Working Under Hot Conditions

MISSION: ZERO

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Introduction

- Regulation 70 of *The Occupational Health and Safety Regulations, 1996* requires employers in every indoor place of employment to maintain thermal conditions that are reasonable and appropriate for the work performed.
- The employer must take effective measures to protect workers from heat stress disorders if it is not reasonably practicable to adequately control indoor conditions, or where work is done outdoors.
- The employer must provide suitable monitoring equipment if workers are concerned about their thermal conditions.

This publication discusses how to control hot conditions and prevent heat stress disorders. We will discuss the following topics:

- heat stress disorders
- preventing heat stress disorders
- measuring the risk of heat stress disorders
- recommended rest break schedules

If more information is desired for managing hot conditions in office environments, please refer to the OSH Answers Fact Sheets (https://www.ccohs.ca/oshanswers/), maintained by the Canadian Centre for Occupational Health and Safety, titled “Thermal Comfort for Office Work”.

Heat stress disorders

Numerous factors, like work load, clothing, and environmental conditions (i.e. temperature, humidity, air current & radiant heat), contribute to the heat balance in our bodies. If any of the factors are overlooked when managing work in hot conditions, heat stress disorders can develop.

Heat stress disorders occur when our bodies cannot maintain an average body temperature of 37°C as we try to get rid of heat. High heat and humidity force our sweat glands to work harder. If these glands cannot handle the heat stress, body temperature will rise. If unchecked, this can cause vital organs to malfunction and ultimately fail. Sickness and even death can result. Three common heat disorders are:

- heat cramps
- heat exhaustion
- heat stroke

Heat cramps

Painful cramps in the chest, abdomen, arms and legs can result if heavy sweating drains a person of salt. Cramps may occur immediately or be delayed by a few hours. Cramps are a warning that more serious heat disorders may occur if the stress continues. When heat cramps occur, move the worker(s) to a cool area, loosen their clothing and have them drink cool water or a sports drink.

Seek medical attention immediately if the cramps last for more than an hour, the worker is on a low sodium diet or the worker has heart problems.

Heat exhaustion

Heat exhaustion occurs when the body's cooling system cannot keep up with the heat stress. Sweat contains a balance of important fluids and salts. If lost water and salt are not replaced, the body becomes dehydrated. Signs of heat exhaustion include:

- heavy sweating
- cool, pale, and moist skin
- body temperature greater than 38°C
- fast, weak pulse
- normal or low blood pressure

Victims may be tired, weak, clumsy, upset or confused. They are usually very thirsty, panting and may have blurred vision. They can also be nauseated and vomit or faint. Affected workers should be moved to a cool area, have their clothing loosened, given sips of water and put a cool, wet cloth on the body or take a cool bath.

Since heat exhaustion can lead to heat stroke, provide first aid and send workers to a doctor.

Heat stroke

Heat stroke develops when all the water and salt available for sweating has been used up. The body's temperature rises to above 40°C, the skin becomes hot, dry and red. Affected workers may act strange, be weak, confused, have a fast and strong pulse, headache, feel nauseated or be dizzy. In later stages, victims may faint or have convulsions.

Heat stroke can kill. Anyone in this condition must be taken to a hospital immediately. During transport:

- remove excess clothing from the victim
- fan and spray their body with cool water
- offer sips of cool, salted water

Preventing heat stress disorders

In Saskatchewan, conditions that cause heat stress usually occur during summer heat waves or near hot, humid work processes. Engineering and administrative controls can control heat stress. Both should be implemented by the employer with the help of the local occupational health committee or representative.

Engineering controls

Engineering controls should be used if workers must frequently work indoors under hot conditions.

- Use isolation, relocation, redesign or substitution to remove heat sources from work areas.
- Use air conditioning to cool the entire workplace.
- Use spot cooling for hot areas and work sites.
- Use local exhaust to remove heat from hot work processes.
- Use screens, awnings or other appropriate material to shield or block the sun's rays. Insulate hot equipment and surfaces to contain radiant heat.
- Ensure that your maintenance program quickly and effectively fixes problems, such as steam leaks, that create hot conditions.
- Cover or contain heat sources, such as steaming tanks, vats and drains.
- Use labour saving devices to reduce hot work.
- Automate or replace hot processes.

