
Workplace Health and Safety Bulletin



Working in the Cold

Introduction

Many Alberta workers may be at risk of exposure to cold temperatures and cold water during their work activities. Exposure to cold conditions occurs during outdoor, seasonal work, and indoors in refrigerated or cold storage areas. Workers exposed to cold conditions may have their health, safety, and productivity affected.

The human body functions most efficiently within a narrow temperature range. At 2°C above or below the body’s normal temperature of 37°C, additional stress is placed on the body to regulate its temperature e.g. shivering to keep warm and perspiring to keep cool. Sources of heat external to the body can help to maintain and regain body temperature. However, preserving the heat generated internally by the body and maintaining the body’s ability to produce this heat are key to maintaining personal comfort and performance in the cold.

Susceptibility to cold injury varies from person to person. Table 1 summarizes some of the factors involved in cold stress.

Table 1 Factors Involved in Cold Stress

Environmental	Personal Characteristics	Other
<ul style="list-style-type: none"> ▪ Temperature ▪ Wind ▪ Humidity 	<ul style="list-style-type: none"> ▪ Age ▪ Weight ▪ Fitness ▪ impaired circulation ▪ previous cold injury ▪ acclimatization to cold 	<ul style="list-style-type: none"> ▪ clothing ▪ physical activity ▪ fatigue ▪ a worker’s use of medication(s) ▪ consumption of alcohol or use of nicotine

Heat Loss and Maintaining Heat Balance

Body heat can be lost in any of the following ways:

- (a) immersion of body parts e.g. the hands and feet (or the entire body) in cool or cold liquids;
- (b) direct contact with cold surfaces e.g. the ground, tools, machinery, products being handled;
- (c) conduction of heat through wet or damp clothing, including clothing damp with perspiration;
- (d) exposure to cold air, including inhaled and exhaled cold air;
- (e) evaporation of sweat; and
- (f) consumption of cold liquids or foods.

The body maintains heat balance in two main ways:

- (1) *Restricting blood flow* – the body automatically reduces the amount of blood circulating through the skin and cooled body parts by constricting blood vessels supplying blood to those regions. By doing so, warm blood is diverted to the body's core, maintaining the temperature of internal organs and the brain.
- (2) *Shivering* - this can temporarily raise a person's body temperature. Slight to moderate shivering is not uncomfortable and will warm a person. Severe, uncontrolled shivering occurs when body temperature falls to 35 EC (normal body temperature is 37EC). During severe shivering, body heat production can rise to as high as 4 to 5 times normal. Severe shivering is a sign of danger and a severely shivering worker should be immediately removed from exposure to the cold.

The Effects of Cold on Performance

The ability of workers to function and work normally is affected by exposure to cold conditions. The changes to human performance under such conditions are due to two factors:

- (1) the environmental temperature; and
- (2) the clothing required to function at a particular temperature.

As temperature decreases and the duration of exposure increases, the following changes can be experienced:

- reduced dexterity of the hands and feet;
- reduced tactile sensation;
- impaired ability to perceive heat, cold, and pain;
- reduced joint mobility;
- reduced grip strength;

- hypothermia i.e. reduced body temperature, which in its extreme form can result in death;
- frostbite i.e. frozen tissue, or frostnip – very mild, superficial freezing of exposed skin;
- reduced coordination; and
- reduced decision-making ability.

The clothing worn to maintain personal comfort in the cold can limit performance in the following ways:

- hats and hoods may interfere with hearing, vision, and movement;
- bulky clothing layers may restrict movement
- gloves, mittens, and overmitts may reduce dexterity and tactile “feel”;
- footwear may be heavy and bulky, compromising the ability to use footholds and vehicle foot pedals; and
- the weight and bulk of clothing increases the amount of effort required when moving.

Most of these clothing limitations can be overcome by carefully selecting clothing appropriate for the tasks being performed and the temperatures at which they are performed.

Prevention and Control

If workers are or may be exposed to conditions that could cause hypothermia or cold-related injury, a risk assessment should be performed to determine areas and tasks where the workers may be at risk. The potential for accidental exposure to cold conditions should be included in this assessment.

