6 HEAT STRESS

The Construction Safety Association of Ontario thanks the following for their help in developing this chapter:

- American Conference of Governmental Industrial Hygienists (ACGIH)
- Sarnia Regional Labour-Management Health and Safety Committee.

WHERE DOES HEAT STRESS OCCUR IN CONSTRUCTION?

Construction operations involving heavy physical work in hot, humid environments can put considerable heat stress on workers. Hot and humid conditions can occur either indoors or outdoors.

Indoors

- steel mills and foundries
- boiler rooms
- pulp and paper mills
- electrical utilities
- petrochemical plants
- smelters
- furnace operations
- oil and chemical refineries
- electrical vaults
- interior construction and renovation.

Outdoors

- roadbuilding
- homebuilding
- work on bridges
- trenching
- pouring and spreading tar or asphalt
- working on flat or shingle roofs
- excavation and grading.

Asbestos removal, work with hazardous wastes, and other operations that require workers to wear semi-permeable or impermeable protective clothing can contribute significantly to heat stress. Heat stress causes the body's core temperature to rise.

WHAT HAPPENS WHEN THE BODY'S CORE TEMPERATURE RISES?

The human body functions best within a narrow range of internal temperature. This "core" temperature varies from 36°C to 38°C. A construction worker performing heavy work in a hot environment builds up body heat. To get rid of excess heat and keep internal temperature below 38°C, the body uses two cooling mechanisms:

1) The heart rate increases to move blood—and heat—from heart, lungs, and other vital organs to the skin.
2) Sweating increases to help cool blood and body. Evaporation of sweat is the most important way the body gets rid of excess heat.

When the body's cooling mechanisms work well, core temperature drops or stabilizes at a safe level (around 37°C). But when too much sweat is lost through heavy labour or working under hot, humid conditions, the body doesn't have enough water left to cool itself. The result is dehydration. Core temperature rises above 38°C. A series of heat-related illnesses, or heat stress disorders, can then develop.

HOW CAN WE RECOGNIZE HEAT STRESS DISORDERS?

Heat stress disorders range from minor discomforts to life-threatening conditions:

- heat rash
- heat cramps
- heat exhaustion
- heat stroke.

Heat rash

Heat rash—also known as prickly heat—is the most common problem in hot work environments. Symptoms include

- red blotches and extreme itchiness in areas persistently damp with sweat
- prickling sensation on the skin where sweating occurs.

Treatment—cool environment, cool shower, thorough drying. In most cases, heat rashes disappear a few days after heat exposure ceases. If the skin is not cleaned frequently enough the rash may become infected.

Heat cramps

Under extreme conditions, such as removing asbestos from hot water pipes for several hours in heavy protective gear, the body may lose salt through excessive sweating. Heat cramps can result. These are spasms in larger muscles—usually back, leg, and arm. Cramping creates hard painful lumps within the muscles.

Treatment—stretch and massage muscles; replace salt by drinking commercially available carbohydrate/electrolyte replacement fluids.

Heat exhaustion

Heat exhaustion occurs when the body can no longer keep blood flowing to supply vital organs and send blood to the skin to reduce body temperature at the same time. Signs and symptoms of heat exhaustion include

- weakness
- difficulty continuing work
- headache
- breathlessness
- nausea or vomiting
- feeling faint or actually fainting.

Workers fainting from heat exhaustion while operating machinery, vehicles, or equipment can injure themselves and others. Here's one example from an injury description filed with the Workplace Safety and Insurance Board:

High temperature and humidity in the building contributed to employee collapsing. When he fell, his head struck the concrete floor, causing him to receive stitches above the right eye.

Treatment—heat exhaustion casualties respond quickly to prompt first aid. If not treated promptly, however, heat exhaustion can lead to heat stroke—a medical emergency.

- Call 911.
- Help the casualty to cool off by
  - resting in a cool place
  - drinking cool water
  - removing unnecessary clothing
  - loosening clothing
  - showering or sponging with cool water.

It takes 30 minutes at least to cool the body down once a worker becomes overheated and suffers heat exhaustion.

