SAFE WORK

S SPOT THE HAZARD
A ASSESS THE RISK
F FIND A SAFER WAY
E EVERYDAY

EVERYONE'S RESPONSIBILITY

Guideline for Thermal Stress

September 2007

Manitoba

Guideline

for

Thermal Stress

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Manitoba

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INTRODUCTION

This guideline will help you develop and implement a thermal stress management program in your workplace to protect workers in both hot and cold environments.

Workplace Safety and Health Regulation Requirements

General Workplace Requirements Regulation, Part 4, addresses thermal stress as follows:

> 4.12 When a workplace or work process exposes a worker to conditions that may create a risk to the worker's safety or health because of heat or cold, an employer must implement safe work procedures and control measures to ensure that
>
> a) the threshold limit values for thermal stress established by ACGIH in its publication, *Threshold Limit Value for Chemical Substances and Physical Agents and Biological Indices,* are followed; and
>
> b) the worker is provided with information, instruction and training in the symptoms of thermal stress and the precautions to be taken to avoid injury from thermal stress.

Workplace Program for Hot or Cold Conditions

A workplace or work site with potential heat or cold-related concerns should have a program in place to address these situations if they arise. The program should include procedures for monitoring and educating workers. It should also have a plan for providing first aid to affected workers.

Prevention is the key. Many factors that contribute to heat or cold-related illnesses or injuries can be controlled to reduce the potential for harm.

Training

Employers must make sure workers exposed to safety or health risks because of hot or cold conditions at the workplace are provided with information, instruction and training on recognizing and avoiding injury or illness from thermal stress.

Provide Effective Supervision

Employers must make sure all supervisors know about heat and cold related illnesses, symptoms, prevention and treatment. Supervisors must be able to recognize unsafe conditions and take corrective action immediately.

Promote Internal Responsibility

Employers should involve the workplace safety and health committee or representative, managers/supervisors and workers in identifying heat and cold stress symptoms, and taking required action immediately.

HOT ENVIRONMENTS

Hot Environments and the Human Body

The human body functions best within a narrow internal temperature range of 36 to 38 degrees Celsius. Below this range, the body's temperature control center in the brain goes to work, directing more blood to vital internal organs and causing shivering to help keep the body warm. In hot environments, more blood is directed toward the skin surface and perspiration increases to help cool the body. When heat loss or gain becomes more than the body can balance, internal systems will begin to fail and shut down, leading to illness and possibly death.

Definitions (for the purpose of this document, the following definitions apply):

Acclimatization – is a gradual process in which the body becomes accustomed to temperature extremes.

Conduction - the transfer of heat to the body by direct contact with a warm object. This is a relatively insignificant source of heat when considering heat gain in the body.

