CCOHS CCHST
Canadian Centre for Occupational Health and Safety · Centre canadien d'hygiène et de sécurité au travail

# Hot Environments

# Hot Environments - Control Measures

## On this page



## How can I measure occupational heat stress exposure?

Feeling hot or cold depends on:

- Air temperature.
- Relative humidity of the air.
- The presence of hot or cold objects in the surrounding area.
- Presence of air movement (breeze, ventilation).
- Physical exertion.
- Clothing.

Various methods of measuring occupational heat exposure combine these environmental factors to obtain a single number as a measure of overall heat load. The most used measure in the workplace is the wet bulb globe temperature (WBGT) index.

Please Note: This OSH Answers document contains information on the prevention of and control of heat-related illnesses. Please see Hot Environments - Health Effects and First Aid and Cold Environments - Health Effects and First Aid for information about the health effects of working in hot and cold environments.

**The Wet Bulb Globe Temperature (WBGT)**
The wet bulb globe temperature is calculated using a formula that takes into account air temperature, speed of air movement, radiant heat from hot objects, sunshine, and body cooling due to sweat evaporation.

Air temperature is measured using a conventional thermometer.

The contribution due to radiant heat is measured using a black globe thermometer. A conventional thermometer is inserted through a rubber stopper into a hollow, six-inch diameter copper ball which is coated with a flat black paint. The thermometer bulb is positioned at the centre of the copper ball. The black globe thermometer normally requires at least 20 minutes to come to equilibrium reading.

The cooling effect of evaporation and air movement is taken into account using a natural wet bulb thermometer. A natural wet bulb thermometer is a conventional thermometer with its bulb wrapped with an absorbent cotton wick. The wick extends 30 to 35 millimetres above the thermometer bulb, and the lower end of the wick is immersed in distilled water. About 25 mm of moistened wick is exposed between the water and the bulb of the thermometer. The moist wick continuously provides water for evaporation. As with the black globe thermometer, the natural wet bulb thermometer also requires at least 20 minutes to reach equilibrium.

Two different methods are used to calculate WBGT: one for workplaces with direct sunlight, and the other for workplaces without direct sunlight.

When workplace conditions fluctuate widely, time-weighted WBGT is often used. The question below "How do I calculate the WBGT Index?" gives examples of WBGT calculations. WBGT direct reading meters, often called heat stress analyzers, are also available. These meters give direct WBGT readings, and no calculations are necessary.

## How do I calculate the WBGT Index?

The wet bulb globe temperature (WBGT) is calculated by using the following equations.

- For conditions in direct sun exposure:

> $WBGT = 0.7 \times Temp_{wet\ bulb} + 0.2 \times Temp_{globe} + 0.1 \times Temp_{dry\ bulb}$

- For shaded or indoor conditions:

> $WBGT = 0.7 \times Temp_{wet\ bulb} + 0.3 \times Temp_{globe}$

where:

$Temp_{wet\ bulb}$ = natural wet bulb temperature measured by using a thermometer whose bulb is covered with wet cotton cloth and is cooled by the natural air movement

$Temp_{globe}$ = temperature measured using a black globe thermometer

$Temp_{dry\ bulb}$ = temperature measured using a conventional thermometer

All temperatures are to be expressed in °C.

**Example**

Workers employed in an outdoor workplace with direct exposure to the sun. Measurement of workplace conditions produced the following results.

$Temp_{wet\ bulb}$ = 24°C

$Temp_{globe}$ = 42°C

$Temp_{dry\ bulb}$ = 40°C

WBGT = 0.7 x 24 + 0.2 x 42 + 0.1 x 40 = 29.2°C

**Time-Weighted Average (TWA)**

When thermal conditions of the workplace fluctuate widely, time-weighted average (TWA) WBGT is used to assess heat exposure.

$$\text{TWA WBGT} = \frac{WBGT_1 \times t_1 + WBGT_2 \times t_2 + \dots + WBGT_n \times t_n}{t_1 + t_2 + \dots + t_n}$$

$WBGT_1$,$WBGT_2$, etc. = the wet bulb globe temperatures measured or calculated

$t_1$, $t_2$, etc. = the elapsed time spent in the corresponding conditions described by $WBGT_1$, $WBGT_2$, etc., respectively.