Heat stroke

Heat stroke occurs when the body can no longer cool itself and body temperature rises to critical levels.

WARNING: Heat stroke requires immediate medical attention.

The following case is taken from a coroner's report.

On June 17, 1994, a rodworker was part of a crew installing rebar on a new bridge. During the lunch break, his co-workers observed him in the hot sun on the bulkhead of the bridge; the recorded temperature by Environment Canada for that day was 31ºC with 51% humidity. Shortly thereafter the rodworker was found lying unconscious on the scaffold, apparently overcome by the intense heat. He was taken to a local hospital, then transferred to a Toronto hospital. However, despite aggressive treatment by numerous specialists, he died. Cause of death: heat stroke.

The primary signs and symptoms of heat stroke are

- confusion
- irrational behaviour
- loss of consciousness
- convulsions
- lack of sweating
- hot, dry skin
- abnormally high body temperature—for example, 41°C.

Treatment

For any worker showing signs or symptoms of heat stroke,

- Call 911.
- Provide immediate, aggressive, general cooling.
  - Immerse casualty in tub of cool water or
  - place in cool shower or
  - spray with cool water from a hose.
  - Wrap casualty in cool, wet sheets and fan rapidly.
- Transport casualty to hospital.
- Do not give anything by mouth to an unconscious casualty.

WARNING

- Heat stroke can be fatal even after first aid is administered. Anyone suspected of suffering from heat stroke should not be sent home or left unattended unless that action has been approved by a physician.
- If in doubt as to what type of heat-related disorder the worker is suffering from, call for medical assistance.

Heat Stress Disorders

	Cause	Symptoms	Treatment
Heat rash	Hot humid environment; plugged sweat glands.	Red bumpy rash with severe itching.	Change into dry clothes and avoid hot environments. Rinse skin with cool water.
Sunburn	Too much exposure to the sun.	Red, painful, or blistering and peeling skin.	If the skin blisters, seek medical aid. Use skin lotions (avoid topical anaesthetics) and work in the shade.
Heat cramps	Heavy sweating drains a person's body of salt, which cannot be replaced just by drinking water.	Painful cramps in arms, legs or stomach which occur suddenly at work or later at home. Heat cramps are serious because they can be a warning of other more dangerous heat-induced illnesses.	Move to a cool area; loosen clothing and drink cool salted water (1 tsp. salt per gallon of water) or commercial fluid replacement beverage. If the cramps are severe or don't go away, seek medical aid.
Fainting	Fluid loss and inadequate water intake.	Sudden fainting after at least two hours of work; cool moist skin; weak pulse	GET MEDICAL ATTENTION. Assess need for CPR. Move to a cool area; loosen clothing; make person lie down; and if the person is conscious, offer sips of cool water. Fainting may also be due to other illnesses.
Heat exhaustion	Fluid loss and inadequate salt and water intake causes a body's cooling system to start to break down.	Heavy sweating; cool moist skin; body temperature over 38°C; weak pulse; normal or low blood pressure; tired and weak; nausea and vomiting; very thirsty; panting or breathing rapidly; vision may be blurred.	GET MEDICAL AID. This condition can lead to heat stroke, which can kill. Move the person to a cool shaded area; loosen or remove excess clothing; provide cool water to drink; fan and spray with cool water.
Heat stroke	If a person's body has used up all its water and salt reserves, it will stop sweating. This can cause body temperature to rise. Heat stroke may develop suddenly or may follow from heat exhaustion.	High body temperature (over 41°C) and any one of the following: the person is weak, confused, upset or acting strangely; has hot, dry, red skin; a fast pulse; headache or dizziness. In later stages, a person may pass out and have convulsions. **AN IMMEDIATE MEDICAL EMERGENCY. PROMPT ACTION MAY SAVE THE CASUALTY'S LIFE.**	CALL AMBULANCE. This condition can kill a person quickly. Remove excess clothing; fan and spray the person with cool water; offer sips of cool water if the person is conscious.

Table courtesy of the Ontario Ministry of Labour: www.labour.gov.on.ca/english/hs/guidelines/gl_heat.html

WHAT FACTORS ARE USED TO ASSESS HEAT STRESS RISK?