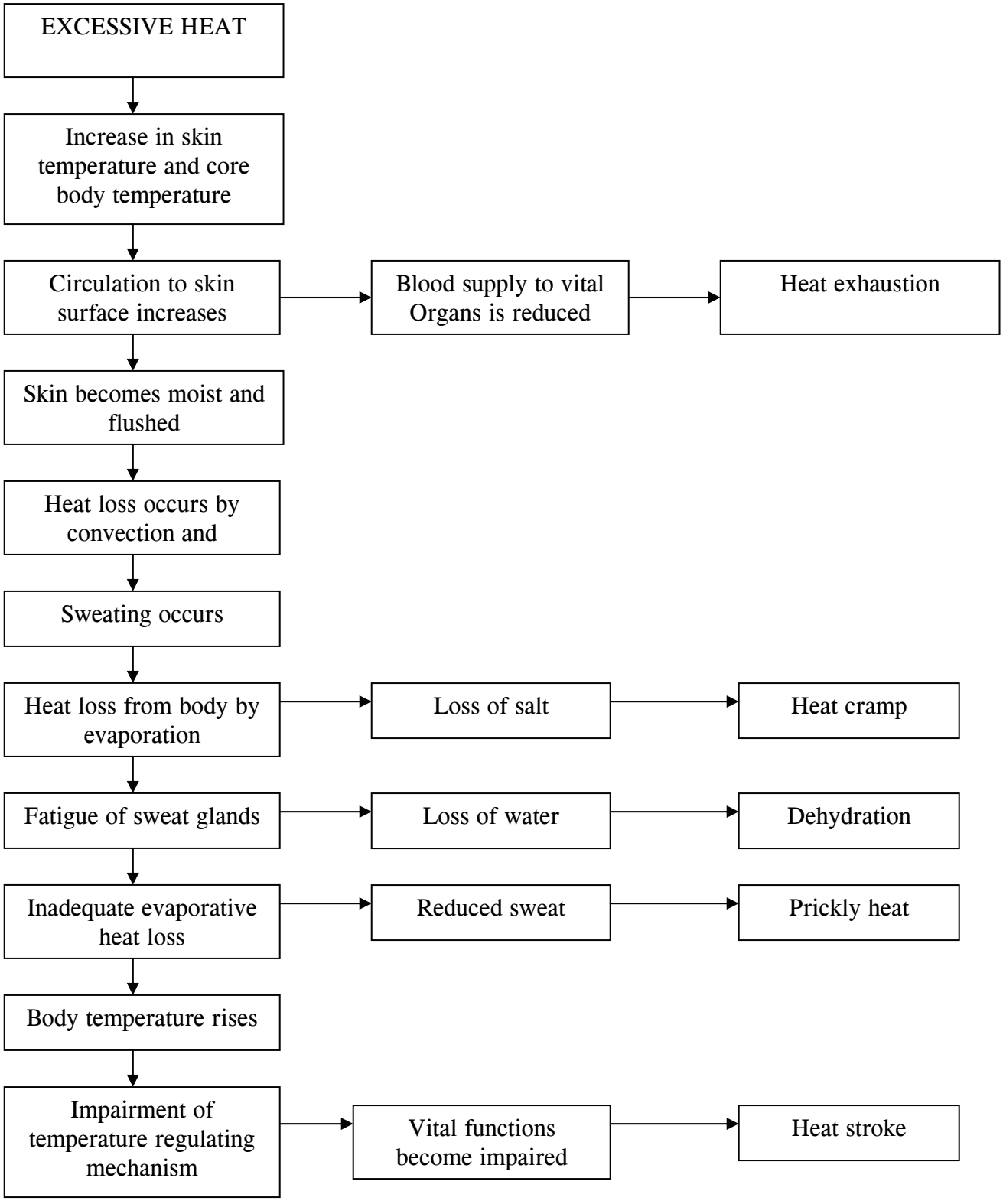
Convection - the exchange of body heat with the surrounding air. If the moving air is cooler than the body temperature, it will cool the body; if warmer, it will increase the heat load. Air speed is an important factor in heat loss or gain.

Evaporation - evaporation of perspiration from the skin is usually the main method of heat removal from the body. As temperature, humidity and rate-of-work go up, so does the rate of perspiration. At very high humidity, sweat does not evaporate as quickly, however, high air speed and low humidity increases evaporation. If it is very hot and dry, excessive perspiration may lead to dehydration (excessive fluid loss from the body).

Heat Stress – The heat load a worker may be exposed to from a combination of metabolic heat while working, environmental factors (ex: air temperature, humidity, air movement, and radiant heat exchange), and clothing requirements. Mild or moderate heat stress may cause discomfort and may negatively affect performance and safety. As the heat stress increases, the risk of heat related health disorders increase.

Radiation - the transfer of heat to the body through air, from a hot source, such as a furnace, an oven or the sun. This is important to note as heat is only lost from the body if the surrounding air is cooler than the body.

BODY RESPONSE TO EXCESSIVE HEAT



The Body's Responses to Heat

Dehydration is a common concern when working in a hot environment. As shown in the illustration on page 3, it is caused by failure to replace the salt and water lost through perspiration. Although perspiring helps the body cool, it is necessary to replace lost fluid and salt.