Fans

Fans can increase the air flow and reduce humidity. Improving the air flow increases the cooling effect of sweating. However, if the air temperature is at or above body temperature, fans will simply expose the body to more hot air. This increases the heat load and the risk of heat stress disorders.

Implement cooling measures in hot work situations

Employers should implement other controls for occasional hot indoor and outdoor work situations. To implement these controls:

- Provide rest breaks every hour as shown in Table 3. The recommended rest break schedules tables are on page 13 of this publication.
- Provide adequate supplies of drinking water. Workers should be strongly encouraged to frequently drink small amounts of water or other cool (but not cold) fluids. One cup of fluid every 15 - 20 minutes should replace water lost in sweat. If workers drink only when they are thirsty, they may not get enough fluid.
- Workers engaged in strenuous physical activity could benefit from drinking electrolyte drinks. And unacclimatized workers should be advised to salt their food well. This will maintain the correct levels of body salt. **Do not use salt tablets.**
- Train workers and supervisors to recognize and treat heat stress disorders.
- Ensure that first aid providers at the worksite are well trained in recognizing and treating heat stress disorders.
- Where reasonably practicable, move pregnant employees away from hot work areas.
- Require workers to wear lightly coloured, light weight, loose- fitting cotton clothing that allows for sweat evaporation and blocks the radiant heat.
- Schedule hot work for cooler times of the day.
- Where practicable, have workers set their own work pace.
- Consider workers with special needs.

Acclimatize workers by gradually increasing the time spent in hot work conditions over a one week period. Re-acclimatize workers who have been away from the hot work environment, as noticeable loss in acclimatization occurs after four days and acclimatization may be completely lost in three to four weeks.

During summer heat waves, acclimatization may not be possible. By the time a worker is acclimatized, the heat wave is over. In this case, consider engineering controls or place more emphasis on work pace, time of day and/or rest breaks.

Measuring the risk of heat stress disorders

Factors such as work load, air temperature, humidity, air flow and radiant heat must be taken into account to give a more accurate measurement of risk. To do this, several indices have been developed to assist workplaces in managing heat stress. Some indices are more sensitive to the heat stress that workers experience by design but nonetheless, all of the indices are intended to be used as a guidance tool to evaluate and monitor a heat stress situation. There are limitations in relying solely on indices to manage heat stress, therefore, symptoms of **heat stress disorders should NEVER be ignored**. Signs of heat stress disorders always take precedence over any indices value. Moreover, the usage of the following indices **DOES NOT** guarantee workers' protection from heat stress.

This technical document will discuss the following in detail: Wet Bulb Globe Temperature (WBGT) index, Botsball (Wet Globe Temperature) index, and the Humidex.

Wet Bulb Globe Temperature (WBGT) readings

The WBGT reading combines air temperature, humidity, air flow and radiant heat to measure the risk of heat stress disorders. In general, WBGT readings are substantially below simple thermometer readings. For example, a 26.1°C WBGT could be roughly equivalent to an outdoor temperature of 35°C in the sun and 36.7°C in the shade.

Botsball readings

The Botsball (or wet globe temperature) can also be used to evaluate hot conditions. It can be quite effective for measuring hot conditions in laundries, kitchens, restaurants and most indoor environments. So, under certain circumstances, the Botsball can be used as an alternative to WBGT because the Botsball thermometer is usually cheaper and simpler to use than the WBGT device.

However, in extremely hot and dry environments and the outdoors, a Botsball reading is not as accurate or reliable as a WBGT reading. WBGT should always be used to measure extreme conditions.

Humidex values

Humidex is readily obtained through the use of Humidex calculators on the internet (ie. The Environment Canada Wind Chill and Humidex Calculators) or measured using a thermal hygrometer and later calculated. These values may also be reported by Canadian weather networks and it describes how hot, humid conditions are felt and perceived by the average person. The Humidex value takes into account of temperature and humidity and is reported as a unit-less number.

Procedures for measuring heat stress

A WBGT thermometer, Botsball thermometer or thermal hygrometer are instruments that can be used to measure heat stress for the aforementioned indices. These instruments shall be operated and maintained in accordance with the manufacturer's instructions to ensure proper performance.

Wet Bulb Globe Temperature (WBGT) Thermometer

The unit measures both radiant and evaporative temperatures via specialized assemblies called globe and wet bulb. The assemblies can be used separately or combined. The American Conference of Governmental Industrial Hygienists (ACGIH) uses the setup shown in Figure 1.