Factors that should be considered in assessing heat stress include

- personal risk factors
- environmental factors
- job factors.

Personal risk factors

It is difficult to predict just who will be affected by heat stress and when, because individual susceptibility varies. There are, however, certain physical conditions that can reduce the body's natural ability to withstand high temperatures:

- **Weight**
  Workers who are overweight are less efficient at losing heat.
- **Poor physical condition**
  Being physically fit aids your ability to cope with the increased demands that heat places on your body.
- **Previous heat illnesses**
  Workers are more sensitive to heat if they have experienced a previous heat-related illness.
- **Age**
  As the body ages, its sweat glands become less efficient. Workers over the age of 40 may therefore have trouble with hot environments. Acclimatization to the heat and physical fitness can offset some age-related problems.
- **Heart disease or high blood pressure**
  In order to pump blood to the skin and cool the body, the heart rate increases. This can cause stress on the heart.
- **Recent illness**
  Workers with recent illnesses involving diarrhea, vomiting, or fever have an increased risk of dehydration and heat stress because their bodies have lost salt and water.
- **Alcohol consumption**
  Alcohol consumption during the previous 24 hours leads to dehydration and increased risk of heat stress.
- **Medication**
  Certain drugs may cause heat intolerance by reducing sweating or increasing urination. People who work in a hot environment should consult their physician or pharmacist before taking medications.
- **Lack of acclimatization**
  When exposed to heat for a few days, the body will adapt and become more efficient in dealing with raised environmental temperatures. This process is called acclimatization. Acclimatization usually takes 6 to 7 days. Benefits include
  - lower pulse rate and more stable blood pressure
  - more efficient sweating (causing better evaporative cooling)
  - improved ability to maintain normal body temperatures.

  Acclimatization may be lost in as little as three days away from work. People returning to work after a holiday or long weekend—and their supervisors—should understand this. Workers should be allowed to gradually re-acclimatize to work conditions.

Environmental factors

Environmental factors such as ambient air temperature, air movement, and relative humidity can all affect an individual's response to heat. The body exchanges heat with its surroundings mainly through radiation and sweat evaporation. The rate of evaporation is influenced by humidity and air movement.

Radiant Heat

Radiation is the transfer of heat from hot objects through air to the body. Working around heat sources such as kilns or furnaces will increase heat stress. Additionally, working in direct sunlight can substantially increase heat stress. A worker is far more comfortable working at 24°C under cloudy skies than working at 24°C under sunny skies.

Humidity

Humidity is the amount of moisture in the air. Heat loss by evaporation is hindered by high humidity but helped by low humidity. As humidity rises, sweat tends to evaporate less. As a result, body cooling decreases and body temperature increases.

Air Movement

Air movement affects the exchange of heat between the body and the environment. As long as the air temperature is less than the worker's skin temperature, increasing air speed can help workers stay cooler by increasing both the rate of evaporation and the heat exchange between the skin surface and the surrounding air.

Job factors

Clothing and Personal Protective Equipment (PPE)

Heat stress can be caused or aggravated by wearing PPE such as fire- or chemical-retardant clothing. Coated and non-woven materials used in protective garments block the evaporation of sweat and can lead to substantial heat stress. The more clothing worn or the heavier the clothing, the longer it takes evaporation to cool the skin. Remember too that darker-coloured clothing absorbs more radiant heat than lighter-coloured clothing.

Workload

The body generates more heat during heavy physical work. For example, construction workers shoveling sand or laying brick in hot weather generate a tremendous amount of heat and are at risk of developing heat stress without proper precautions. Heavy physical work requires

careful evaluation even at temperatures as low as 23°C to prevent heat disorders. This is especially true for workers who are not acclimatized to the heat.

ARE THERE MEASURES FOR EVALUATING HEAT STRESS RISK?

To prevent heat stress, scientists from the World Health Organization (WHO) have determined that workers should not be exposed to environments that would cause their internal body temperature to exceed 38°C. The only true way of measuring internal body temperature is rectally (oral or inner ear measurements are not as accurate). As an alternative, the American Conference of Governmental Industrial Hygienists (ACGIH) has developed a method of assessing heat stress risk based on a wet bulb globe temperature (WBGT) threshold (Table 2).

