Humidex Rating and Work

What is humidex?

Humidex is a measure of how hot we feel. It is a parameter intended for the general public to express how the combined effects of warm temperatures and humidity are perceived. It provides a number that describes how hot people feel, much in the same way the equivalent chill temperature, or "wind chill factor," describes how cold people feel.

Environment Canada uses humidex ratings to inform the general public when conditions of heat and humidity are possibly uncomfortable.

Table 1

Humidex

Range	Degree of Comfort
20-29	comfortable
30-39	some discomfort
40-45	great discomfort; avoid exertion
above 45	dangerous; heat stroke possible

Source: Warm season weather hazards. Government of Canada

What is the importance of humidity?

The body attempts to maintain a constant internal temperature of 37°C at all times. In hot weather, the body produces sweat, which cools the body as it evaporates. As the humidity or the moisture content in the air increases, sweat does not evaporate as readily. Sweat evaporation stops entirely when the relative humidity reaches about 90 percent. Under these circumstances, the body temperature rises and may cause illness.

What are some of the hazards of working in hot environments?

There are several common heat-related illnesses. Some are more severe than others.

Heat rash, or prickly heat, occurs when blocked sweat glands become inflamed. This painful rash reduces the body's ability to sweat and to tolerate heat.

Heat cramps are painful spasms of the muscles. The muscles used in doing the work are most susceptible. The spasms are caused by the failure of the body to replace its lost body salts and usually occur after heavy sweating.

Heat exhaustion results when the body loses large amounts of fluid by sweating during work in hot environments. The skin becomes cool and clammy. Symptoms include profuse sweating, weakness, dizziness, nausea, and headaches.

Heat stroke is the most serious condition and requires immediate medical attention. The body temperature becomes very high (even exceeding 41°C). Complete or partial loss of consciousness is possible. Sweating is not a good symptom of heat stress as there are two types of heat stroke – "classical" where there is little or no sweating (usually occurs in children, persons who are chronically ill, and the elderly), and "exertional" where body temperature rises because of strenuous exercise or work and sweating is usually present.

Can workplaces use humidex to monitor conditions that may result in heat-related illness?

Humidex as reported by weather forecasters is intended for the general public to express the combined effects of warm temperatures and humidity.

Heat-related illnesses depend on many workplace factors in addition to air temperature and humidity. Wind speed or air movement, work load, radiant heat sources and a person's physical condition are also important.

Under certain workplace conditions, the humidex may serve as an indicator of discomfort resulting from occupational exposures to heat.

For example, when humidity is high, but when work load, wind speed and radiant heat sources do not significantly contribute to the heat burden, humidex may be useful. Offices are typical of workplaces where humidex could be used. It is important to use the values of the temperature and relative humidity obtained by actual measurements taken in the workplace. Conditions inside the workplace may significantly differ from those given by the Weather Service.

How do I know what the humidex is?

If you know the temperature and relative humidity, the following chart can be used to determine the humidex rating. For example, if the temperature is 30°C and the relative humidity is 70%, the humidex rating is 41. This level is considered a level of "great discomfort" and exertion should be avoided.

See the humidex table from Governemnt of Canada for a guide to humidex in compaison to termperature and humidity. As noted by the Government of Canada:

"An extremely high Humidex reading is any reading over 40. In such conditions, you should reduce all unnecessary physical activity. If the reading is in the mid to high 30s, then you should tone down or modify certain types of outdoor exercise, depending on the individual age and health, physical shape, the type of clothes worn and other weather conditions.

If working outdoors is an absolute necessity, drink plenty of liquids and take frequent rest breaks. In hot, humid conditions, there is a considerable risk of heat stroke and sunstroke."

How is humidex interpreted?

The relation between humidex and comfort is subjective. It varies widely between individuals.

Workplaces must use caution when applying the humidex rating. A high humidex rating can serve as a cue to assess workplace conditions more precisely.

For more information, please see the OSH Answers fact sheets on:

Temperature Coniditions - Hot

Hot Environments - Control Measures

Hot Environments - Health Effects and First Aid

The Occupational Health Clinics for Ontario Workers Inc. (OHCOW) created a humidex-based response plan that translated the TLVs® WBGTs into humidex values and developed recommended responses for each humidex range. This plan was developed as a tool to help workplaces as most find using the WBGT complicated and expensive.

While technically there is no way to directly compare WBGT and humidex values, this humidex response plan provides an additional guideline that uses information that is easily available to most employers. OHCOW notes, "in the translation process some simplifications and assumptions have been made, therefore, the plan may not be applicable in all circumstances and/or workplaces (follow steps 1 through 5 to ensure the humidex plan is appropriate for your workplace)" which is available on their website at Source: Occupational Health Clinics for Ontario Workers (OHCOW) - Humidex Based Heat Response Plan.