Radiant temperature is simulated by inserting a thermometer midway into a blackened globe. This is referred to as globe temperature. The globe is a six-inch diameter copper ball that is painted flat black.

Evaporative temperature is measured by a thermometer with the bulb end covered by a white cotton wick (known as a wet bulb temperature). The wick is kept damp by inserting one end into a vessel of distilled water. The wick covered thermometer bulb must always be exposed to the ambient air to record the evaporative temperature.

Reference temperature is measured by the regular thermometer and is often referred to as the dry bulb temperature.

Using the WBGT

- Position the unit as close as possible to the position of the worker involved. Avoid placing the unit close to a hot surface or in a draft unless this represents the worker's environment.
- Be sure to keep the wick damp and clean at all times. Use only distilled water.
- Allow at least 15 minutes for the unit to stabilize after it has been set up.
- Record the radiant, evaporative, and reference temperatures in Table 1.
- Choose the appropriate formula for the workplace that is being monitored. The formulas for indoor and outdoor heat stress situations are shown below.
- Calculate the WBGT temperature using the appropriate formula.

Indoor heat stress situations:

$$WBGT_{Indoor} = 0.7 \times T_{wb} + 0.3 \times T_g$$

Where:

T_{wb} = Wet bulb or evaporative temperature measured by the wick

T_g = Radiant or globe temperature measured by the black globe

Outdoor heat stress situations:

$WBGT_{Outdoor}=0.7\times T_{wb}+0.2\times T_g+0.1\times T_{db}$

Where:

T_{wb} = Wet bulb or evaporative temperature measured by the wick

T_g = Radiant or globe temperature measured by the black globe

T_{db} = Dry bulb or reference temperature measured by the regular thermometer

- Compare your resultant value to the guidelines in Table 3. Recommended rest break schedules. Take corrective action when required.
- If an electronic WBGT monitor is used, the stabilization time could be shorter than 15 minutes. Always refer to the owner's manual or consult with the manufacturer to ensure the effectiveness and accuracy of the device's performance.
- If an electronic WBGT monitor is used, usually, the device will perform the calculations to give a numeric output on the screen. Simply compare the reading on the screen to guidelines in Table 3. The recommended rest break schedules are on page 13. Take corrective action when required.

Figure 1 - Suggested instrument arrangement for WBGT measurements (After NIOSH, 1972)