**Example**

Measurement and/or calculation of WBGT during a two-hour job produced the following results.

| Exposure duration (hours) | WBGT (°C) |
|---|---|
| 0.5 | 25 |
| 1.0 | 27 |
| 0.5 | 28 |

These data would yield the following time-weighted average.

$$\text{TWA WBGT} = \frac{25 \times 0.5 + 27 \times 1.0 + 28 \times 0.5}{0.5 + 1.0 + 0.5} = 26.75°C$$

## What are the exposure limits for heat stress?

Exposure limits intended to minimize the risk of heat-related illnesses are represented by a range of acceptable temperatures for specific circumstances. The Threshold Limit Values® (TLVs®) for heat stress as published by the American Conference of Governmental Industrial Hygienists (ACGIH) have been formally adopted as occupational exposure limits in some jurisdictions, while other jurisdictions use the TLVs® as guidelines. See the OSH Answers Temperature Conditions - Legislation for a list of legislation from each jurisdiction.

ACGIH defines heat stress as the net heat load to which a worker may be exposed from the combined contributions of metabolic heat, air temperature, air movement, humidity, radiant energy, and clothing.

Heat strain is defined by ACGIH as the overall physiological response resulting from heat stress.

The ACGIH gives these limits in units of WBGT degrees Celsius (°C). The WBGT value considers environmental factors, such as air temperature, humidity, and air movement, which contribute to the perceived temperature. In some workplace situations, solar load (heat from radiant sources) is also considered in determining the WBGT.

WBGT values are not the same as humidex values. For relevant information, please see the OSH Answers document Humidex Rating and Work.

The ACGIH publication "2025 TLVs® and BEIs®" (or the most current booklet) provides recommended screening criteria for heat stress exposure for workers (Table 1).
The ACGIH exposure limits are intended to protect most workers from heat-related illnesses. The limits are higher than they would have been if they had been developed to prevent discomfort. This publication and the "Documentation of TLVs® and BEIs®" should be consulted for more detailed information on these screening criteria, categories of work demands, guidelines for limiting heat strain and heat strain management.

**Table 1**
**ACGIH Screening Criteria for Heat Stress Exposure (WBGT values in °C) for 8 hour work day five days per week with conventional breaks**

| Allocation of Work in a Work/Rest Cycle | Acclimatized Workers | | | | Unacclimatized Workers (Action Limit) | | | |
|---|---|---|---|---|---|---|---|---|
| | Light | Moderate | Heavy | Very Heavy | Light | Moderate | Heavy | Very Heavy |
| 75-100% | 31.0 | 28.0 | -- | -- | 28.0 | 25.0 | -- | -- |
| 50-75% | 31.0 | 29.0 | 27.5 | -- | 28.5 | 26.0 | 24.0 | -- |
| 25-50% | 32.0 | 30.0 | 29.0 | 28.0 | 29.5 | 27.0 | 25.5 | 24.5 |
| 0-25% | 32.5 | 31.5 | 30.5 | 30.0 | 30.0 | 29.0 | 28.0 | 27.0 |

**Notes:**

Table 1 is intended as a screening tool to evaluate if a heat stress situation may exist. ACGIH states that this table is more protective than the TLV® or Action Limit. Because the values are more protective, they are not intended to prescribe work and recovery periods.

Assumes 8-hour workdays in a 5-day workweek with conventional breaks.

TLVs assume that workers exposed to these conditions are adequately hydrated, are not taking medication, are wearing lightweight clothing (long-sleeve shirts and pants) and are in generally good health.

See the TLV® booklet for additional guidance.

**Examples of workloads:**

**Rest** - sitting (quietly or with moderate arm movements)

**Light work** - sitting or standing to control machines; performing light hand or arm work (e.g. using a table saw); occasional walking; driving

**Moderate work** - walking about with moderate lifting and pushing or pulling; walking at a moderate pace; e.g. scrubbing in a standing position

**Heavy work** - pick and shovel work, digging, carrying, pushing/pulling heavy loads; walking at fast pace; e.g. carpenter sawing by hand

**Very Heavy** - very intense activity at fast to maximum pace; e.g. shovelling wet sand

Adapted from: 2025TLVs® and BEIs® - Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati: American Conference of Governmental Industrial Hygienists (ACGIH), 2025, p.236 and 237.