This method of assessment involves the three main components of the heat burden experienced by workers:

1) thermal environment
2) type of work
3) type of clothing.

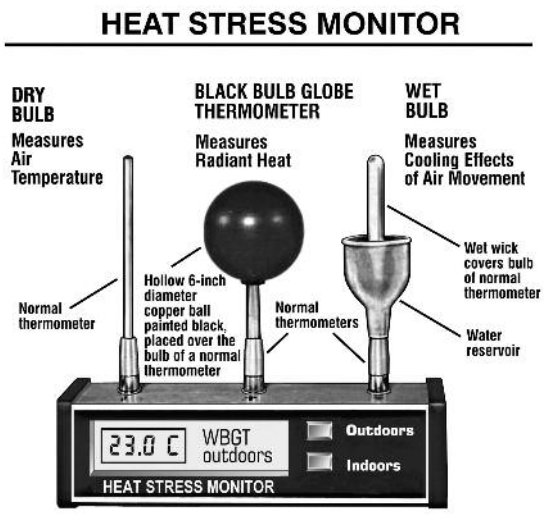
Thermal environment

The first factor in assessing heat stress is the thermal environment as measured by WBGT index. WBGT is calculated in degrees Celsius using a formula which incorporates the following three environmental factors:

- air temperature
- radiant heat (heat transmitted to the body through the air from hot objects such as boilers or shingles heated by the sun)
- cooling effects of evaporation caused by air movement (humidity).

To measure WBGT, a heat stress monitor consisting of three types of thermometers is required:

1) A normal thermometer called a **dry bulb thermometer** is used to measure air temperature.
2) Radiant heat is measured by a **black bulb globe thermometer**. This consists of a hollow, 6-inch diameter copper ball painted flat black and placed over the bulb of a normal thermometer.
3) A **wet bulb thermometer** measures the cooling effect of evaporation caused by air movement (wind or fan). It consists of a normal thermometer wrapped in a wick kept moist at all times. As air moves through the wet wick, water evaporates and cools the thermometer in much the same way that sweat evaporates and cools the body.



Heat stress monitors currently available calculate WBGT automatically. The equipment required and the method of measuring WBGT can be found in the ACGIH booklet *TLVs® and BEIs®: Threshold Limit Values…Biological Exposure Indices*. The booklet also outlines permissible exposure limits for heat stress. Older instruments, however, require calculation by the operator.

Calculation depends on whether sunlight is direct (outdoors) or not (indoors).

Working outdoors in direct sunlight

For work in direct sunlight WBGT is calculated by taking 70% of the wet bulb temperature, adding 20% of the black bulb temperature, and 10% of the dry bulb temperature.

WBGT (out) = [70% (0.7) x wet bulb temperature] + [20% (0.2) x black bulb globe temperature] + [10% (0.1) x dry bulb temperature]

Working indoors (no sunlight)

For work indoors or without direct sunlight, WBGT is calculated by taking 70% of the wet bulb temperature and adding 30% of the black bulb temperature.

WBGT (in)= [70% (0.7) x wet bulb temperature] + [30% (0.3) x black bulb globe temperature]

Example

Suppose it's a bright sunny day and a crew of roofers is working 20 feet above ground. Our assessment yields the following readings:

Wet bulb temperature (cooling effects of evaporation) = 20°C

Black bulb globe temperature (radiant heat) = 36°C

Dry bulb temperature (air temperature) = 33°C

Using the formula for work in direct sunlight, we calculate as follows:

WBGT = (0.7 x wet bulb temperature) + (0.2 x black bulb globe temperature) + (0.1 x dry bulb temperature)
= (0.7 x 20) + (0.2 x 36) + (0.1 x 33)
= 14 + 7.2 + 3.3
WBGT (outdoors) = 24.5 °C

Type of work

The second factor in assessing heat stress is the type of work being performed. Following are the four categories, with some examples of each:

Light work	• Using a table saw • Some walking about • Operating a crane, truck, or other vehicle • Welding
Moderate work	• Laying brick • Walking with moderate lifting or pushing • Hammering nails • Tying rebar • Raking asphalt • Sanding drywall
Heavy work	• Carpenter sawing by hand • Shoveling dry sand • Laying block • Ripping out asbestos • Scraping asbestos fireproofing material
Very Heavy Work	• Shoveling wet sand • Lifting heavy objects

Type of clothing

Free movement of cool, dry air over the skin maximizes heat removal. Evaporation of sweat from the skin is usually the major method of heat removal. WBGT-based heat exposure assessments are based on a traditional summer work uniform of long-sleeved shirt and long pants. With regard to clothing, the measured WBGT value can be adjusted according to Table 1.

TABLE 1: Additions to measured WBGT values for some types of clothing

Clothing Type	**Addition to WBGT**
Summer work uniform	0
Cloth (woven material) overalls	+3.5
Double-cloth overalls	+5

Note: These additions do not apply to encapsulating suits, thermal-insulated clothing, or clothing impermeable or highly resistant to water vapour or air movement. Special garments such as these, and multiple layers of clothing, severely restrict sweat evaporation and heat removal. As a result, body heat may produce life-threatening heat stress even when environmental conditions are considered cool.

Determine work/rest schedules

The WBGT can be used to determine work/rest schedules for personnel under various conditions. Knowing that the WBGT is 24.5°C in the example above, you can refer to Table 2 and determine that workers accustomed to the heat ("acclimatized"), wearing summer clothes, and doing "heavy" work can perform continuous work (100% work).

Suppose work is being performed indoors at a pulp and paper mill under the following conditions:

- Workers are wearing cloth coveralls.
- Boilers are operational.
- Work load is moderate.
- General ventilation is present.

Our assessment yields the following readings:

Wet bulb temperature
(cooling effects of evaporation) = 23°C
Black bulb globe temperature (radiant heat) = 37°C
Dry bulb temperature (air temperature) = 34°C

Using the formula for work indoors, we calculate as follows:

WBGT = (0.7 x wet bulb temperature)
+ (0.3 x black bulb globe temperature)
= (0.7 x 23) + (0.3 x 37) = 27.2°C
Addition for cloth overalls
(Table 1) = 3.5
WBGT (indoors) = 30.7°C

Referring to Table 2, we determine that workers accustomed to the heat (acclimatized), wearing cloth overalls, and performing "moderate" work can work 15 minutes per hour (25% work; 75% rest).

The WBGT must never be used as an indicator of safe or unsafe conditions. It is only an aid in recognizing heat stress. The ultimate assessment and determination of heat stress must lie with the individual worker or co-worker trained to detect its symptoms. Supervisors must allow individual workers to determine if they are capable of working in heat.

Table 2 is intended for use as a screening step only. Detailed methods of analysis are fully described in various technical and reference works. Contact CSAO for further information.

TABLE 2: Screening Criteria for Heat Stress Exposure using WBGT
(Values are WBGTs in °C. These are **NOT** air temperatures.)

	Acclimatized				**Unacclimatized**			
Work Demands	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	29.5	27.5	26		27.5	25	22.5	
75% Work; 25% Rest	30.5	28.5	27.5		29	26.5	24.5	
50% Work; 50% Rest	31.5	29.5	28.5	27.5	30	28	26.5	25
25% Work; 75% Rest	32.5	31	30	29.5	31	29	28	26.5

Notes

- WBGT values are expressed in °C. WBGT is NOT air temperature.
- WBGT-based heat exposure assessments are based on a traditional summer work uniform of long-sleeved shirt and long pants.
- If work and rest environments are different, hourly time-weighted averages (TWA) should be calculated and used. TWAs for work rates should also be used when the demands of work vary within the hour.
- Because of the physiological strain produced by very heavy work among less fit workers, the table does not provide WBGT values for very heavy work in the categories *100% Work* and *75% Work; 25% Rest*.