On average, one to two cups of water per hour are required to replace fluid lost from heavy perspiration. Sugary drinks such as soda pop, and fluids containing caffeine and alcohol should be avoided. Cool, but not cold, water should be provided in a location convenient to workers. Because the feeling of thirst may not be enough to ensure adequate water intake, workers in hot environments should be encouraged to drink at least one cup per hour. Too much water (more than two cups) should not be taken at one time since workers may develop abdominal cramps.

Most people consume enough salt as table salt and as naturally occurring salt in foods. Fruit and vegetable juices can be good sources of natural salt. Encourage workers on salt-restricted diets to discuss salt needs with their doctor. Salt tablets should only be taken on a doctor’s advice.

Heat-Related Illnesses

The table on page 7 summarizes heat-related illnesses in increasing order of severity. It lists signs and symptoms to watch for; factors that influence heat-related illnesses; and a summary of prevention and treatment.

Factors Contributing to Heat-Related Illnesses

Factors other than the environment and workload can influence the body's ability to acclimatize and cope with heat. To avoid heat related illness, such factors should be taken into consideration when assigning worker tasks and deciding on control measures.

HEAT-RELATED ILLNESSES SYMPTOMS, PREVENTION AND TREATMENT

SIGNS & SYMPTOMS	CAUSES	PREVENTION	TREATMENT
HEAT FATIGUE Irritability, tiredness, loss of skill for fine or precision work. Lower ability to concentrate. No change in body temperature.	Lack of acclimatization. Other emotional or psychological stresses. Discomfort in heat.	Proper acclimatization. Rest breaks.	None necessary unless other heat illness present. Removal may be necessary if acclimatization in-effective.
HEAT RASH Prickling sensation during heat exposure. Itchy, tiny red spots on skin covered by clothing. A result of plugged sweat glands.	Skin continuously wet from sweat. Humid heat.	Shower to keep skin clean. Apply powder and mild drying lotions (e.g. calamine).	Keep skin dry. Rest in cool place. May take several days to subside.
HEAT SYNCOPE Giddiness and fainting while standing in hot environment.	Pooling of blood in legs causing drop in blood pressure. Lack of acclimatization. Loss of body fluid from sweating.	Moving from time to time. Proper acclimatization. Drink extra fluids.	Rest in cool area. Recovery usually fast. May need to see physician.
HEAT CRAMPS Sharp pains in muscles of arms, legs or abdominal muscles. May occur during or after work.	Heavy sweating causing loss of salt. Drinking large amounts of water without salt replacement.	Add salt to foods. Drink fluids naturally containing salt (e.g. fruit and vegetable juices).	Move to cool place. Give salted fluids. If severe, may need to see physician.
HEAT EXHAUSTION Headache, nausea, dizziness, weakness, intense thirst. Skin moist and clammy. Rapid, weak pulse.	Loss of water and salt from heavy sweating. Lowered volume of circulating blood. Lack of acclimatization. Sustained exertion in high temperatures.	Drink cool fluids often. Take extra salt in food. Drink fruit juices. Proper acclimatization.	Rest lying down in cool area. Replace body fluids and salt. If vomiting, refer to physician.
HEAT STROKE OR HEAT HYPER-PYREXIA Nausea, headache, dizziness. Hot dry skin (moist in hyperpyrexia). Body temperature 40 c or over. Rapid strong pulse. Convulsions, coma may occur.	Failure of central control of sweating. Prolonged work in hot environment. Unfit, unacclimatized workers. High humidity. Pre-existing medical conditions, use of medications, high alcohol intake.	Medical assessment prior to hot work. Acclimatization. Monitoring of workers during periods of work in heat. Work-rest regimes. Adequate fluid/salt replacement.	Immediate medical attention! Immediate first aid-remove clothing, spray with cool water, fanning, cool wet sheets.

Workers should ask a health professional whether any drugs being taken may increase the risk of heat illnesses. Age generally brings a decrease in efficiency of sweat glands, heart and lungs (after age 45). Gender is an influencing factor since men tend to have a higher sweat rate and larger oxygen intake, and therefore tend to acclimatize better than women. Fitness, size and other factors affect the differences in people's ability to acclimatize.

