Introduction

- Section 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

Thermal comfort is addressed in the publication *Thermal Comfort in Offices and Retail Outlets*.

Heat stress disorders

Heat stress disorders occur when our bodies cannot sweat fast enough 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. Sickness and even death can result. Three common heat disorders are:

- heat cramps
- heat exhaustion
- heat stroke

Heat cramps

Painful cramps in the stomach, arms and legs can result if heavy sweating drains a person of salt. Cramps may occur suddenly - at work or after hours. Cramps are a warning that more serious heat disorders may occur if the stress continues. Lost salt cannot be replaced by drinking water alone. When heat cramps occur, move the victims to a cool area, loosen their clothing and have them drink cool, salted water (mix at one teaspoon of salt per gallon of water). If cramps continue, provide first aid and take victims to a doctor.

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, moist skin
- body temperature greater than 38^0C
- 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. Victims should be moved to a cool area, given cool, salted water to drink and have their clothing loosened. Since heat exhaustion can lead to heat stroke, provide first aid and send victims 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 40^0C, the skin becomes hot, dry and red. Victims may act strangely, be weak, confused, have a fast pulse rate, headache 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 victims
- fan and spray their bodies 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.

Administrative and other effective measures

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 the *Recommended Rest Break Schedules* tables on page 15 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 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.
- 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 environment.

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

Thermometer readings alone cannot measure the risk. Factors such as air temperature, humidity, air flow and radiant heat must be taken into account. To do this, an index known as the **wet bulb globe thermometer (WBGT)** has been developed.

Web bulb globe thermometer (WBGT) readings

The WBGT index combines air temperature, humidity, air flow and radiant heat to measure the risk of heat stress disorders. In general, WBGT indices are substantially below simple thermometer readings. For example, a 26.1^{0}C WBGT could be roughly equivalent to an outdoor temperature of 35^{0}C in the sun and 36.7^{0}C in the shade.

Botsball readings

The **Botsball** (or wet globe thermometer) can also be used to evaluate hot conditions. Botsball readings are based on the WBGT index. But, the botsball is cheaper and simpler to use than a WBGT. It can be quite effective for measuring hot conditions in laundries, kitchens, restaurants and most indoor environments. However, in extremely hot and dry environments and outdoors, a botsball is not as accurate or reliable as a WBGT. A WBGT must always be used to measure extreme conditions.

Procedures for measuring heat stress

A wet bulb globe thermometer (WBGT) or a botsball can be used to measure heat stress. This section deals with the construction and operation of a basic WBGT and botsball WBGT unit. Units from safety instrument manufacturers should be operated according to their instruction manuals.

Wet Bulb Globe Thermometer

The unit requires the measurement of both radiant and evaporative temperatures. This is done with the following two assemblies, *globe* and *wet bulb*. The assemblies can be used separately or combined. The American Conference of Governmental Industrial Hygienists (ACGIH) uses the designs 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 four-inch diameter copper toilet float that is painted flat black.

Evaporative temperature is measured by a thermometer with the bulb end covered by a cotton wick (known as a *wet bulb*). 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.

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 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 and evaporative temperatures in Table 2.

- Use a regular thermometer as a reference temperature (this is known as a *dry bulb* temperature).
- Use the appropriate conversion factors from Table 1 to calculate the WBGT index. The calculations for indoor and outdoor heat stress situations are shown below.

  Indoor heat stress situations:

  WBGT = 0.7 x Wet Bulb Temperature + 0.3 x Globe Temperature. In other words: WBGT = Factor A + Factor B.

  Outdoor heat stress situations:

  WBGT = 0.7 x Wet Bulb Temperature + 0.2 x Globe Temperature + 0.1 x Reference Temperature.

- Compare your readings to the guidelines in the *Recommended Rest Break Schedules* table. Take corrective action when required.