See Table 2 for details.

Notes: These humidex levels are for unacclimatized workers performing moderate physical activity. The ACGIH specifies an action limit and a TLV® to prevent workers' body temperature from exceeding 38°C (38.5°C for acclimatized workers). Below the action limit (Humidex 1 for work of moderate physical activity) most workers will not experience heat stress. Most healthy, well-hydrated, acclimatized workers not on medications will be able to tolerate heat stress up to the TLV®. (Humidex 2 for

moderate physical activity). Between Humidex 1 and Humidex 2, general heat stress controls are needed and above Humidex 2 job-specific controls are needed.

Table 2

Recommended Actions Based on the Humidex Reading

Table 3 - Recommended Actions Based on the Humidex Reading

IMPORTANT: Consult with the OHCOW material for interpretation and use of this chart. ALWAYS follow steps 1 to 5 as listed on the OHCOW web site. Also see the Humidex-based Heat Stress Calculator.

What index should workplaces use to monitor conditions that may result in heat-related illness?

Occupational (Industrial) hygienists recommend using the Wet Bulb Globe Temperature (WBGT) index to measure workplace conditions. This method closely relates to the human body's response to heat.

The WBGT measurement takes into account air temperature, air movement, radiant heat and humidity. There are direct-reading WBGT meters. These are also called "heat-stress indicators," commercially available. The WBGT measurements can then be related to the physical demands of the job. Only qualified professionals, whether they be in-house staff, consultants, or from the local occupational health and safety regulatory agency, should perform the measurement.

Direct comparison between WBGT and humidex is not possible--there are no conversion tables or mathematical formulas to do such conversions. However, one can estimate WBGT and humidex for a given ambient air temperature and humidity when radiant heat sources (hot and cold surfaces) are absent and air movement is less than 0.5 m/sec. (100 feet per minute). Under these conditions the globe temperature equals room temperature and the natural wet bulb temperature (on the WBGT apparatus) is approximately 2°F (1.1°C) higher than the wet bulb temperature measured using a psychrometer.

Standard charts are available to determine wet bulb temperature from given air temperature and relative humidity values. For indoor or outdoor conditions with no direct sunlight, WBGT is calculated by using the following formula:

WBGT = 0.3 x globe temperature + 0.7 x natural wet bulb temperature

Hot Environments - Control Measures

What are exposure limits for heat stress?

Exposure limits intended to minimize the risk of heat-related illnesses are set by provincial and territorial governments for most Canadian workplaces, and by Employment and Social Development Canada (ESDC) for workplaces under the federal jurisdiction. These agencies generally use the exposure guidelines recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

The ACGIH gives these limits in units of WBGT (wet bulb globe temperature) degrees Celsius (°C). The WBGT unit takes into account environmental factors, such as air temperature, humidity and air movement, which contribute to perception of hotness by people. WBGT values are not the same as humidex values. In some workplace situations, solar load (heat from radiant sources) is also considered in determining the WBGT. More details about WBGT are available below.

The ACGIH publication "2016 TLVs® and BEIs®" (or the most current booklet) provides recommended screening criteria for heat stress exposure for workers (Table 1). 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 Action Limit (Unacclimatized)

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:

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, and are in generally good health.

Examples of work loads:

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 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: 2016 TLVs® and BEIs® - Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati: American Conference of Governmental Industrial Hygienists (ACGIH), 2016, p. 218.

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. If you are wearing heavier clothing then the exposure limit should be lowered. ACGIH recommendations for such situations are suggested in Table 2.

Table 2

Correction of TLV for Clothing

(Values cannot be added when wearing multiple layers)

Clothing Type	WBGT Correction (°C)
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

Note: These values are not to be used for completely encapsulating suits. Coveralls assume only modest clothing is underneath, not a second layer of clothing.

For example, an acclimatized worker wearing double-layer woven clothing doing moderate work would have a corrected exposure level of: 30.0 + 3 = 33ºC, which would lower his or her allowable exposure to 0-25% work (from 25-50% work)

Adopted from: 2016 TLVs® and BEIs®: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 2016. p. 217

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

As an example, the air temperature was measured by WBGT as 27.0ºC for an 8 hour work period. The worker is not used to hot conditions (i.e., unacclimatized) and is performing moderately heavy cleaning duties (e.g., scrubbing floors and walls). These ACGIH guidelines suggest that an acclimatized worker can do this work for approximately 25 to 50% of an 8 hour period. A "rest break" includes other job duties, being cautious of activities that involve high activity or exertion levels as these activities may not allow a person's body to cool effectively.