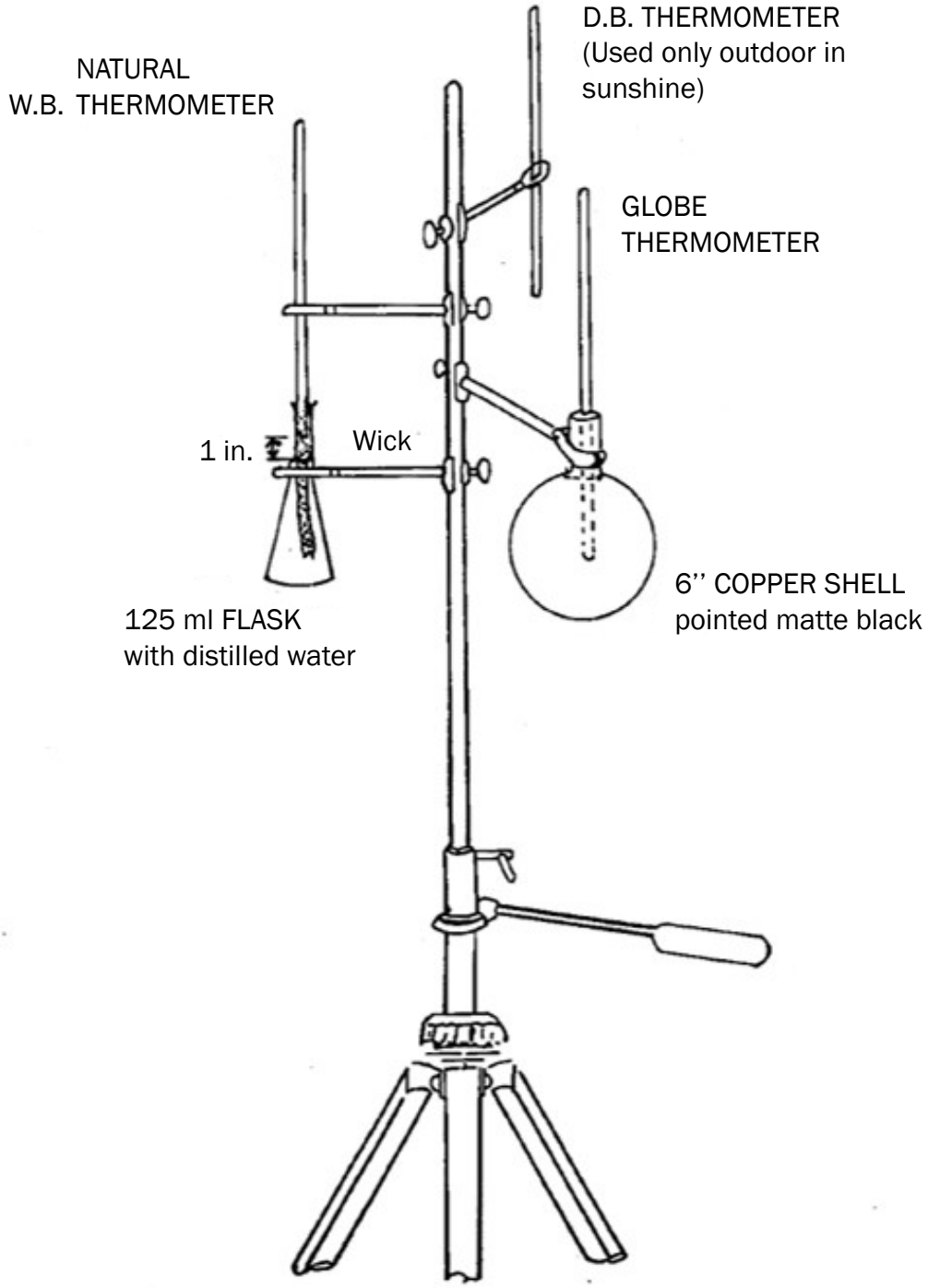
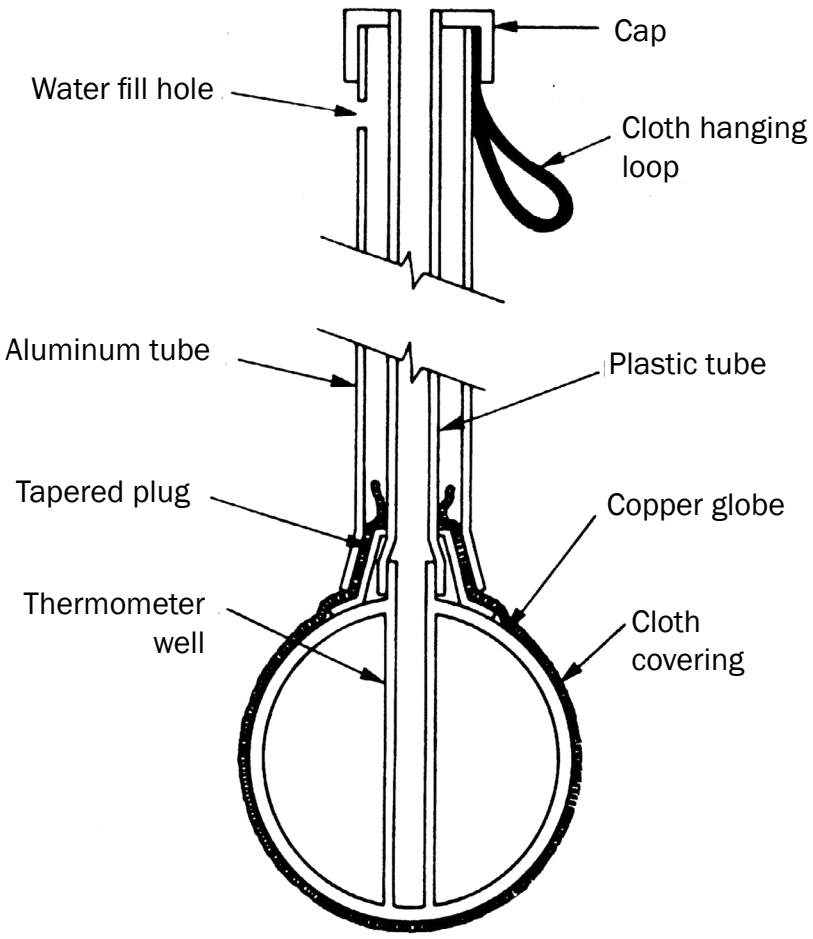