(1) Environmental Measures

- (a) Temperature and wind conditions at the work location should be known e.g. weather report on the radio, current weather office information.
- (b) Steps should be taken to protect workers from wind (or indoors from drafts or forced air from air handling units). The combination of low temperatures and even moderate winds can quickly create dangerous working conditions. Table 2 clearly demonstrates the effects of temperature and wind speed.
- (c) Ensure that heated rest areas such as a truck cab, tent or hut are available.

Table 2 Cooling Power Of Wind On Exposed Flesh Expressed As An Equivalent Chill Temperature

		Actual Temperature Reading (°C)										
Estimated Wind Speed In kph	10	4	-1	-7	-12	-18	-23	-29	-34	-40	-46	-51
Equivalent Chill Temperature												
Calm	10	4	-1	-7	-12	-18	-23	-29	-34	-40	-46	-51
8	9	3	-3	-9	-14	-21	-26	-32	-34	-44	-49	-56
18	4	2	-9	-16	-23	-31	-36	-43	-50	-56	-64	-71
24	2	-6	-13	-21	-28	-38	-43	-50	-58	-65	-73	-80
32	0	-8	-16	-23	-32	-39	-47	-55	-63	-71	-79	-85
40	1	-9	-18	-26	-34	-42	-51	-59	-67	-76	-83	-92
48	-2	-11	-19	-28	-36	-44	-53	-62	-70	-78	-87	-96
56	-3	-12	-20	-29	-37	-46	-55	-63	-72	-81	-89	-98
64	-3	-12	-21	-29	-38	-47	-56	-65	-73	-82	-91	-100

Wind speeds greater than 64 kph have little additional effect

Little Danger
If exposure is for less than one hour and skin and clothing are dry. However, workers should be aware of a false sense of security.

Increasing Danger
Exposed flesh may freeze within one minute

Great Danger
Exposed flesh may freeze within 30 seconds

(From ACGIH 1999)

(2) Work Practices

A schedule of regular rest breaks should be established to allow workers to warm up. These breaks should be not less than 10 minutes in length and should be taken in a heated area. Outer clothing should be removed to prevent overheating and sweating when in the heated area. Returning to cold work while damp or sweaty may result in rapid chilling. The following recommended work practices should be followed (adapted from ACGIH, 1999):

Under conditions of continuous work in the cold:

- (a) heated warming shelters (tents, cabins, rest rooms etc.) should be provided. Workers should be encouraged to use these at regular intervals, the frequency of use depending on the severity of environmental exposure;
- (b) when entering the heated shelter, outer and middle clothing layers (as necessary) should be removed to prevent overheating and to permit dampness to evaporate. A change of dry clothing may be necessary;
- (c) warm fluids should be consumed at the work site to provide energy, warmth, and replace fluids lost during work. Significant fluid loss can occur in the cold due to sensible and insensible sweating, breathing, and the extra energy requirements of working in the cold. Dehydration in the cold is a serious concern, increasing a worker's susceptibility to hypothermia; and
- (d) the onset of severe shivering, the feeling of excessive fatigue, drowsiness, irritability or euphoria are indications for immediate return to the shelter.

The following additional precautions apply at colder temperatures:

- (e) workers should be under constant protective observation by a buddy or supervisor;
- (f) work rate should not be high enough to cause sweating. If heavy work must be performed, rest periods in heated shelters and the opportunity to change into dry clothing should be provided;
- (g) new employees should not be required to work full-time in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing;

- (h) weight and bulkiness of clothing should be included in estimating required work performance;
- (i) work should be arranged to minimize periods of standing or sitting still; and
- (j) workers should be appropriately trained as outlined in Section (4) Worker Training.

(3) Personal Measures

(a) Diet

Workers have increased energy requirements when working in the cold. Consider adding additional wholesome foods to the diet such as pasta, potatoes, rice, dairy products, nuts, meat, herring, and salmon. Light snacks and warm fluids should be taken during rest breaks.

Alcohol must not be consumed when working in the cold. Alcohol produces a deceptive feeling of warmth but may contribute to dehydration and impair judgement.