See below for more information about controls and acclimatization.

How can I measure occupational heat exposure?

Feeling of hot or cold depends on:

Air temperature.

Relative humidity of air.

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 commonly used measure in the workplace is the wet bulb globe temperature (WBGT) index.

Please Note: This OSH Answers document contains information relating to prevention from and control of heat related illnesses. Please see Hot Environments - Health Effects and First Aid for information about the effects on the body from working in hot 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 in the workplace: one for workplaces with direct sunlight, and the other for workplaces without direct sunlight.

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

What control measures can be used to reduce the effects of heat?

The risk of heat-related illnesses can be reduced by:

Engineering controls to provide a cooler workplace.

Safe work practices to reduce worker exposure.

Training employees to recognize and prevent heat illnesses.

Table 3 (below) provides a summary of these controls.

Engineering Controls

Engineering controls are the most effective means of reducing excessive heat exposure. The examples which follow 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.

Reducing the Radiant Heat Emission from Hot Surfaces: Covering hot surfaces with sheets of low emissivity material such as aluminum or paint that reduces the amount of heat radiated from this hot surface 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 stations. 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 a 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 to provide cool work stations. Cooled observation booths allow workers to cool down after brief periods of intense heat exposure while still allowing them to monitor equipment.

Reducing the Humidity: Air conditioning, dehumidification, and elimination of open hot water baths, drains, and leaky steam valves help reduce humidity.

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.

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 which 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 added heat burden as the clothing reduces the body's ability to dissipate heat. Under such circumstances, it is often necessary to reduce the exposure limit values of WBGT to levels below those appropriate for workers wearing light clothing.

Table 3

Summary of Control Measures

Methods of Control	Actions
Engineering controls	
Reduce body heat production	Mechanize tasks.
Stop exposure to radiated heat from hot objects	Insulate hot surfaces. Use reflective shields, aprons, remote controls.
Reduce convective heat gain	Lower air temperature. Increase air speed if air temperature below 35°C. Increase ventilation. Provide cool observation booths.
Increase sweat evaporation	Reduce humidity. Use a fan to increase air speed (movement).
Clothing	
	Wear loose clothing that permits sweat evaporation but stops radiant heat. Use cooled protective clothing for extreme conditions.
Administrative controls	
Acclimatization	Allow sufficient acclimatization period before full workload.
Duration of work	Shorten exposure time and use frequent rest breaks.
Rest area	Provide cool (air-conditioned) rest-areas.
Water	Provide cool drinking water.

Pace of Work If practical, allow workers to set their own pace of work.

First aid and medical care Define emergency procedures. Assign one person trained in first aid to each work shift. Train workers in recognition of symptoms of heat exposure.

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 occurs even after a long weekend. As a result of reduced heat tolerance, it is often not advisable for anyone to work under very hot conditions on the first day of the week.

New employees should acclimatize before assuming a full workload. It is advisable to assign about half of the normal workload to a new employee on the first day of work and gradually increased on subsequent days.

Although well-trained, physically fit workers tolerate heat better than people in poor physical condition, fitness and training do not substitute 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.

How can I prevent heat related illnesses?

If practical, workers in hot environments should be encouraged to set their own work and rest schedules. 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.

People are generally unable to notice their own heat stress related symptoms. Their survival depends on their coworker's ability to recognize these symptoms and seek timely first aid and medical help.

Salt and Fluid Supplements: A person working in a very hot environment loses water and salt through sweat. This loss should be compensated by water and salt intake. Fluid intake should equal fluid loss. On average, about one litre of water each 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. Alcoholic drinks should NEVER be taken as alcohol dehydrates the body.

An acclimatized worker loses relatively little salt in their sweat and, therefore, the salt in the 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 the 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.

Sport drinks, fruit juice, etc: 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. Drinks with alcohol or caffeine should never be taken, as they dehydrate the body. For most people, water is the most efficient fluid for re-hydration.

Emergency Action Plan: In extreme environments, an emergency plan is needed. The plan should include procedures for providing affected workers with first aid and medical care.

More information is available in our OSH Answers document Extreme Hot or Cold Temperature Conditions.

How do I calculate the WBGT Index?

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

For outdoors with direct sun exposure:

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

For indoors or outdoors without direct sun exposure:

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

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

$Temp_{air}$ 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.

$Temp_{wet\ bulb} = 24°C$

Tempglobe = 42°C

Tempair = 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.