Figure 1

A WBGT

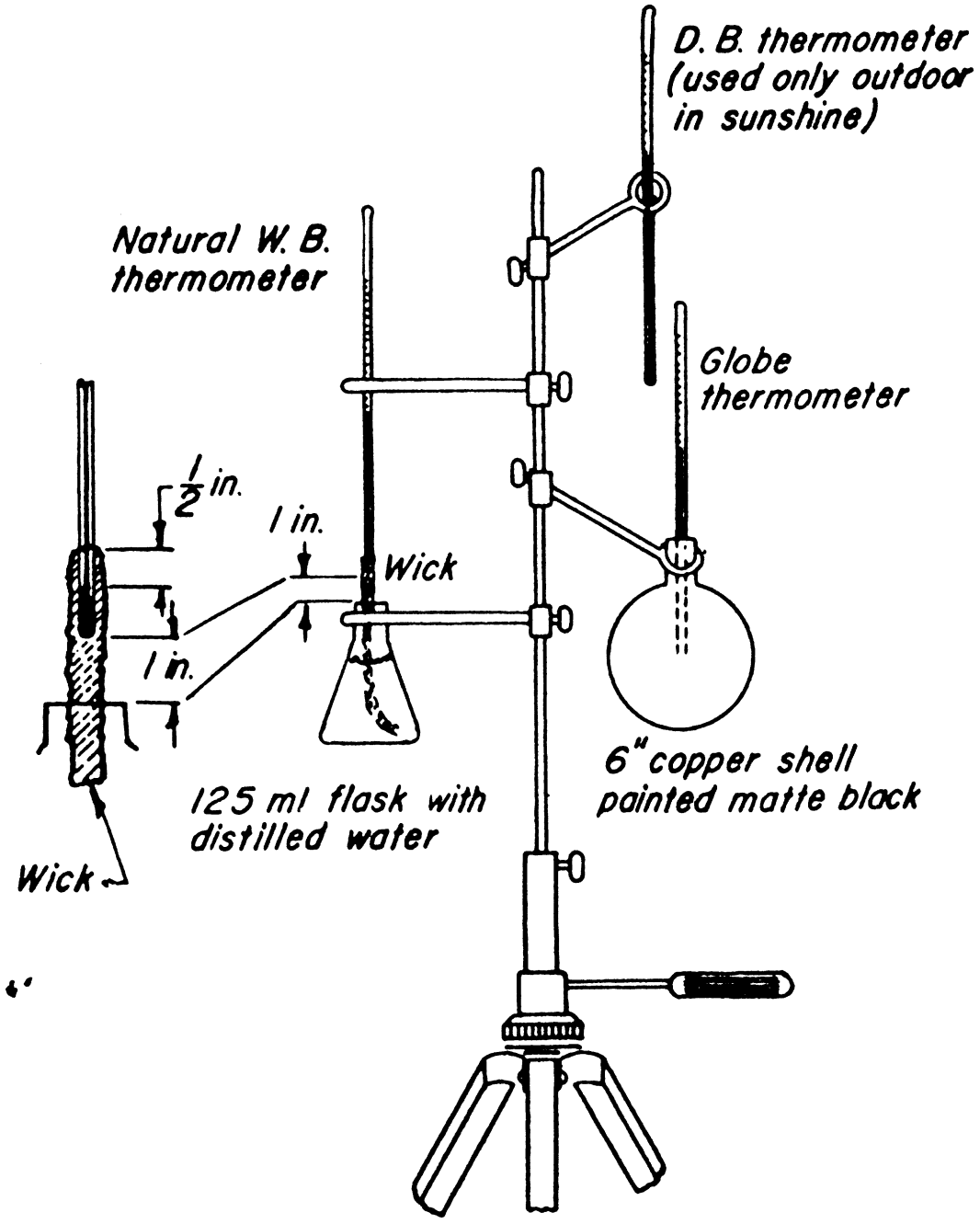


Table 1: Indoor Heat Stress Factors			
Wet Bulb Conversion: Factor A (Wet Bulb Temperature)		Globe Conversion: Factor B (Globe Temperature)	
^{0}C	Factor	^{0}C	Factor
10	7.0	20	6.0
11	7.7	21	6.3
12	8.4	22	6.6
13	9.1	23	6.9
14	9.8	24	7.2
15	10.5	25	7.5
16	11.2	26	7.8
17	11.9	27	8.1
18	12.6	28	8.4
19	13.3	29	8.7
20	14.0	30	9.0
21	14.7	31	9.3
22	15.4	32	9.6
23	16.1	33	9.9
24	16.8	34	10.2
25	17.5	35	10.5
26	18.2	36	10.8
27	18.9	37	11.1
28	19.6	38	11.4
29	20.3	39	11.7
30	21.0	40	12
31	21.7	41	12.3
32	22.4	42	12.6
33	23.1	43	12.9
34	23.8	44	13.2
35	24.5	45	13.5

Table 2: Indoor Heat Stress Calculation

WBGT Heat Stress Measurements

Date	Time	Location	Wet Bulb	Factor A	Globe Temp.	Factor B	WBGT A+B	Ref. Temp.