Table 1. Indoor or outdoor WBGT heat stress measurements								
Date	Time	Location	Wet bulb, °C (0.7×Twb)	Globe temp, °C		Dry bulb, °C (0.1×Tdb)	WBGT	Notes/Comments
				Indoor (0.3×Twb)	Outdoor (0.2×Twb)			
Company					Department			
Measurements taken by					Position			

Botsball

The Botsball combines the ambient temperature, radiant heat and evaporative effects into one thermometer reading. It is more portable than a WBGT, but has some problems with water leakage. Water is put in the upper tube. It bleeds down onto the cloth covering a blackened copper globe. A thermometer is placed in the central core (Figure 2).

Figure 2



Sectional sketch of the Botsball

Using the Botsball:

- Hold/hang the Botsball in a position that represents workers' exposure. Allow the unit to stabilize for 10 – 15 minutes or until the Botsball reading has stabilized for one minute.
- Record readings in Table 2 as often as necessary to evaluate the work environment.
- Always use a regular thermometer as a reference temperature.
- Replenish water before each use. Use distilled water only.
- Either replace or clean the cloth covering on the ball if it becomes dirty or stained.
- Never use a Botsball in environments with very low humidity and/or very high radiant heat. Under extreme conditions such as these, use a WBGT.
- Compare your Botsball thermometer value to Table 3. Recommended rest break schedules. Take corrective action when required.

If an electronic Botsball monitor is used, the stabilization time could be shorter than 15 minutes. Always refer to the owner's manual or consult with the manufacturer to ensure the effectiveness and accuracy of the device's performance.

Table 2. Botsball measurements					
Date	Time	Location	Botsball reading, °C	Reference temperature, °C	Notes/Comments
Company			Department		
Measurements taken by			Position		

Table 3. Recommended rest break schedules

WBGT INDEX				
Work load	**Work rate**			
	Continuous work	**15 minutes rest per hour**	**30 minutes rest per hour**	**45 minutes rest per hour**
Very heavy	Not recommended	Not recommended	Up to 28.0 °C	28.0 °C up to 30.0 °C
Heavy	Not recommended	Up to 27.5 °C	27.5°C up to 29.0°C	29.0°C up to 30.5°C
Moderate	Up to 28.0°C	28.0°C up to 29.0°C	29.0°C up to 30.0°C	30.0°C up to 31.5°C
Light	Up to 30.0°C	30.0°C up to 31.0°C	31.0°C up to 32.0°C	32.0°C up to 32.5°C
BOTSBALL INDEX				
Work load	**Work rate**			
	Continuous work	**15 minutes rest per hour**	**30 minutes rest per hour**	**45 minutes rest per hour**
Very heavy	Not recommended	Not recommended	Up to 25.5 °C	25.5°C up to 27.0°C
Heavy	Not recommended	Up to 25.0°C	25.0°C up to 26.0°C	26.0°C up to 27.5°C
Moderate	Up to 25.5°C	25.5°C up to 26.0°C	26.0°C up to 27.0°C	27.0°C up to 28.0°C
Light	Up to 27.0°C	27.0°C up to 27.5°C	27.5°C up to 28.5°C	28.5°C up to 29.0°C

- The WBGT index in the above tables is based on the American Conference of Governmental Industrial Hygienists (ACGIH) 2018 TLV Handbook. The Botsball Index was developed by using the WBGT cut-off values in the ACGIH 2018 Handbook and the values were calculated based on the WBGT-to-Botsball conversion equation developed by Sundin et al, (1973).
- These indices are not equivalent to regular thermometer readings. **The tables apply only to healthy, acclimatized workers who are wearing lightweight, light coloured, loose-fitting cotton clothing.** Adjustments must be made to these indices for unacclimatized workers and workers with special needs.
- Intended to be used as an initial screening tool to evaluate whether a heat stress situation may exist.
- **Very Heavy means** – Very intense activity at fast to maximum pace.
- **Heavy work means** – Intense arm and trunk work, carrying, shoveling, manual sawing, pushing and pulling heavy loads; and walking at a fast pace.
- **Moderate work means** – Sustained moderate hand and arm work, moderate arm and leg work, moderate arm and trunk work, or light pushing and pulling. Normal walking.
- **Light work means** – Sitting with light manual work with hands or hands and arms, and driving. Standing with some light arm work and occasional walking.
- **Continuous work** - Assumes that there are short morning and afternoon breaks and a longer lunch break in an eight-hour day.
- **Rest breaks** – Includes all breaks, such as regular work breaks and unscheduled pauses during work. If rest breaks occur in an area that is significantly cooler than the work position, the WBGT is modified. See next section.