TWA WBGT

WBGT1,WBGT2, etc. the wet bulb globe temperatures measured or calculated

t1, t2, etc. the elapsed time spent in the corresponding conditions described by WBGT1, WBGT2, 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.

Formula

Hot Environments - Health Effects and First Aid

CLOSE ALL

What is heat stress?

"Heat stress" is the "net [overall] heat load to which a worker may be exposed from the combined contributions of metabolic heat, environmental factors (i.e., air temperature, humidity, air movement, and radiant heat), and clothing requirements." Metabolic heat is the heat produced by the body through chemical processes, exercise, hormone activity, digestion, etc. [Reference: 2016 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 2016. p.214.] Other heat-related terms are defined at the end of this document in the Glossary of Terms.

Heat may come from many sources. For example:

In foundries, steel mills, bakeries, smelters, glass factories, and furnaces, extremely hot or molten material is the main source of heat.

In outdoor occupations, such as construction, road repair, open-pit mining and agriculture, summer sunshine is the main source of heat.

In laundries, restaurant kitchens, and canneries, high humidity adds to the heat burden.

In all instances, the cause of heat stress is a working environment which can potentially overwhelm the body's ability to deal with heat.

Most people feel comfortable when the air temperature is between 20°C and 27°C and when the relative humidity ranges from 35 to 60%. When air temperature or humidity is higher, people feel uncomfortable. Such situations do not cause harm as long as the body can adjust and cope with the additional heat. Very hot environments can

overwhelm the body's coping mechanisms leading to a variety of serious and possibly fatal conditions.

This OSH Answers document contains information about the health effects of hot environments. Please see Hot Environments - Control Measures for information about the prevention and control for heat exposure.

How does the human body react to hot environments?

The healthy human body maintains its internal temperature around 37°C. Variations, usually of less than 1°C, occur with the time of the day, level of physical activity or emotional state. A change of body temperature of more than 1°C occurs only during illness or when environmental conditions are more than the body's ability to cope with extreme heat.

As the environment warms-up, the body tends to warm-up as well. The body's internal "thermostat" maintains a constant inner body temperature by pumping more blood to the skin and by increasing sweat production. In this way, the body increases the rate of heat loss to balance the heat burden. In a very hot environment, the rate of "heat gain" is more than the rate of "heat loss" and the body temperature begins to rise. A rise in the body temperature results in heat illnesses.

How does the body control heat gain and heat loss?

The main source of heat in normal conditions is the body's own internal heat. Called metabolic heat, it is generated within the body by the biochemical processes that keep us alive and by the energy we use in physical activity. The body exchanges heat with its surroundings mainly through radiation, convection, and evaporation of sweat.

Radiation is the process by which the body gains heat from surrounding hot objects, such as hot metal, furnaces or steam pipes, and loses heat to cold objects, such as chilled metallic surfaces, without contact with them. No radiant heat gain or loss occurs when the temperature of surrounding objects is the same as the skin temperature (about 35°C).

Convection is the process by which the body exchanges heat with the surrounding air. The body gains heat from hot air and loses heat to cold air which comes in contact with the skin. Convective heat exchange increases with increasing air speed and increased differences between air and skin temperature.

Evaporation of sweat from the skin cools the body. Evaporation occurs more quickly and the cooling effect is more noticeable with high wind speeds and low relative humidity. In hot and humid workplaces, the cooling of the body due to sweat evaporation is limited because the air cannot accept more moisture. In hot and dry workplaces, the cooling due to sweat evaporation is limited by the amount of sweat produced by the body.

The body also exchanges small amounts of heat by conduction and breathing. By conduction, the body gains or loses heat when it comes into direct contact with hot or cold objects. Breathing exchanges heat because the respiratory system warms the inhaled air. When exhaled, this warmed air carries away some of the body's heat. However, the amount of heat exchanged through conduction and breathing is normally small enough to be ignored in assessing the heat load on the body.

What are the effects of heat on the body?

When the air temperature or humidity rises above the range for comfort, problems can arise. The first effects relate to how you feel. Exposure to more heat can cause health problems and may affect performance.

As the temperature or heat burden increases, people may feel:

Increased irritability.

Loss of concentration and ability to do mental tasks.

Loss of ability to do skilled tasks or heavy work.

In moderately hot environments, the body "goes to work" to get rid of excess heat so it can maintain its normal body temperature. The heart rate increases to pump more

blood through outer body parts and skin so that excess heat is lost to the environment, and sweating occurs. These changes place additional demands on the body. Changes in blood flow and excessive sweating reduce a person's ability to do physical and mental work. Manual work creates additional metabolic heat and adds to the body heat burden. When the environmental temperature rises above 30°C, it may interfere with the performance of mental tasks.