Note: All temperatures are in degrees

Company name: Department

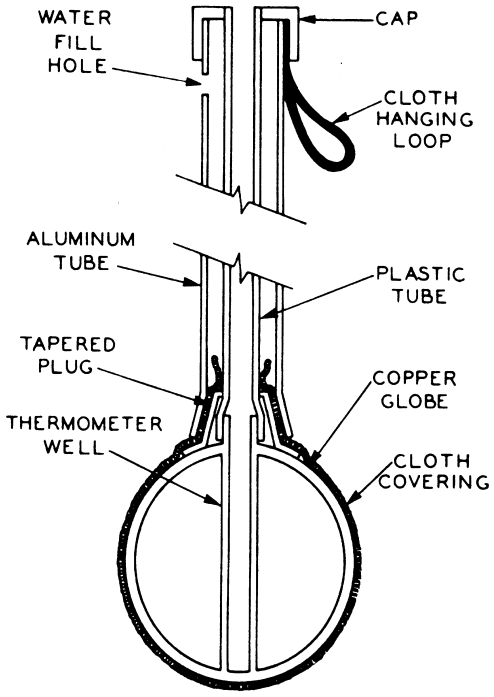
Measurements taken by: Position

The 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



To use the botsball:

- Hang the botsball in a position that represents workers' exposure. Allow the unit to stabilize for about five minutes.
- Record readings in Table 3 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.
- Compare your readings to the guideline tables. Take appropriate measures.
- 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.

Table 3: Botsball Measurements

Date	Time	Location	Botsball Reading	Reference Temp.

Note: All temperatures are in degrees Celsius.

Company name: Department

Measurements taken by: Position

Recommended Rest Break Schedules

WET BULB GLOBE TEMPERATURE (WBGT) INDEX

Work Load	Work Rate			
	Continuous Work	15 minutes rest per hour	30 minutes rest per hour	45 minutes rest per hour
Heavy	up to 25.0°C	25.0°C up to 26.0°C	26.0°C up to 28.0°C	28.0°C up to 30.0°C
Moderate	up to 27.0°C	27.0°C up to 28.0°C	28.0°C up to 29.0°C	29.0°C up to 31.0°C
Light	up to 30.0°C	30.0°C up to 30.6°C	30.6°C up to 31.4°C	31.4°C up to 32.2°C

BOTSBALL INDEX

Work Load	Work Rate			
	Continuous Work	15 minutes rest per hour	30 minutes rest per hour	45 minutes rest per hour
Heavy	<23.0°C	23.0°C up to 24.0°C	24.0°C up to 25.0°C	25.0°C up to 27.0°C
Moderate	<24.5°C	24.5°C up to 25.5°C	25.5°C up to 26.5°C	26.5°C up to 27.5°C
Light	<27.0°C	27.0°C up to 27.5°C	27.5°C up to 28.0°C	28.0°C up to 28.5°C

- The WBGT index in the above tables is based on American Conference of Governmental Industrial Hygienists (ACGIH) TLV Documentation. The Botsball Index is based on: Sundin et al, (1973) conversion of the ACGIH WBGT Index.
- These indices are not equivalent to regular thermometer readings. The tables apply only to acclimatized workers without special needs who are wearing lightweight, light coloured, loose-fitting cotton clothing. Adjustments must be made to these indices for workers with special needs.
- **Heavy work means -** Intermittent lifting, pushing or pulling (such as pick and shovel work) or hard sustained work, such as assembly line activities where workers are paced by machines and cannot stop.
- **Moderate work means -** (1) Work done in a sitting position, but requiring heavy arm and leg motions; or (2) work done while standing and involving moderate work at a machine or bench; or (3) work done while walking about and involving moderate lifting or pushing activities.
- **Light work means -** Sitting or standing; work at a machine or bench that requires mostly arm work.
- **Continuous work -** Assumes that there are short morning and afternoon breaks and a longer lunch break in an eight hour day.
- **Rest breaks -** This 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.

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 vacation or sick leave should be allowed a week to acclimatize. Start with a short exposure to hot work - 20 percent of the time on the first day. Another 20 percent should be added each day after that.

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 30^0C for light work, 27^0C for moderate work and 25^0C for heavy work for any one hour of continuous work. The weighted average is determined by the equation:

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

Where:

- $WBGT_1$ is the work area index
- $WBGT_2$ is the rest area index
- t_1 is the time worked every hour
- t_2 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 30^0C for 45 minutes of each hour if the 15 minute resting period is spent in a 22^0C 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 40
- the obese
- alcohol abusers
- unconditioned or 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 indices exceed the table guidelines

Higher heat exposures than shown in the table should only be permitted where:

- A competent person will determine the maximum safe length of worker exposure to extreme heat, based on past experience in similar conditions.
- Each worker will pace the speed of work and will be able to terminate any particular heat exposure because of strain or discomfort.
- A doctor will determine the fitness of each worker for work in extreme heat.
- Workers will be watched by a trained supervisor or worker who can recognize signs 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 it. Use the precautions previously discussed if necessary.

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 a wet bulb globe thermometer (WBGT) or by a botsball. The WBGT is more 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.