(b) Dressing for the Cold

To stay warm in the cold,

- (1) clothes must be layered to manage moisture and keep dry,
- (2) insulating layers must trap air to stay warm, and
- (3) the worker must be protected from the wind and weather.

To remain comfortable as weather and work conditions change, clothing layers should be added or removed, or ventilation openings in clothing opened or closed to remain comfortable. Clothing layers should be managed to remain comfortably warm.

Every effort must be made to avoid sweating and becoming damp. Clothing selections are normally made on the basis of staying warm while inactive. Consider the work to be performed and the weather conditions, then have workers dress so that layers can be shed and they can still remain comfortably warm. If clothing layers do become damp and remain that way, workers should be prepared to replace them *before* becoming chilled and hypothermic. If a worker is sweating, then their clothing is probably too warm for the conditions and tasks being performed.

The following approach of using three clothing layers – inner, middle and outer – is applicable to all situations. However, the recommended synthetic fabrics may not be appropriate for situations requiring clothing with fire resistant (FR) or anti-static properties. FR clothing next to the skin must be made of non-melting natural fibres such as wool or silk or an acceptable fire retardant material. The general practices described below should be followed, recognizing that the fabrics selected may be limited by specific, special work applications.

Inner Layer

- The first layer of clothing should manage moisture by moving perspiration away from the skin to keep the worker dry and comfortable.
- Avoid cotton, especially in long underwear and socks. Once cotton is wet, whether through perspiration, rain, or snow, it loses all insulating properties.
- For long underwear, brands made of synthetic fibers (e.g. polyester, polypropylene, etc.), silk, or wool retain body heat when wet and wick perspiration to outer clothing layers for evaporation, leaving the body dry. Many types of long underwear are available in varying thicknesses or weights depending upon intended activity level and weather conditions. Select an appropriate style and thickness of long underwear.

Middle Layer

- The second or middle layer(s) should trap warm air escaping from the body and hold it in open spaces within the layer(s) to keep the worker warm and insulated. Workers should wear several thin layers of clothing rather than one heavy garment. Layers can be added or removed, depending upon weather and activity level.
- Select lightweight clothing that provides freedom of movement. Multiple middle layers give a worker the ability to tailor their need for warmth based on environmental temperature and activity level.
- Look for middle layers that can be added or removed easily. Zippered neck openings and zippered leggings allow for ventilation.
- A down vest or jacket may be an appropriate middle layer.

Outer Layer

- The outer layer should provide protection from wind, rain, sleet, snow and identified workplace hazards. It should also keep cold air and moisture from penetrating into the middle layer(s). Breathable fabrics may or may not be necessary. Windproofness is a critical feature of an outer layer used in the cold outdoors.
- Two-way zippered front openings can be used to regulate heat load and ventilate the body.
- An outer layer having arm-pit zippers can be helpful in providing ventilation.
- Windproof pants or “wind pants”, fully zippered from ankle to hip, can be added or removed without footwear having to be removed.
- Jackets with hoods offer an additional layer of protection for the head. Newer hood designs provide unimpeded views and free movement.
- Cotton twill made water and windproof may be an alternative.

The extremities must also be protected. The following suggestions apply to the hands, head and feet.

Handwear

- Mittens keep hands warmer than gloves since fingers are together. With gloves, fingers are separated, losing heat from one another.
- Have workers wear thin glove liners under gloves or mittens. Liners need not be removed when removing the gloves.
- Removable glove and mitten liners can be replaced and dried when they become damp.
- New mitten styles include three-finger “lobster claws” which keep fingers warm yet offer good dexterity.
- Windproof overmitts offer additional hand protection without adding significant bulk.

Headwear

- Up to 50 percent of body heat is lost through the head. A hat or other head protection must be worn in the cold.
- Avoid cotton and use synthetic fabrics or wool instead.
- Workers must use an appropriate hard hat liner to reduce heat loss when wearing a hard hat.

- Select a hat appropriate for the weather conditions and activity level. Consider thickness, extent of head coverage (e.g. open-faced or full balaclava, ear coverage, etc.), need for windproofness, effect on vision and hearing, and ability to fit into or over protective headwear if required.
- A facemask and eye protection may be necessary under some circumstances.