Does everyone react to heat the same way?

The risk of heat-related illness varies from person to person. A person's general health influences how well the person adapts to heat (and cold).

Those with extra weight often have trouble in hot situations as the body has difficulty maintaining a good heat balance. Age (particularly for people about 45 years and older), poor general health, and a low level of fitness will make people more susceptible to feeling the extremes of heat.

Medical conditions can also increase how susceptible the body is. People with heart disease, high blood pressure, respiratory disease and uncontrolled diabetes may need to take special precautions. In addition, people with skin diseases and rashes may be more susceptible to heat. Other factors include circulatory system capacity, sweat production and the ability to regulate electrolyte balance.

Substances -- both prescription or otherwise -- can also have an impact on how people react to heat.

The National Institute for Occupational Safety and Health (NIOSH) reports that several studies comparing the heat tolerances of men and women have concluded that women are less heat tolerant than men. While this difference seems to diminish when such comparisons take into account cardiovascular fitness, body size, and acclimatization, women tend to have a lower sweat rate than men of equal fitness, size and acclimatization. This lower sweat rate means that there can be an increase in body temperature.

What are the illnesses caused by heat exposure?

Heat exposure causes the following illnesses:

Heat edema is swelling which generally occurs among people who are not acclimatized to working in hot conditions. Swelling is often most noticeable in the ankles. Recovery occurs after a day or two in a cool environment.

Heat rashes are tiny red spots on the skin which cause a prickling sensation during heat exposure. The spots are the result of inflammation caused when the ducts of sweat glands become plugged.

Heat cramps are sharp pains in the muscles that may occur alone or be combined with one of the other heat stress disorders. The cause is salt imbalance resulting from the failure to replace salt lost with sweat. Cramps most often occur when people drink large amounts of water without sufficient salt (electrolyte) replacement.

Heat exhaustion is caused by loss of body water and salt through excessive sweating. Signs and symptoms of heat exhaustion include: heavy sweating, weakness, dizziness, visual disturbances, intense thirst, nausea, headache, vomiting, diarrhea, muscle cramps, breathlessness, palpitations, tingling and numbness of the hands and feet. Recovery occurs after resting in a cool area and consuming cool drinks (e.g., water, clear juice, or a sports drink).

Heat syncope is heat-induced dizziness and fainting induced by temporarily insufficient flow of blood to the brain while a person is standing. It occurs mostly among unacclimatized people. It is caused by the loss of body fluids through sweating, and by lowered blood pressure due to pooling of blood in the legs. Recovery is rapid after rest in a cool area.

Heat stroke is the most serious type of heat illness. Signs of heat stroke include body temperature often greater than 41°C, and complete or partial loss of consciousness. Sweating is not a good sign of heat stress as there are two types of heat stroke - "classical" where there is little or no sweating (usually occurs in children, persons who

are chronically ill, and the elderly), and "exertional" where body temperature rises because of strenuous exercise or work and sweating is usually present.

Heat stroke requires immediate first aid and medical attention. Delayed treatment may result in death.

What are symptoms and first aid steps for heat exhaustion?

Symptoms of heat exhaustion may start suddenly, and include:

Nausea or irritability.

Dizziness.

Muscle cramps or weakness.

Feeling faint.

Headache.

Fatigue.

Thirst.

Heavy sweating.

High body temperature.

First aid for heat exhaustion includes:

Get medical aid. Stay with the person until help arrives.

Move to a cooler, shaded location.

Remove as many clothes as possible (including socks and shoes).

Apply cool, wet cloths or ice to head, face or neck. Spray with cool water.

Encourage the person to drink water, clear juice, or a sports drink.

What are the symptoms and first aid steps for heat stroke?

Heat exhaustion may quickly develop into heat stroke. Symptoms of heat stroke include:

Hot, dry skin or profuse sweating.

Confusion.

Loss of consciousness.

Seizures.

Very high body temperature.

First aid for heat stroke includes:

Call 911 immediately. Heat stroke is a medical emergency.

Stay with the person until help arrives.

Move to a cooler, shaded location.

Remove as many clothes as possible (including socks and shoes).

Wet the person's skin and clothing with cool water.

Apply cold, wet cloths or ice to head, face, neck, armpits, and groin.

Do not try to force the person to drink liquids.

What are the illnesses caused by long-term (chronic) heat exposure?

NIOSH reports that certain heart, kidney, and liver damage are thought by some researchers to be linked to long-term heat exposure. However, the evidence supporting these associations is not conclusive.