## How do I use the heat stress exposure table (Table 1)?

As an example, the wet bulb globe air temperature was measured with a WBGT direct reading meter at 27.0ºC for an 8-hour work period.  The worker is not used to hot conditions (i.e., unacclimatized) and is performing moderate cleaning duties (e.g., scrubbing floors and walls). Considering these factors, ACGIH guidelines suggest that an unacclimatized worker can perform this work for approximately 25 to 50% of an 8-hour workday.  A "rest break" can include other job duties. Duties involving high activity or exertion levels may not allow a person’s body to cool effectively and should be avoided during the rest period. When it is very hot, breaks should be distributed appropriately (e.g., shorter breaks every hour) rather than working for a longer time and taking longer breaks.
See below for more information about controls and acclimatization.

If workers are wearing heavier clothing or personal protective equipment, the WBGT value must be adjusted to reflect a higher heat load. ACGIH recommendations for such situations are suggested in Table 2.

| Table 2<br>**Clothing Adjustment Values (CAV) added to WBGT to estimate $WBGT_{eff}$** | |
|---|---|
| Clothing Type | CAV (°C) |
| Short sleeves and pants of woven material | -1 |
| Work clothes (long sleeve shirt and pants) | 0 |
| Cloth (woven material) coveralls | 0 |
| SMS (Spunbonded - Meltdown - Spunbonded) polypropylene coveralls | +0.5 |
| Polyolefin coveralls | +1 |
| Double-layer woven clothing | +3 |
| Limited-use vapour-barrier coveralls | + 11 |
| Adding a hood (full head and neck covering; not face) | +1 |

**Notes:**

1. These values are not to be used for completely encapsulating suits, often called Level A as defined by OSHA.
2. CAVs are not additive for multiple layers.
3. Coveralls assume that only undergarments are worn underneath, not a second layer of clothing.
4. There is no evidence to suggest that respirators or face coverings add to the heat stress burden.

Adopted from: 2025 TLVs® and BEIs®: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 2025 p. 235

For example, an acclimatized worker wearing double-layer woven clothing doing moderate work at a WBGT of 28°C would have a corrected exposure level of 28.0 + 3 = 31°C, which would lower their allowable exposure to 0-25% work (from 75 -100% work). If the measured WBGT is 30°C, then the adjusted WBGT value would be 33°C, which is higher than all the screening values in Table 1. When working in this type of condition, the employer should monitor the workers for heat strain and implement controls as needed.

## Can physiological monitoring be used to measure heat stress exposures?

Physiological responses to heat stress, such as an increased heart rate and body temperature, can be measured to determine how a worker is responding to heat. Simple measurements, such as counting your pulse or measuring body weight throughout the day, and more sophisticated devices, such as wearable physiological monitoring devices, can be used.

Wearable physiological monitoring devices provide a continuous, individualized, and quantitative measurement of a worker's physiological response to heat. These devices can provide workers with information that can help them detect heat-related illnesses before they happen and can educate workers on their own physiological responses so they can positively alter their behaviours at work (for example, remove themselves from the environment and take a break). The information from wearable physiological monitoring devices can also be used to help alter the work environment or procedures and to determine whether current control measures for heat stress are effective.

In contrast to environmental monitoring such as wet bulb globe temperature (WBGT) measurements, wearable physiological monitoring devices can monitor a worker's level of heat tolerance and consider personalized conditions like the use of personal protective equipment.

Wearable physiological monitoring devices can be considered in high-risk heat environments and for tasks that require impermeable protective clothing. which can contribute to heat illnesses at lower temperatures. Their use can be helpful if a work-rest regimen cannot be followed due to extreme WBGT measurements or excessive personal protective equipment.