Lack of acclimatization – the body has not had enough time to adjust, or other factors prevent the body from adjusting to the heat

General state of health – the following medical conditions may be a factor in causing heat illness or may be aggravated by heat:

a) Skin disorders may limit sweating (ex: dermatitis, when aggravated by heat/moisture).

b) Heart and lung diseases may limit ability to cope with heat and may be aggravated by it.

c) Diabetes, poorly controlled, may contribute to dehydration and may be aggravated by excessive heat.

d) Diarrhea may contribute to dehydration.

e) Obesity requires increased energy to move around and the extra insulation reduces heat loss – both contribute to the body's overall heat gain.

Facts about acclimatization – Physically fit, healthy individuals generally acclimatize more quickly. Acclimatization will last for about one week if away from the heat and will disappear completely in three weeks. Drinking extra fluids hastens the acclimatization process.

Medication/drugs – can affect the body's responses to heat and may affect acclimatization. Different medications/drugs may affect different parts of the body:

a) the brain's thermostat is affected by ASA, phenothiazines

b) the sweating function is affected by pilocarpine, and anticholinergic drugs such as hyoscine

c) the circulatory system is affected by antihypertensives, antiarrhythmics, diuretics, alcohol, street drugs

d) the metabolic rate is affected by thyroxin, alcohol, street drugs

Acclimatization

Acclimatization is an important part of working in heat extremes. This section shows ways to help achieve heat acclimatization.

Acclimatization is a gradual process in which the body becomes accustomed to temperature extremes. During initial exposures to a hot environment, workers often feel very tired, irritable and too hot. Body temperatures often rise. After repeated exposures, these symptoms decrease or disappear. When this occurs, a person is considered acclimatized. In the same way that many factors may lead to heat illness, there are differences in people that affect the rate at which they acclimatize.

Acclimatization Schedule

As a rule, acclimatization may take from five to seven days for a healthy worker. New workers with no recent heat exposure should be started (on their first day) with 50 per cent of a normal workload. This may be increased by 10 per cent each day until a full workload is reached. Workers may be assigned to work in cooler areas for portions of the day until fully acclimatized. The added workload will need to be varied if other factors that contribute to heat-related illness are present. Also, adequate fluids must be provided and encouraged for all workers, especially new or returning workers. Workers who have been off the job for a week should be re-acclimatized for two to three days.

Measurement of Occupational Heat Exposure

The *Workplace Safety and Health Act* or regulations do not specify a maximum temperature above which work must stop. Rather, the combination of environmental conditions must be measured and evaluated against a set of exposure limits recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). These exposure limits or threshold limit values (TLV) are published annually in a booklet titled, *Threshold Limit Values and Biological Exposure Indices.*

To measure occupational heat exposure, combine the environmental factors that contribute to heat load, as discussed earlier. The most common method involves the wet bulb globe thermometer (WBGT) or a direct-reading meter, available commercially. These instruments calculate air temperature, air movement, radiant heat and evaporation, indoors or out.

WBGT readings are widely used to estimate the effect of temperature, humidity and solar radiation on humans over time.

The WBGT is composed of three separate temperatures:

1. The air (shade) temperature (Tdb) consists of a thermometer shielded from the radiation. It is the standard temperature normally given in weather observations and forecasts.

2. The natural wet-bulb temperature (Tnwb) is measured by a thermometer with its bulb covered with a wet cotton wick. The cotton wick is always wet, allowing continuous evaporative cooling of the thermometer's bulb, simulating the evaporation of sweat. This temperature reading represents the effect of radiation, humidity and wind.

3. The black globe thermometer (Tg) consists of a black globe with a thermometer located in the center. This temperature reading represents the effects of wind and solar radiant heat.

WBGT values are calculated as follows:

With direct exposure to sunlight:

$$WBGT_{out} = 0.7\ T_{nwb} + 0.2\ T_g + 0.1\ T_{db}$$

Without direct exposure to the sun:

$$WBGT_{in} = 0.7\ T_{nwb} + 0.3\ T_g$$

Information may also be obtained by contacting Workplace Safety and Health at 204-945-3446.