Chronic heat exhaustion, sleep disturbances and susceptibility to minor injuries and sicknesses have all been attributed to the possible effects of prolonged exposure to heat.

Heat exposure has been associated with temporary infertility in both women and men, with the effects being more pronounced in men. Sperm density, motility, and the percentage of normally shaped sperm can decrease significantly when the temperature

of the groin is increased above a normal temperature. Workers exposed to high heat loads should inform their family doctors of their exposure.

Laboratory study of animals has shown that exposure of the pregnant females to high temperatures may result in a high incidence of embryo deaths and malformations of the head and the central nervous system (CNS). There is no conclusive evidence of teratogenic effects of high temperatures in humans. The NIOSH criteria document (Draft: 2013) recommends that a pregnant worker's body temperature should not exceed 39-39.5°C during the first trimester of pregnancy.

(Reference: Criteria for a Recommended Standard: Occupational exposure to heat and hot environments. Revised Criteria 2013. Cincinnati, Ohio: National Institute for Occupational Safety and Health, Draft, 2013)

What are some of the terms used in this document (Glossary of Terms)?

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 diarrhea. 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, and ingestion of water without replacing salt.

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 milliaria) - 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 105F) and mental dysfunction.

Heat syncope - Temporary loss of consciousness 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.

Natural Wet Bulb Temperature - Air temperature measured using a thermometer in which the bulb is covered with wet cotton wick and cooled by the natural movement of air.

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

Prickly heat - See Heat rash.

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.

Humidex Rating and Work

CLOSE ALL

What is humidex?

Humidex is a measure of how hot we feel. It is a parameter intended for the general public to express how the combined effects of warm temperatures and humidity are perceived. It provides a number that describes how hot people feel, much in the same way the equivalent chill temperature, or "wind chill factor," describes how cold people feel.

Environment Canada uses humidex ratings to inform the general public when conditions of heat and humidity are possibly uncomfortable.

Table 1

Humidex

Range	Degree of Comfort
20-29	comfortable
30-39	some discomfort
40-45	great discomfort; avoid exertion
above 45	dangerous; heat stroke possible

Source: Warm season weather hazards. Government of Canada

What is the importance of humidity?

The body attempts to maintain a constant internal temperature of 37°C at all times. In hot weather, the body produces sweat, which cools the body as it evaporates. As the humidity or the moisture content in the air increases, sweat does not evaporate as readily. Sweat evaporation stops entirely when the relative humidity reaches about 90 percent. Under these circumstances, the body temperature rises and may cause illness.

What are some of the hazards of working in hot environments?

There are several common heat-related illnesses. Some are more severe than others.

Heat rash, or prickly heat, occurs when blocked sweat glands become inflamed. This painful rash reduces the body's ability to sweat and to tolerate heat.

Heat cramps are painful spasms of the muscles. The muscles used in doing the work are most susceptible. The spasms are caused by the failure of the body to replace its lost body salts and usually occur after heavy sweating.

Heat exhaustion results when the body loses large amounts of fluid by sweating during work in hot environments. The skin becomes cool and clammy. Symptoms include profuse sweating, weakness, dizziness, nausea, and headaches.

Heat stroke is the most serious condition and requires immediate medical attention. The body temperature becomes very high (even exceeding 41°C). Complete or partial loss of consciousness is possible. Sweating is not a good symptom of heat stress as there are two types of heat stroke – "classical" where there is little or no sweating (usually occurs in children, persons who are chronically ill, and the elderly), and "exertional" where body temperature rises because of strenuous exercise or work and sweating is usually present.

Can workplaces use humidex to monitor conditions that may result in heat-related illness?

Humidex as reported by weather forecasters is intended for the general public to express the combined effects of warm temperatures and humidity.

Heat-related illnesses depend on many workplace factors in addition to air temperature and humidity. Wind speed or air movement, work load, radiant heat sources and a person's physical condition are also important.

Under certain workplace conditions, the humidex may serve as an indicator of discomfort resulting from occupational exposures to heat.

For example, when humidity is high, but when work load, wind speed and radiant heat sources do not significantly contribute to the heat burden, humidex may be useful. Offices are typical of workplaces where humidex could be used. It is important to use the values of the temperature and relative humidity obtained by actual measurements taken in the workplace. Conditions inside the workplace may significantly differ from those given by the Weather Service.

How do I know what the humidex is?

If you know the temperature and relative humidity, the following chart can be used to determine the humidex rating. For example, if the temperature is 30°C and the relative humidity is 70%, the humidex rating is 41. This level is considered a level of "great discomfort" and exertion should be avoided.