Use of the WBGT is not recommended in these cases. Detailed and/or physiological monitoring should be used instead.
- Consult the latest issue of *TLVs® and BEIs®*: Threshold Limit Values® and Biological Exposure Indices®, published by the American Conference of Governmental Industrial Hygienists, for guidance on how to properly measure, interpret, and apply the WBGT.

Because of the variable and transient nature of construction sites it may not be practical to measure the WBGT. It's therefore reasonable to ask if there are other ways to evaluate heat stress risk.

IS IT POSSIBLE TO USE THE HUMIDEX TO EVALUATE HEAT STRESS RISK?

The humidex is a measure of discomfort based on the combined effect of excessive humidity and high temperature. As noted already, heat-related disorders involve more than air temperature and humidity. **Other factors—air movement, workload, radiant heat sources, acclimatization—must also be considered in assessing heat stress.** But humidex readings can signal the need to implement procedures for controlling heat stress in the workplace.

Environment Canada provides the following humidex guidelines.

- Where humidex levels are less than 29°C, most people are comfortable.
- Where humidex levels range from 30°C to 39°C, people experience some discomfort.
- Where humidex levels range from 40°C to 45°C, people are uncomfortable.
- Where humidex levels are over 45°C, many types of labour must be restricted.

In the hazard alert *Heat Stress and Heat Stroke in Outdoor Work*, the Ontario Ministry of Labour recommends using the WBGT to evaluate heat stress. However, the humidex can be permissible instead if equivalency is demonstrated.

In the absence of any heat-related incidents, a Ministry of Labour inspector is not likely to issue orders against any employer with a comprehensive heat stress program based on the humidex.

If the humidex rather than the WBGT is being used to monitor conditions, the employer should have

- documentation describing the heat stress policy
- training that emphasizes recognition of heat stress symptoms
- thorough investigation of any heat stress incidents to determine whether the heat stress policy is deficient.

Because humidex readings can vary substantially from point to point it is important that a reading be taken at the actual workplace.

See the Appendix for a five-step approach for using the humidex.

HOW CAN HEAT STRESS BE CONTROLLED?

Heat stress can be controlled through education, engineering, and work procedures. Controls will

- **Protect health**
  Illness can be prevented or treated while symptoms are still mild.
- **Improve safety**
  Workers are less liable to develop a heat-related illness and have an accident. Heat stress often creeps up without warning. Many heat-induced accidents are caused by sudden loss of consciousness.
- **Increase productivity**
  Workers feel more comfortable and are likely to be more productive as a result.

Training and education

According to the U.S. National Institute of Occupational Safety and Health (NIOSH), heat stress training should cover the following components:

- knowledge of heat stress hazards
- recognition of risk factors, danger signs, and symptoms
- awareness of first-aid procedures for, and potential health effects of, heat stroke
- employee responsibilities in avoiding heat stress
- dangers of using alcohol and/or drugs (including prescription drugs) in hot work environments.

Engineering controls

Engineering controls are the most effective means of preventing heat stress disorders and should be the first method of control. Engineering controls seek to provide a more comfortable workplace by using

- reflective shields to reduce radiant heat
- fans and other means to increase airflow in work areas
- mechanical devices to reduce the amount of physical work.

Given the constantly changing nature of construction sites, engineering controls are not usually feasible. Proper work procedures are therefore required to prevent heat stress disorders.

Work procedures

The risks of working in hot construction environments can be diminished if labour and management cooperate to help control heat stress.

Management

- Give workers frequent breaks in a cool area away from heat. The area should not be so cool that it causes cold shock—around 25°C is ideal.
- Increase air movement by using fans where possible. This encourages body cooling through the evaporation of sweat.
- Provide unlimited amounts of cool (not cold) drinking water conveniently located.
- Allow sufficient time for workers to become acclimatized. A properly designed and applied acclimatization program decreases the risk of heat-related illnesses. Such a program exposes employees to work in a hot environment for progressively longer periods. NIOSH recommends that for workers who have had previous experience in hot jobs, the regimen should be
  - 50% exposure on day one
  - 60% on day two

- 80% on day three
- 100% on day four.

For new workers in a hot environment, the regimen should be 20% on day one, with a 20% increase in exposure each additional day.