Heat Exposure Limits

The allowable work/rest to prevent heat stress is shown in Table 1 and is adjusted for light, moderate, or heavy work. Recommendations are made for rest breaks when these temperatures are exceeded. See Table 2 for examples of what is meant by these workloads, and for the recommended work-rest schedule when the WBGT temperatures increase.

TABLE 1: Work/Recovery Schedule to Prevent Heat Stress

	WBGT values in Celsius			
Allocation of Work in a Cycle of Work and Recovery	**Light**	**Moderate**	**Heavy**	**Very Heavy**
75% to 100%	31.0	28.0	–	–
50% to 75%	31.0	29.0	27.5	–
25% to 50%	32.0	30.0	29.0	28.0
0% to 25%	32.5	31.5	30.5	30.0

TABLE 2: Classification of Rate of Work

Resting	Sitting quietly, sitting with moderate arm movements
Light	- Sitting with moderate arm and leg movements - Standing with light work at machine or bench, while using mostly arms and/or some walking - Using a table saw
Moderate	- Walking about with moderate pushing or lifting - Walking on level at six kilometres per hour while carrying three kilograms - Scrubbing in a standing position
Heavy	- Carpenter sawing by hand - Intermittent heavy lifting with pushing or pulling (i.e. shovel & pick work) - Shovelling dry sand - Heavy assembly work on a non continuous basis
Very Heavy	- Shovelling wet sand

The values in Table 1 are based on healthy, acclimatized workers wearing one layer of customary work clothing. Water-vapour-impermeable, air-impermeable, thermally insulating clothing, multiple layers of clothing and encapsulating suits severely restrict heat removal. Variations from the customary clothing require modification of the TLV. See Table 3 for suggested modifications.

TABLE 3. Clothing-Adjustment Factors for Some Clothing Ensembles*

Clothing Type	Addition to WBGT [C]
Work clothes (long sleeve shirt and pants)	0
Cloth (woven material) coveralls	0
Double-layer woven clothing	3
SMS polypropylene coveralls	0.5
Polyolefin coveralls	1
Limited-use vapor-barrier coveralls	11

* These values must not be used for completely encapsulating suits, often called Level A. Clothing Adjustment Factors cannot be added for multiple layers. The coveralls assume that only modest clothing is worn underneath, not a second layer of clothing.

Prevention and Control Measures

The risk of heat-related illnesses can be reduced by preventive and control measures, including:

a) engineering controls to provide a cooler workplace
b) administrative controls to reduce exposure and recognize symptoms of heat-related illness
c) personal protective equipment, when necessary, to further limit exposure

Engineering Controls

Engineering controls are the most effective means of reducing occupational heat exposure, including:

- planning during the workplace construction if a hot environment is anticipated
- shielding the radiant heat at the source through insulation and reflective barriers
- exhausting heat and water-vapour (steam) to the outside
- reducing temperature and humidity through ventilation or air-conditioning
- providing cooled observation booths or air-conditioned rest areas
- increasing general air movement if temperature is less than skin temperature (approximately 36 degrees C)
- reducing air movement if air temperature is greater than skin temperature
- reducing physical exertion by changing processes or using machines designed to assist

Administrative Controls

Administrative controls like these are the easiest to put in place, for or by the worker:

- apply a work schedule to allow for heat acclimatization
- increase frequency and length of rest breaks
- schedule hot jobs during cooler times of day
- provide cool drinking water near the work location and encourage workers to drink even if not feeling thirsty
- slow down work pace or assign additional workers to decrease workload
- allow for self-limitation of exposures and encourage co-workers to observe signs and symptoms of heat stress in each other
- provide workers with accurate written and verbal instructions, frequent training programs and other information on heat stress
- consider requiring that, as a condition of hiring, prospective employees provide medical evidence that they are not susceptible to systemic heat related illness
- use air-conditioned rest areas