See the humidex table from Governemnt of Canada for a guide to humidex in compaison to termperature and humidity. As noted by the Government of Canada:

"An extremely high Humidex reading is any reading over 40. In such conditions, you should reduce all unnecessary physical activity. If the reading is in the mid to high 30s, then you should tone down or modify certain types of outdoor exercise, depending on the individual age and health, physical shape, the type of clothes worn and other weather conditions.

If working outdoors is an absolute necessity, drink plenty of liquids and take frequent rest breaks. In hot, humid conditions, there is a considerable risk of heat stroke and sunstroke."

How is humidex interpreted?

The relation between humidex and comfort is subjective. It varies widely between individuals.

Workplaces must use caution when applying the humidex rating. A high humidex rating can serve as a cue to assess workplace conditions more precisely.

For more information, please see the OSH Answers fact sheets on:

Temperature Coniditions - Hot

Hot Environments - Control Measures

Hot Environments - Health Effects and First Aid

The Occupational Health Clinics for Ontario Workers Inc. (OHCOW) created a humidex-based response plan that translated the TLVs® WBGTs into humidex values and developed recommended responses for each humidex range. This plan was developed as a tool to help workplaces as most find using the WBGT complicated and expensive.

While technically there is no way to directly compare WBGT and humidex values, this humidex response plan provides an additional guideline that uses information that is easily available to most employers. OHCOW notes, "in the translation process some simplifications and assumptions have been made, therefore, the plan may not be applicable in all circumstances and/or workplaces (follow steps 1 through 5 to ensure the humidex plan is appropriate for your workplace)" which is available on their website at Source: Occupational Health Clinics for Ontario Workers (OHCOW) - Humidex Based Heat Response Plan.

See Table 2 for details.

Notes: These humidex levels are for unacclimatized workers performing moderate physical activity. The ACGIH specifies an action limit and a TLV® to prevent workers' body temperature from exceeding 38°C (38.5°C for acclimatized workers). Below the action limit (Humidex 1 for work of moderate physical activity) most workers will not experience heat stress. Most healthy, well-hydrated, acclimatized workers not on medications will be able to tolerate heat stress up to the TLV®. (Humidex 2 for

moderate physical activity). Between Humidex 1 and Humidex 2, general heat stress controls are needed and above Humidex 2 job-specific controls are needed.

Table 2

Recommended Actions Based on the Humidex Reading

Table 3 - Recommended Actions Based on the Humidex Reading

IMPORTANT: Consult with the OHCOW material for interpretation and use of this chart. ALWAYS follow steps 1 to 5 as listed on the OHCOW web site. Also see the Humidex-based Heat Stress Calculator.

What index should workplaces use to monitor conditions that may result in heat-related illness?

Occupational (Industrial) hygienists recommend using the Wet Bulb Globe Temperature (WBGT) index to measure workplace conditions. This method closely relates to the human body's response to heat.

The WBGT measurement takes into account air temperature, air movement, radiant heat and humidity. There are direct-reading WBGT meters. These are also called "heat-stress indicators," commercially available. The WBGT measurements can then be related to the physical demands of the job. Only qualified professionals, whether they be in-house staff, consultants, or from the local occupational health and safety regulatory agency, should perform the measurement.

Direct comparison between WBGT and humidex is not possible--there are no conversion tables or mathematical formulas to do such conversions. However, one can estimate WBGT and humidex for a given ambient air temperature and humidity when radiant heat sources (hot and cold surfaces) are absent and air movement is less than 0.5 m/sec. (100 feet per minute). Under these conditions the globe temperature equals room temperature and the natural wet bulb temperature (on the WBGT apparatus) is approximately 2°F (1.1°C) higher than the wet bulb temperature measured using a psychrometer.

Standard charts are available to determine wet bulb temperature from given air temperature and relative humidity values. For indoor or outdoor conditions with no direct sunlight, WBGT is calculated by using the following formula:

WBGT = 0.3 x globe temperature + 0.7 x natural wet bulb temperature

Humidex Rating and Work

CLOSE ALL

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Temperature Conditions - Legislation

CLOSE ALL

What does the legislation state about temperature conditions at work?

In some cases, legislation provides a range of acceptable temperatures for specific circumstances. In other cases, occupational health and safety jurisdictions use the Threshold Limit Values® for heat stress or cold stress as published by the American Conference of Governmental Industrial Hygienists (ACGIH). Some Canadian jurisdictions have adopted these TLVs as occupational exposure limits and others use them as guidelines.

What does the legislation require?

