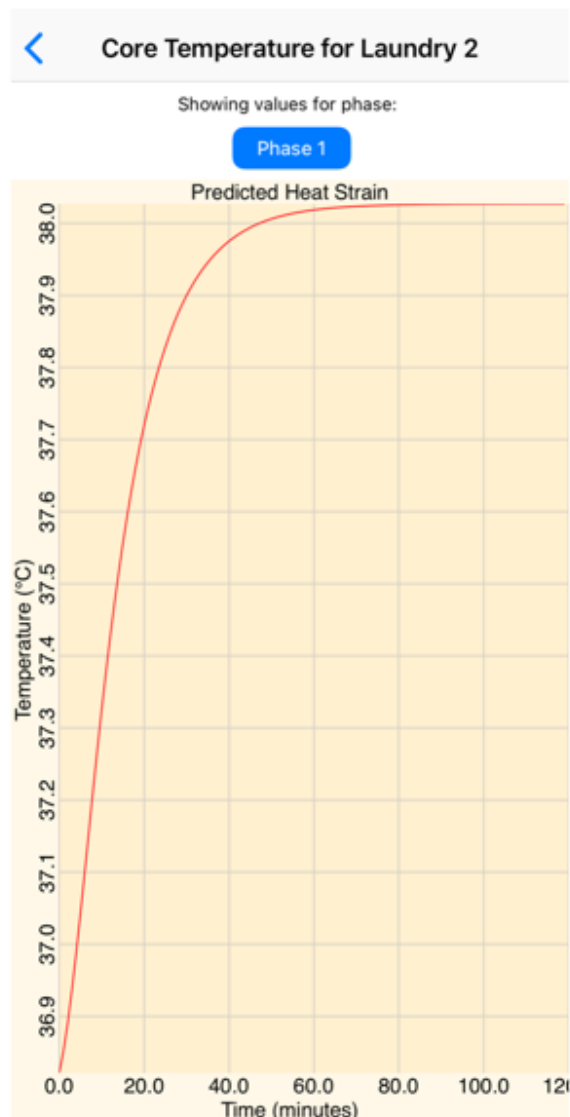


Figure A5 Predicted core temperature of laundry worker after increasing air flow

The preceding example scenarios demonstrate some of the approaches that can be employed to assess the work environment, some simple and others more complex.

Sometimes the controls are quite obvious, and other times require a more comprehensive and or technical approach. Given the level of variation in environment, individual and task already discussed, whatever method is utilised it should be recognised that these are guides only and are not definitive safe/unsafe criteria.

Where an individual is showing signs and symptoms of a heat related illness it should always take precedence over any calculated assessment and the exposure suspended.

Utilising a Level 3 Assessment Process.

In particularly hot and complex work environments or where high levels of PPE such as water/vapour proof coveralls are employed, the use of physiological monitoring may be required. There are numerous such instruments currently available and before selection and use it is important that advice is sought from an independent occupational health professional with appropriate knowledge in the area.

Whilst the method and parameters monitored may vary instrument by instrument a very basic output would be something similar to the chart in the figure below. In the figure, white is indicating the core temperature and purple the heart rate for the duration of the working cycle. Most modern instrumentation have built in alarm systems based on algorithms which calculate the various parameters and may alarm when preset criteria are exceeded.

Scenario 4. Asbestos Removal.

Workers are involved in the removal of asbestos lagging from a hot vessel. The worker spends approximately one hour in the enclosure setting up and then 45 minutes removing material from the walls of the vessel. A short break is taken outside of the enclosure and then the worker re-enters and continues the removal. Once complete the tools and equipment are removed from the enclosure and the tasks end for the day.

- Job will last approx. 4 hours.
- The task has been undertaken in an encapsulating bubble in mid-summer in Northern Australia.
- Asbestos removalists will be wearing impermeable disposable coveralls.
- There is no access to food or drink whilst in the enclosure.
- Worker is 25 years of age

Figure A6 is a simple example of an output for the task described above. As can be seen some basic physiological limits have been exceeded on a number of occasions (note the thermal sensor dislodged at 1330).

Improvements to this task could include:

- Using a balanced negative air unit in conjunction with chilled air for the enclosure (preferred).
- The changing of the time of day in which the task is undertaken (i.e., night shift instead of day).
- Modifying the work rest regime
- Cycling of workers.

Guide limits
38.0°C Core temp.
180 – age Sustained HR



Figure A6 Physiological output from an asbestos removal. (Source: Monitor Consulting Services)

This is a basic view of a physiological monitoring; modern instrumentation can provide more detailed information if required. There are other parameters and assessments which can also be utilised by experienced OHS professionals such as recovery rates and physiological strain indices.

Appendix 4: Cold Stress Case Study Scenarios

The following is an example of a cold stress risk assessment based on a three level approach adapted from (ISO 1573 Annex E. p.26).

Scenario 5. Food processing industry.

A number of areas of a food processing factory were to be assessed for the potential of cold stress risk for the employees, The areas were: sausage production, meat and marinated frozen meat packing departments. Air temperature in the departments was 3°C to 6°C. Air velocity was usually less than 0,2 m/s, but occasionally higher near openings. Humidity was about 80 %. The temperature of the products and machine surfaces was usually kept between 3 °C and 4 °C, and sometimes -2°C (marinated meat). The pauses about 8 min every hour, with 35 min for lunch - were taken at normal room temperature (about 21 °C). The clothing worn by the workers consisted of long underwear and middle wear and a special one-layer outer garment. Thin cotton gloves covered by thin plastic gloves were used.