Wearable physiological monitoring devices can complement an existing heat stress program in the workplace. However, employers need to consider several factors when implementing their use, including:

- Data privacy – Ownership of the data and how the data will be shared
- Data analysis and interpretation
- Legal implications and guidelines
- The accuracy and precision of the device
- Worker acceptance
- Alternatives to physiological monitoring

## Can we become acclimatized to hot environments?

The body adapts to a new thermal environment by a process called acclimatization. Complete heat acclimatization generally takes six to seven days, but some individuals may need longer. Loss of acclimatization occurs gradually when a person is moved permanently away from a hot environment. However, a decrease in heat tolerance can occur even after a few days away from work and can be completely lost in three weeks. Therefore, it is not advisable for anyone to assume a full workload under very hot conditions on the first day of their return to work.

Returning employees should acclimatize before assuming a full workload. It is advisable to assign about half of the normal workload on the first day of work and gradually increase it over the subsequent days (reaching 100% on about day 4). Complete heat acclimatization generally takes six to seven days, but some individuals may need longer.  New workers should acclimatize at a rate of no more than 20% exposure on day 1 and an increase of no more than 20% on each additional day.

Although well-trained, physically fit workers tolerate heat better than people in poor physical condition, fitness and training are not substitutes for acclimatization.

Some medications interfere with acclimatization. For example, hypotensives (drugs causing low blood pressure), diuretics, antispasmodics, sedatives, tranquilizers, antidepressants, and amphetamines decrease the body's ability to cope with heat. Workers should seek a doctor's advice on the suitability of a medication for them if they work in hot environments. Consumption of alcohol also interferes with acclimatization.

## What can workplaces do to reduce the risk of heat stress?

The risk of heat-related illnesses can be reduced by implementing control measures based on the hierarchy of controls.

### Engineering Controls

Where elimination and substitution of hot environments are not possible, engineering controls are the most effective means of reducing excessive heat exposure. The following examples illustrate some engineering approaches to reducing heat exposure.

- **Reducing metabolic heat production (heat produced by the body)**: Automation and mechanization of tasks minimize the need for heavy physical work and the resulting buildup of body heat.
- **Using mechanical aids**: Mechanical aids, such as carts and turn tables, reduce the amount of physical effort needed to perform a task and hence reduce metabolic heat production.
- **Reducing radiant heat emission from hot surfaces**: Covering hot surfaces with sheets of low-emissivity material, such as aluminum or paint, reduces the amount of heat radiated into the workplace.

- **Insulating hot surfaces**: Insulation reduces the heat exchange between the source of heat and the work environment.
- **Shielding**: Shields stop radiated heat from reaching work areas. Two types of shields can be used. Stainless steel, aluminum or other bright metal surfaces reflect heat back towards the source. Absorbent shields, such as water-cooled jackets made of black-surfaced aluminum, can effectively absorb and carry away heat.
- **Ventilation and air conditioning:** Ventilation, localized air conditioning, and cooled observation booths are commonly used. Cooled observation booths allow workers to cool down after brief periods of intense heat exposure while still allowing them to monitor equipment.
- **Using fans to cool off:** Fans do not cool the air – they just move the air around and can keep you cool by increasing the rate of sweat evaporation.
- **Reducing humidity**: Air conditioning, dehumidification, and elimination of open hot water baths, drains, and leaky steam valves help reduce humidity.

## Administrative Controls

Administrative controls are used to minimize heat stress risks by controlling work schedules, work locations, and work procedures and include:

- **Acclimatization**: Allow for new and returning workers to acclimatize to the hot environment before a full workload. Increase the duration and level of physical activity gradually.
- **Rest area**: Establish rest areas in cooler environments. Consider the type of work and the temperature to determine the duration of rest breaks.
- **Rescheduling work**: Rearrange work activities, especially those that are strenuous, to cooler times of the day, such as mornings, late afternoons, or evenings.
- **Job rotation**: Rotate workers throughout the day to reduce exposures to heat and exertion.
- **Pace of work**: If practical, workers in hot environments should be encouraged to set their own work and rest schedules based on industry standards such as the ACGIH Screening Criteria in Table 1 (see above). Infrequent or irregular tasks, such as emergency repairs of hot process equipment, often result in heat exposure. Experienced workers can often judge heat strain and limit their exposure accordingly. Inexperienced workers may need special attention as they may continue to work beyond the point at which signs of heat strain appear.
- **Work-rest regimen:** Provide an appropriate work-rest regimen as recommended in health and safety legislation and guidance.