A summary of legislation concerning temperature is provided below. This list does not cite the exact text of each section. In all cases, consult with your jurisdiction to confirm what legislation applies in your situation, and that the most current legislation is applied. A list of contact information for all Canadian occupational health and safety jurisdictions is available.

Table 1

Canadian health and safety regulations with respect to thermal conditions in the workplace

Jurisdiction Regulation Temperature

(This list does not cite the exact text of each section

Canada, Federal Canada Occupational Health and Safety Regulations Section 9.9: personal service food preparation area: 18°C minimum/29°C maximum

Section 14.9(2): motorized materials handling equipment, operators' compartment: 26°C maximum

Section 16.10(2)(b) First aid room: 21°C to 24°C

National Joint Council (Public Service Canada) Occupational Health and Safety Directive Section 2.2 Environmental Conditions: Ideal range between 20-26°C. Temperatures between 17°C and 20°C and above 26°C can be uncomfortable, and occupancy in each of those extremes should not exceed 3 hours daily or 60 hours annually.

Humidex 40°C maximum (as measured at workstation)

British Columbia Occupational Health and Safety Regulations Heat: Sections 7.27 to 7.32: current ACGIH TLVs®

Cold: Sections 7.33 to 7.38: current ACGIH TLVs®

Alberta (Guidelines only)

Saskatchewan Occupational Health and Safety Regulations Section 70: Thermal conditions: Provide and maintain measures to protect workers, and offer reasonable thermal comfort to workers

Manitoba Workplace Safety and Health Regulation Section 4.12: Thermal Stress: current ACGIH TLVs® for heat and cold exposure

Section 4.13: Thermal Conditions: appropriate to work being done

Ontario Occupational Health and Safety Act Clause 25(2)(h): General duty clause

Ministry of Labour fact sheet on heat stress states: "For compliance purposes, the Ministry of Labour recommends the Threshold Limit Values (TLVs) for Heat Stress and Heat Strain published by the American Conference of Governmental Industrial Hygienists (ACGIH). These values are based on preventing workers' core body temperatures from rising above 38°C."

Construction Projects Regulations Section 260(3)(d): Change room for underground workers, 27°C minimum

Section 357(7): Medical locks, minimum of 18°C

Section 380 (2): Air lock used for people, maximum of 27 °C. Also see Section 384(2), 38 °C maximum

Industrial Establishment

Regulations Section 129. Enclosed workplace, minimum of 18°C.

Quebec Regulation respecting occupational health and safety Sections 116 to 120: Heating Environment – Appropriate temperature considering the work being done.

Sections 121 to 124: Heat Stress

Schedule IV: Standards of Temperature in Establishments. Minimum depends on work being done (e.g., heavy work 12°C; light work 20°C)

Schedule V: Evaluation of Heat Stress – Outlines work/rest schedule and Wet Bulb-Globe Temperature (WBGT) equations.

New Brunswick General Regulations Section 21: In an enclosed place of employment, minimum depends on work being done (e.g., heavy work 12°C; light work 20°C)

Section 22: Extremes of Temperature: 1997 ACGIH TLVs® for heat and cold exposure

Nova Scotia Workplace Health and Safety Regulation Section 2.1 and 2.3: current ACGIH TLVs® for heat and cold exposure

Prince Edward Island General Regulations Section 11.10 and 11.11: In an enclosed place of employment, minimum depends on work being done (e.g., heavy work 12°C; light work 20°C). Exceptions apply.

Section 11.9: relative humidity in an office environment must be minimum of 30%

Section 42.1: Extremes of temperature - current ACGIH TLVs® for heat and cold exposure

Newfoundland and Labrador Occupational Health and Safety Regulations
Section 44: Reasonable and consistent with the nature and degree of work performed , as established by current ACGIH TLVs®

Section 566: Refuge station to be at minimum 10°C

Northwest Territories Occupational Health and Safety Regulations Section 74: Thermal conditions. Appropriate to nature of the work, effective protection of worker health and safety, and reasonable thermal comfort

Mine Health and Safety Regulations Sections 9.57 to 9.62: Program required when thermal conditions and nature of work can cause distress. 1994-1995 ACGIH TLVs®.

Nunavut Occupational Health and Safety Regulations Section 74: Thermal conditions. Appropriate to nature of the work, effective protection of worker health and safety, and reasonable thermal comfort

Mine Health and Safety Regulations Sections 9.57 to 9.62: Program required when thermal conditions and nature of work can cause distress. 1994-1995 ACGIH TLVs®.

Yukon Territory Occupational Health and Safety Regulations Section 5.75: Conditions specific to tower cranes

Occupational Health Regulations Section 9: Thermal environment. Reasonable and appropriate to the work performed.