Applying the recommended rest break schedule

The schedule applies to workers who are fully acclimatized. New workers and workers returning from more than two weeks away from work should be allowed at least one week to acclimatize. Start with a short exposure to hot work 20 per cent of the time on the first day. Another 20 per cent should be added each day after that. Additionally, there has been shown to be a carry-over effect from the previous day's exposure, so work and rest schedules shall be adjusted accordingly.

For unacclimatized workers, apply Table 3. Recommended rest break schedules using one work load level higher. For example, the digital WBGT devices gives a reading of 30.0°C and you have unacclimatized workers doing light work, the recommended break schedule would be 45 minutes of rest per hour (same work rest schedule as acclimatized workers doing moderate work at a WBGT of 30.0°C).

The schedule assumes that the WBGT index of the resting place is the same or similar to that of the workplace. Where the WBGT of the work area is different from that of the rest area, a time weighted average should be used. The weighted average should not exceed a WBGT of 30°C for light work, 27°C for moderate work, 26°C for heavy work, and 25°C for very heavy work in a one hour duration. The weighted average is determined by the equation:

$$\text{Time weighted average} = \frac{WBGT_1 \times t_1 + WBGT_2 \times t_2)}{(t_1 + t_2)}$$

Where:

- WBGT1 is the work area index
- WBGT2 is the rest area index
- t1 is the time worked every hour
- t is the length of the rest period every hour

This calculation can also be used for Botsball readings. For example, a worker doing moderate work can be allowed to work at a WBGT of 30°C for 45 minutes of each hour if the 15 minutes resting period is spent in a 22°C WBGT environment.

Special situations

If a job requires specialized clothing such as heavy coveralls, "turn out gear" for firefighters or chemical-resistant clothing, the WBGT index must be adjusted down. The WBGT index should also be adjusted down for special needs workers, such as:

- persons over age 40
- workers who are obese
- alcohol abusers
- workers with other health conditions and on certain medications

- unacclimatized workers who are likely more susceptible to heat stress disorders

In these situations, obtain advice from a competent person or a physician if needed.

When WBGT index exceed Table 3. Guidelines

Higher heat exposures than shown in Table 3. Recommended rest break schedules should only be permitted where:

- An experienced physician has evaluated the workers and deemed them fit for work in extreme heat.
- Each worker is trained and experienced in being able to pace the speed of work and will be able to terminate any particular heat exposure because of strain or discomfort.
- A competent person (one who has the appropriate training, knowledge and experience) will determine the maximum safe length of worker exposure to extreme heat.
- Workers will be watched by a trained and experienced supervisor or other professional who can recognize signs and symptoms of heat effects.
- Appropriate protective clothing or equipment will be provided to reduce the intensity of heat exposure.
- An emergency plan will be in place to rescue and treat workers who become ill.

If a high heat exposure is measured on a Botsball, use a WBGT to confirm. Use the precautions previously discussed if necessary.

Humidex

Humidex is a calculated, unit-less, numeric value that describes the combined effect of humidity and temperature on the human perception of how hot we feel. By design, it only takes into consideration two contributing factors to heat stress, which makes it less sensitive than the Botsball and WBGT at approximating our physiological responses to hot environments. However, since the Humidex value is readily obtainable, it still provides good guidance for workplaces when they want to screen and monitor for heat stress.

The usage of the Humidex table, or even the WBGT and Botsball tables, **DOES NOT** guarantee workers' protection from heat stress. It is important to train workers on the identification of heat stress symptoms, so that they can recognize early symptoms and respond accordingly.