- Make allowances for workers who must wear personal protective clothing and equipment that retains heat and restricts the evaporation of sweat.
- Schedule hot jobs for the cooler part of the day; schedule routine maintenance and repair work in hot areas for the cooler seasons of the year.
- Consider the use of cooling vests containing ice packs or ice water to help rid bodies of excess heat.

Labour

- Wear light, loose clothing that permits the evaporation of sweat.
- Drink small amounts of water—8 ounces (250 ml)—every half hour or so. Don't wait until you're thirsty.
- Avoid beverages such as tea, coffee, or beer that make you pass urine more frequently.
- Where personal PPE must be worn,
  - use the lightest weight clothing and respirators available
  - wear light-colored garments that absorb less heat from the sun
  - use PPE that allows sweat to evaporate.
- Avoid eating hot, heavy meals. They tend to increase internal body temperature by redirecting blood flow away from the skin to the digestive system.
- Don't take salt tablets unless a physician prescribes them. Natural body salts lost through sweating are easily replaced by a normal diet.

WHAT ARE THE RESPONSIBILITIES OF WORKPLACE PARTIES REGARDING HEAT STRESS?

Employers

The *Occupational Health and Safety Act* and its regulations do not specifically cover worker exposure to heat. However, under the *Occupational Health and Safety Act* employers have a general obligation to protect workers exposed to hot environments. Employers should develop a written health and safety policy outlining how workers in hot environments will be protected from heat stress. As a minimum, the following points should be addressed.

- Adjust work practices as necessary when workers complain of heat stress.
- Make controlling exposures through engineering controls the primary means of control wherever possible.
- Oversee heat stress training and acclimatization for new workers, workers who have been off the job for a while, and workers with medical conditions.
- Provide worker education and training, including periodic safety talks on heat stress during hot weather or during work in hot environments.
- Monitor the workplace to determine when hot conditions arise.
- Determine whether workers are drinking enough water.
- Determine a proper work/rest regime for workers.
- Arrange first-aid training for workers.

When working in a manufacturing plant, for instance, a contractor may wish to adopt the plant's heat stress program if one exists.

Workers

- Follow instructions and training for controlling heat stress.
- Be alert to symptoms in yourself and others.
- Avoid consumption of alcohol, illegal drugs, and excessive caffeine.
- Find out whether any prescription medications you're required to take can increase heat stress.
- Get adequate rest and sleep.
- Drink small amounts of water regularly to maintain fluid levels and avoid dehydration.

APPENDIX

ASSESSING HEAT STRESS HAZARDS USING THE HUMIDEX

WBGT is the most common and useful index for setting heat stress limits, especially when sources of radiant heat are present. It has proven to be adequate when used as part of a program to prevent adverse health effects in most hot environments.

However, taking WBGT measurements properly is quite complicated.

This section provides a simplified version of the WBGT by converting the WBGT into **humidex**. The method was developed by the Occupational Health Clinics for Ontario Workers, Inc. It allows workplace parties to measure heat stress using only workplace temperature and humidity. The following five steps are designed to help workplaces determine whether conditions require action to reduce heat stress.

Step 1: Clothing

- The humidex plan assumes workers are wearing regular summer clothes (light shirt and pants, underwear, and socks and shoes).
- If workers wear cotton overalls on top of summer clothes, add 5°C humidex to the workplace humidex measurement.
- Estimate correction factor for other kinds of clothing by comparing them with cotton overalls (e.g., gloves, hard hat, apron, and protective sleeves might be equivalent to a little less than half the evaporation resistance of overalls, so add 1°C or 2°C humidex).

Step 2: Training

- Measurements by themselves cannot guarantee workers protection from heat stress. It is essential that workers learn to recognize the early signs and symptoms of heat stress and know how to prevent them.
- If it's possible, workers need to be able to alter their pace of work, take rest breaks, and drink in response to early symptoms (a cup of water every 20 minutes). The ideal heat stress response plan would let workers regulate their own pace by "listening to their body."