- **Training**: Train and educate workers to develop a high degree of awareness about the potential hazards of working in hot environments and understand ways to prevent adverse health effects.
- **Salt and fluid supplements**: A person working in a very hot environment loses water and salt through sweat. This loss should be compensated for by water and salt intake. Fluid intake should equal fluid loss. On average, about one litre of water per hour may be required to replace the fluid loss. Plenty of cool (10-15°C) drinking water should be available on the job site, and workers should be encouraged to drink water every 15 to 20 minutes, even if they do not feel thirsty.
- **Sport drinks and fruit juice:** Drinks specially designed to replace body fluids and electrolytes may be taken but for most people, they should be used in moderation. They may be of benefit for workers who have very physically active occupations but keep in mind they may add unnecessary sugar or salt to your diet. Fruit juice or sport and electrolyte drinks, diluted to half the strength with water, is an option.
- **Establishing a buddy system**: Individuals are less likely to notice their own symptoms of heat stress. The survival of the affected person may depend on their co-worker's ability to recognize the symptoms and seek timely medical help.
- **Creating an emergency response plan**: An emergency plan is needed in extreme environments. The plan should include procedures for providing affected workers with first aid and medical care.

An acclimatized worker loses relatively little salt in their sweat, and therefore, salt in a normal diet is usually sufficient to maintain the electrolyte balance in the body fluids. For unacclimatized workers who may sweat continuously and repeatedly, additional salt in food may be used. Salt tablets are not recommended because the salt does not enter the body system as fast as water or other fluids. Too much salt can cause higher body temperatures, increased thirst and nausea. Workers on salt-restricted diets should discuss the need for supplementary salt with their doctor.

**Note: Drinks with alcohol or caffeine should be avoided, as they dehydrate the body. Water is the most efficient fluid for rehydration for most.**

## Personal Protection

Ordinary clothing provides some protection from heat radiated by surrounding hot surfaces. Specially designed heat-protective clothing is available for working in extremely hot conditions. In hot and humid workplaces, light clothing allows maximum skin exposure and efficient body cooling by sweat evaporation. When selecting clothing, heat stress prevention should be balanced with other health and safety risks. For example, for outdoor workers, a balance must be achieved between heat stress prevention and protection from ultraviolet exposure.

Workers who move back and forth between very hot, dry indoor environments and cold winter outdoor environments find that long underwear moderates the extremes in temperatures.

Eye protection that absorbs radiation is needed when the work involves very hot objects, such as molten metals and hot ovens.

Work that requires the wearing of impermeable clothing presents an additional heat burden as the clothing reduces the body's ability to dissipate heat. Under such circumstances, it is often necessary to adjust the WBGT value to account for the additional heat burden.

## What precautions can workers take to reduce the risk of heat stress?

In hot environments, workers can use certain preventative strategies to minimize the risk of adverse health effects. Such strategies include:

- Report discomfort and early symptoms of heat-related illness to your supervisor.
- Drink plenty of water even if you do not feel thirsty. Sweating results in the loss of body fluids, and excessive water loss may cause dehydration. Thirst is not a reliable indication of the body's need for fluid replacement. A person should drink approximately 250 millilitres (one cup) of cool water every 20 minutes. Caffeinated beverages, sweet beverages, and alcohol must be avoided.
- Maintain a healthy diet. On hot days, eat light foods such as fruits and vegetables, and avoid heavy foods such as proteins, which increase body heat.
- Limit heat stress exposures outside of work.
- Report any changes in health status to your supervisor. Pregnant workers and those with medical conditions should consult their physician about their occupational exposures to heat stress. Older workers should be particularly cautious due to a decreased ability to sweat.
- Consult your doctor if you are taking medications that may cause heat intolerance or inhibited sweating. Certain antibiotics will cause photosensitivity. People taking such drugs should avoid strong midday sunlight.

Fact sheet last revised: 2025-06-23

## Disclaimer