The work was usually light, consisting of repetitive movements by both arms. Work was usually done in two shifts, starting at 6:00 or 14:30.

About 70 % of the workers were women and the workers' age range was 19 to 56.

Level 1 Qualitative Assessment

For the first observation stage of the risk analysis, a checklist such as shown from Annex A2 in ISO 15743 should be used for identification of potential cold-related problems.

1. Cold air

Observation: Air temperature causes clear problems (score 2). The problems were especially related to hands.

2. Wind/air movements

Observation: Light air movements (e.g. sensation of draught, light wind)

3. Contact with cold surfaces while handling tools/materials or when sitting, kneeling or lying on cold surfaces.

Observation: Working with bare or insufficiently protected hands or for longer periods sitting, kneeling, standing or lying on cold surfaces. Cooling of hands caused performance decrement, cold pain and Occasional numbness.

4. Exposure to water/liquids/wetness

Observation: Long periods of exposure (e.g. continuously handling cold fluids or wet materials).

5. Cold protective clothing (excluding hands, feet and head)

Assessed as sufficient.

6. Protection against cold: hands, feet, head

Observation: Hand protection insufficient.

7. Use of personal protective equipment (helmet, hearing protection, etc.)

Observation: No interference.

8. Other problems related to cold

- Long-term cold exposure/working in the cold (e.g. continuously > 2 h).
- Light work (e.g. measuring, monitoring).
- Varying thermal environments (e.g. frequent moving between in and outdoors).
- Workload did not vary significantly (light/heavy). Limited impact.
- Slipperiness was not deemed an issue.
- No vibrating tools in use.
- Sufficient lighting present.

Conclusions: Long-term repetitive work in the cold environment with insufficiently protected hands caused cold hazards, especially in hands (1., 3. 4., and 6.). The hazards, very common in this type of industry, show immediate need for corrective action.

Level 2 - Analysis

1. Cold air

Calculation of IREQ may be done manually using Annex B of ISO 15743 or from website calculators such as Lund University calculator (<https://www.design.lth.se/english/the-department/research-laboratories/aerosol-climate-laboratory/climate/tools/calculations-for-ireq-and-wct/>). It shows that the need for insulation is 1,8 clo. The available clothing insulation is 1.6 clo to 2.1 clo. Consequently, there are no marked problems with whole-body thermal insulation.

2. Wind/air movement

Air movements do not produce marked problems.

3. Contact cooling

Contact material is meat or sausages. The product temperature is 4 °C. The type of contact is gripping. The contact is very short but repeated. Contact cooling does not cause any immediate danger from frostbite or numbness but gradually the hands cool below 15 °C, causing performance degradation and cold pain.

4. Contact with moist materials

The contact material surface is usually moist. It facilitates contact cooling but does not moisten the inner gloves due to the protection given by the outer plastic gloves.

5. Protective clothing against cold

Thermal insulation of the cold protective clothing is generally sufficient.

6. Protection against cold for hands, feet and head

Finger temperatures decreased often below 15 C, causing cold pain (see ISO 9886 and ISO 10561). This was due to thin gloves, with insufficient thermal insulation, and the accumulation of moisture in the inner gloves due to insensible perspiration. Changing to dry gloves was recommended, as needed. Moreover, use of the correct size of glove was encouraged, in order to maintain optimal hand and finger circulation without impairing manual performance.

7. Possibility of performing the work at a higher room temperature

For hygienic reasons, room temperature could not be increased.

Level 3 - Expertise

Because the cold protection of hands appeared to be the most difficult problem, a special development project was carried out. In the project, all available gloves were compared, and the optimal glove was chosen. The project also increased workers' awareness about cold problems and available solutions.

Scenario 6. Construction in sub-zero climate.

With limited locations where the temperature falls to very low sub-zero temperatures in Australia, a scenario from Canada (WSSC, 2015) will be examined.

A carpenter and work crew is working outside on a -20°C Day in February. They are on the 9th floor of a building under construction. The radio reports a general wind chill of -27.

Hazard Assessment

- On the ninth floor, the wind is blowing work orders around the space. Workers estimate the wind at between 20 and 25 km/h.
- The wind is blowing from a side that has support beams, but no walls.
- The carpenter is doing work that requires dexterity and needs to work without gloves. The work involves moderate physical activity.
- All members of the crew are experienced and have been working at this location for at least 2 months.

Action

- The wind speed on the 9th floor may be more than the wind chill value reported on the radio, so workers decide to use a work warm-up schedule matching -26 to -28 wind chill at 20-25 km/h. This equates to a maximum of 55 minutes of work, with 3 breaks, in a 4-hour shift.
- Workers will take their breaks on the first floor, which is completely enclosed and heated, in an area currently used as meeting area. Since the meeting space is not available in the afternoon, later breaks will be taken in the crew vans.
- The carpenter will do as much measuring and layout as possible on the 8th floor, which has more walls that provide a better wind break than the structure on the 9th floor.
- The crew reviews the health effects and symptoms of cold exposure. Since many of them work in isolation, they agree to check in with an assigned buddy every 30 min.
- They confirm that everyone is dressed appropriately in three layers including an inner layer to wick away sweat, a middle layer to retain heat, and a third outer layer to protect from wind. Workers will remove the two outer layers when in the break room. Hats and extra socks are important. Workers are encouraged to wear their mittens or gloves whenever possible. A change of clothes is necessary if excess sweating occurs. Warm drinks, soup and extra water are provided in the break room.