Personal Protective Equipment

Where engineering or administrative controls are not feasible or practical, occasional use of personal protective equipment may be necessary, including:

- wear insulated or cooled clothing for short-term exposure such as maintenance jobs
- wear clothing that allows free movement of airflow
- wear heat reflective clothing near heat sources such as a hot furnace
- wear light-filtering eye protection when work involves hot objects such as molten metals
- use sunscreen and sun block when working outdoors
- wear a hat and light clothing to protect skin when working in the sun

COLD ENVIRONMENTS

Cold Environments and the Human Body

Cold can be a serious occupational hazard for many workers. Construction, oil and gas extraction, trucking, fire fighting, police work, farming/ranching, fishing, logging and other outdoor jobs are examples of occupations where the potential for serious cold injury exists. Fatal exposures to cold have most commonly resulted from accidental exposures involving immersion in low temperature water and failure to escape from low air temperature environments.

Workers do not need to be exposed to below zero temperatures to experience cold related conditions such as hypothermia. Indoor workers in refrigerated rooms or unheated buildings can also be at risk. Frostbite and hypothermia are two conditions of particular concern.

Cold stress exposure charts can help protect workers from the severest effects of cold stress and cold injury. They describe cold working conditions most workers can handle repeatedly without adverse health effects. They can help workers prevent cold injuries by determining when the risk is too high.

Definitions:

Frostbite – happens when tissue freezes. Any exposed skin is subject to frostbite when temperatures fall below freezing. Frostbite can lead to scarring, permanent tissue damage, possible amputation and disability. Symptoms of frostbite vary according to severity. Mild cases may produce prickling or burning sensations. Severe frostbite can produce extreme pain or none at all if nerve tissues are affected.

Hypothermia - occurs when the core body temperature drops below a level that allows it to maintain normal metabolic function, often only one or two degrees. Initial symptoms include a sensation of cold, followed by pain. As exposure time increases, the sensation of pain is reduced and overall numbness develops. Additional symptoms may include muscle weakness, confusion, slurred speech and drowsiness. Hypothermia can rapidly progress to coma and death.

Wind Chill Cooling Rate – is the heat loss from a body, often expressed in watts per square meter. This rate is a function of air temperature and wind velocity.

Factors that Contribute to the Risk of Cold Injury:

- temperature
- wind speed
- moisture (perspiration or working near water)
- exposure duration
- type of clothing

- work/rest schedule
- type of work performed
- use of certain medications
- degree of acclimatization (previous exposure to the cold)
- age and physical state of the worker

Adequate Insulating Dry Clothing

Workers must wear adequate insulating dry clothing if work is performed in air temperatures below 4 C in order to maintain the core body temperature above 36 C. The cooling power of air and the wind chill cooling rate are critical factors. The lower the air temperature and the higher the wind speed, the greater the insulation value of the protective clothing must be. The combined effect of temperature and wind speed as shown in Table 4 should be used in determining the requirements for warm-work periods.

TABLE 4: The Cooling Power of Wind (°C)

Estimated wind speed (in km/h)	Actual temperature reading (°C)												
	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
	Equivalent chill temperature (°C)												
Calm	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
8	9	3	-2	-7	-12	-18	-23	-28	-33	-38	-44	-49	-54
16	4	-2	-7	-14	-20	-27	-33	-38	-45	-50	-57	-63	-69
24	2	-5	-11	-18	-25	-32	-38	-45	-52	-58	-65	-72	-78
32	0	-7	-14	-21	-28	-35	-42	-50	-56	-64	-71	-78	-84
40	-1	-8	-16	-24	-31	-38	-46	-53	-60	-67	-76	-82	-90
48	-2	-10	-17	-25	-33	-40	-48	-55	-63	-70	-78	-86	-94
56	-3	-11	-18	-26	-34	-42	-50	-58	-65	-73	-81	-89	-96
64	-3	-11	-19	-27	-35	-43	-59	-59	-66	-74	-82	-90	-98
(Wind speeds greater than 64 km/h have little additional effect.)	LITTLE DANGER In < 1 hr with dry skin. Maximum danger of false sense of security.				INCREASING DANGER Danger from freezing of exposed flesh within one minute.			GREAT DANGER Flesh may freeze within 30 seconds.					
	Trenchfoot and immersion foot may occur at any point on this chart.												

Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36°C (96.8° F) per cold stress TLV.

Warm – Up Periods

When continuous work in an equivalent chill temperature (ECT) at or below -7 C is required, heated shelters (cabins, tents, rest rooms etc.) should be available nearby. These shelters should be used as frequently as required, depending on the severity of the cold conditions. Immediate use of the shelter is required by workers with the onset of heavy shivering, minor frostbite, excessive fatigue, irritability, drowsiness or euphoria. When entering a heated shelter, the worker should remove the outer layer of clothing and loosen the remainder of the clothing to allow sweat evaporation. Warm, sweet drinks and soups should be provided for caloric intake and fluid volume. The intake of coffee should be limited due to the effects on the renal and circulatory system.

When working in conditions at or below -12 C ECT, the following measures should be in place:

1. a buddy system or supervision of workers
2. limit the amount of heavy work (to avoid heavy perspiration)
3. provide workers with required protective clothing and allow workers to become accustomed to the cold working conditions
4. all work performance (including weights to be lifted by the worker) should take into consideration the bulkiness and weight of workers' clothing
5. encourage continuous body movement (minimize sitting or standing still) in cold environments, and protect workers from drafts
6. training for workers should include at a minimum:
    - proper clothing practices
    - proper eating and drinking habits
    - proper re-warming procedures and first aid
    - signs and symptoms of impending frostbite
    - signs and symptoms of impending hypothermia
    - safe work practices

Workplace Monitoring

1. Suitable thermometers should be available where the air temperature is below 16 C.

2. When the air temperature falls below -1 C, a dry bulb temperature should be measured and recorded every four hours.

3. Indoor environments: wind speed should be recorded every four hours, whenever air movement exceeds two meters per second.

4. Outdoor work: wind speed should be measured and recorded whenever the air temperature is below -1 C.

5. Equivalent wind chill should be obtained when air movement measurements are required and recorded whenever equivalent chill temperature is below -7 C (see Table 4).

The following Table should be used to determine the ratio of warm up to work periods.

TABLE 5

Work/Warm-up Schedule for Four Hour Shifts and Moderate to Heavy Work Activity*

	No Noticeable Wind		8 km/h Wind		16 km/h Wind		24 km/h Wind		32 km/h Wind	
Air Temperature °C (Sunny Skies)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26 to -28	Normal	1	Normal	1	75 mins.	2	55 mins.	3	40 mins.	4
-29 to -31	Normal	1	75 mins.	2	55 mins.	3	40 mins.	4	30 mins.	5
-32 to -34	75 mins.	2	55 mins.	3	40 mins.	4	30 mins.	5		
-35 to -37	55 mins.	3	40 mins.	4	30 mins.	5				
-38 to -39	40 mins.	4	30 mins.	5						
-40 to -42	30 mins.	5								
-43 and below										

In all shaded areas non-emergency work should cease

This schedule applies to moderate-to-heavy work with breaks of 10 minutes in a warm location to allow workers to warm up. For light-to-moderate work (little physical movement), apply the schedule one step lower. For example at -35°C with no noticeable wind, a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour shift instead of 55 minute work periods and 3 breaks.

* Adapted from Occupational Health & Safety, Saskatchewan Department of Labour

Older Workers or Workers with Circulation Problems

Older workers or workers with circulation problems require special precautionary protection against cold injury, including the use of extra insulating clothing and/or reduced exposure time. Precautionary actions should be determined with the advice of a physician.

Evaluation and Control

1. Continuous skin exposure should not be permitted when air speed and temperature results in an equivalent chill temperature of -32 C. Deep tissue freezing will occur only at temperatures below -1 C, regardless of wind speed.

2. At air temperatures of 2 C or less, workers who become immersed in water, or whose clothing becomes wet, must be provided a change of dry clothing and be treated for hypothermia.

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