Step 3: Select a measurement location

- Divide the workplace into zones which have similar heat exposures.
- Select a representative location in each zone where you can take measurements. **Note:** the Humidex Heat Stress Response (Table B) is based on **workplace** measurements, **not** weather station/media reports (temperatures inside buildings do not necessarily correspond with outside temperatures).

Step 4: Measure workplace humidex

- A thermal hygrometer (usually $20–$60 at hardware or office supply stores) is a simple way to measure the temperature and relative humidity in your workplace. Avoid placing the thermal hygrometer in direct sunlight or in contact with a hot surface. Once you have the temperature and humidity, use Table A (or the humidex calculator located at: http://www.ohcow.on.ca/menuweb/heat_stress_calculator.htm) to determine the corresponding humidex value.
- From Table B select Humidex 1 or Humidex 2 according to the amount of physical activity involved with the work and the level of acclimatization. This helps you determine what steps should be taken to reduce the heat stress. Humidex 1 is for moderate unacclimatized and heavy acclimatized work; Humidex 2 is for light unacclimatized work (sitting/standing doing light arm work).

Step 5: Adjust for radiant heat

- For outdoor work in direct sunlight between the hours of 10 am and 5 pm, add 1–2°C (pro-rate according to percentage cloud cover) to your humidex measurement.
- For indoor radiant heat exposures (such as boilers or furnaces), use common sense to judge whether the exposure involves more or less radiant heat than direct sunlight and adjust the 1–2°C correction factor appropriately.

See Table A and Table B on the following pages.

Table A: Humidex Table

Humidex																			
	Relative Humidity (in %)																		
Temp (in ˚C)	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	Temp (in ˚C)
49																			50	49
48	-																		49	48
47																		50	47	47
46			Never ignore someone's symptoms no matter what you measure!															49	46	46
45																	50	47	45	45
44																	49	46	43	44
43																49	47	45	42	43
42															50	48	46	43	41	42
41															48	46	44	42	40	41
40														49	47	45	43	41	39	40
39													49	47	45	43	41	39	37	39
38												49	47	45	43	42	40	38	36	38
37											49	47	45	44	42	40	38	37	35	37
36									50	49	47	45	44	42	40	39	37	35	34	36
35								50	48	47	45	43	42	40	39	37	36	34	33	35
34							49	48	46	45	43	42	40	39	37	36	34	33	31	34
33					50	48	47	46	44	43	41	40	39	37	36	34	33	32	30	33
32			50	49	48	46	45	44	42	41	40	38	37	36	34	33	32	30	29	32
31	50	49	48	47	45	44	43	42	40	39	38	37	35	34	33	32	30	29	28	31
30	48	47	46	44	43	42	41	40	39	37	36	35	34	33	31	30	29	28	27	30
29	46	45	43	42	41	40	39	38	37	36	35	33	32	31	30	29	28	27	26	29
28	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	28
27	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25			27
26	39	38	37	36	35	34	33	33	32	31	30	29	28	27	26	25				26
25	37	36	35	34	33	33	32	31	30	29	28	27	26	26	25					25
24	35	34	33	33	32	31	30	29	28	28	27	26	25							24
23	33	32	31	31	30	29	28	28	27	26	25									23
22	31	30	30	29	28	27	27	26	25	25										22
21	29	29	28	27	26	26	25													21
	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	

Table B: Response

Humidex 1 (moderate unacclimatized and heavy acclimatized work)	**Response** Never ignore someone's symptoms no matter what you measure!	**Humidex 2** light unacclimatized work (sitting/standing doing light arm work)
30-37	**Low** • Alert workers to potential for heat stress. • Ensure access to water.	**34-41**
38-39	**Medium** • Reduce physical activity (e.g., slower pace, double up, breaks). • Drink a cup of water every 20-30 minutes.	**42-43**
40-42	**Moderate** • Reduce physical activity further. • Drink a cup of water every 15-20 minutes.	**44-45**
43-44	**High** • Ensure sufficient rest and recovery time. Severely curtail physical activity. • Drink a cup of water every 10-15 minutes.	**46-48**
45 or over	**Extreme** • It is hazardous to continue physical activity.	**49 or over**