OHCOW (Occupational Health Clinic for Ontario Workers) has created a document called "Humidex Based Heat Response Plan". The document relates Humidex to WBGT by making simplifications and assumptions to the 2009 ACGIH Heat Stress TLVs. For this reason, we have adopted aspects of OHCOW's publication in this document to increase the sensitivity of using Humidex for measuring the risk of heat stress. For extreme conditions, please use WBGT and refer to the "Heat Stress" section in the ACGIH Handbook or the section titled "When WBGT index exceed Table 3. Guidelines".

Using the Humidex table

- Obtain the Humidex in the workplace. If you are working indoors, split the workplace into heat stress zones and choose a representative location within the zone to take a measurement. In the case that you want to only take one measurement for an indoor workplace, take a measurement from the highest heat stress zone.
- Adjustments need to be made for clothing, as wearing more clothes generally decreases the rate of sweat evaporation and increases heat stress. If workers are wearing anything other than regular summer clothes (ie. light shirt, light pants, underwear, socks & shoes), for instance:
    - Cotton overalls on top of summer clothes: Add five Humidex to workplace measurement.
    - Other clothing arrangements: Approximate the correction factor by comparing it to effect of cotton overalls.
    - Encapsulation suits (and other clothes that does not allow sweat evaporation): Monitor via vital signs and refer to the ACGIH Handbook & the section titled “When WBGT index exceed Table 3. Guidelines”.

Adjustments for radiant heat are also necessary for both indoor and outdoor work. When working outside in direct sun from 10 a.m. to 5 p.m. add two to three Humidex values, depending on the percentage of cloud coverage (cloud coverage reduces radiant heat so the correction factor increases with decreased cloud coverage). If there is noticeable radiant heat in an indoor workplace, use common sense to approximate the effect of the exposure to direct sunlight outdoors and add 2 – 3 Humidex accordingly.

- Determine the workload and state of acclimatization of the workers and choose the Humidex 1 or 2 column.
- When clothing and radiant heat adjustments are necessary, add the appropriate correction factors to the measured Humidex to get a final Humidex value. Find this Humidex value in the Humidex 1 or 2 column in Table 4. Rest break guidelines using Humidex to determine the corresponding response
- When the Humidex is above 30 or the air temperature is above 26°C, monitor at least hourly.

See Table 3. Recommended rest break schedules on page 13 of this document for the definition of light, moderate and heavy work.

Table 4. Rest break guidelines using Humidex				
Humidex 1 Unacclimatized workers doing moderate work OR acclimatized workers doing heavy work		Response	Humidex 2 Unacclimatized workers doing light work OR acclimatized workers doing moderate work	
Humidex values	25 – 29	• Provide cool water as needed	32 – 35	Humidex values
	30 – 33	• Post heat stress alert notice • Encourage workers to drink extra water • Record the temperature and relative humidity (RH) hourly	36 – 39	
	34 – 37	• Post heat stress warning notice • Notify workers that they need to stay hydrated, so drink water more frequently • Workers should be trained to recognize symptoms	40 – 42	
	38 – 39	• Work with 15-minute break per hour • Give at least one cup (240 mL) of cool (10-15°C) water every 20 minutes • Workers with symptoms should seek medical attention	43 – 44	
	40 – 41	• Work with 30-minute break per hour & take all of the aforementioned precautions	*45 – 46*	
	42 – 44	• Work with 45-minute break per hour & take all of the aforementioned precautions	*47 – 49*	
	45 or above	• *ONLY medically supervised work can continue at Humidex above 45*	*50 or above*	

Summary

Heat stress disorders occur when the body can no longer cool itself effectively. Common disorders include heat cramps, heat exhaustion and heat stroke. In Saskatchewan, heat stress disorders usually occur during summer heat waves or in operations involving hot work processes.

The employer can protect workers by implementing engineering and administrative controls. The risk of heat stress can be monitored by either the WBGT index, Botsball index or Humidex. The WBGT is most reliable and must be used to measure extreme conditions. Use the rest break schedules recommended in this publication to pace work under hot conditions. Adjust the schedules appropriately for special situations.

Additional resources

For additional resources and information regarding heat stress monitoring and management, please visit:

- Canadian Center for Occupational Health and Safety (www.ccohs.ca)
- American Conference of Governmental Industrial Hygienists (ACGIH) published TLV and BEI handbook (www.acgih.org)
- Occupational Health Clinic for Ontario Workers (OHCOW) published document titled “Humidex Heat Stress Response Plan” (www.ohcow.on.ca)

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