Footwear

- Warm, insulated safety footwear is essential. Boots should have thick soles for insulation while standing in snow or on cold concrete. Footwear selection should be based on the work being performed, the surfaces on which the worker will work, and the weather conditions to which the worker will normally be exposed. Tight-fitting boots reduce circulation and can make feet feel cold.
- Footwear should be sized so that it will accommodate an extra layer(s) of socks. A synthetic sock liner worn beneath a synthetic blend or wool outer sock wicks moisture away from the skin, keeping feet drier and warmer.

(4) Worker Training

Workers should be instructed in health and safety procedures appropriate to the tasks and environment in which those tasks are performed. This instruction should also include:

- (a) proper rewarming procedures and appropriate first aid treatment;
- (b) how to dress for the cold;
- (c) recognition of frostnip and frostbite; and
- (d) recognition of the signs and symptoms of impending hypothermia.

Additional special training may be required for those workers working in remote locations.

Table 3 presents a recommended schedule of maximum cold weather work periods which should be followed by a rest period. The table takes into account the combination of wind and temperature, and applies to moderate to heavy work activity. The notes at the bottom of the table explain how to adjust its recommendations for lighter work activity.

The cold stress threshold limit values (TLVs) presented in Table 3 are intended to protect workers from the severest effects of cold stress (hypothermia) and cold injury. Table 3 is based on exposure to cold working conditions under which it is believed that nearly all workers can be repeatedly exposed without adverse health effects.

Special Precautions:

- Exposure to vibration may increase a worker's susceptibility to cold injury because of the way that vibration can reduce circulation, particularly in the extremities.
- Work performed in snow- or ice-covered terrain may require tinted safety eyewear and/or sunglasses with side shields. If there is a potential for eye hazards from blowing snow or ice crystals, special safety goggles should be worn. Workers in such situations should be prepared for white-out conditions, having a plan in place regarding movement and navigation under such conditions.
- Alcohol must be avoided. It produces a deceptive feeling of warmth but can affect circulation, fluid balance, and judgement.
- Limit the consumption of caffeine-containing beverages because they act as diuretics, affecting hydration.
- Workers with health conditions that affect normal body temperature regulation or impair circulation e.g. Raynaud's syndrome, diabetes, thrombophlebitis, etc. should take appropriate precautions when working in the cold.
- Body parts that have sustained a frostnip or frostbite injury are sensitive to re-injury. Workers should be aware of this and limit opportunities for re-injury.
- If loose or bulky clothing is worn, special care should be taken when working around moving equipment or machinery to prevent clothing entrapment.

Cold Weather Health Problems

Table 4 summarizes the most common health problems workers are likely to encounter while working in cold – frostbite, trench foot or immersion foot, and hypothermia.

Table 3 Threshold Limit Values (TLV) Work/Warm-Up Schedule for Work in Cold Environments for Four-Hour Shifts

Air Temperature Sunny Day	No Noticeable Wind		8 kph Wind		16 kph Wind		24 kph Wind		32 kph Wind	
°C (approx)	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 work hours and break periods	1	Normal work hours and break periods	1	75 min	2	55 min	3	40 min	4
-29° to -31°	Normal work hours and break periods	1	75 min	2	55 min	3	40 min	4	30 min	5
-32° to -34°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35° to -37°	55 min	3	40 min	4	30 min	5	Non-emergency work should cease			
-38° to -39°	40 min	4	30 min	5	Non-emergency work should cease					
-40° to -42°	30 min	5	Non-emergency work should cease							
-43° & below	Non-emergency work should cease									

From ACGIH 1999

Notes:

- (1) The schedule applies to any 4-hour work period with moderate to heavy work activity, with warm-up periods of 10 minutes in a warm location, and with an extended break (e.g. lunch) at the end of the 4-hour work period in a warm location. For Light-to-Moderate Work (limited 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 period because they generate less body heat when they are less active and therefore, will get colder sooner.
- (2) The following is suggested as a guide for estimating wind velocity if accurate information is not available: 8 kph: light flag moves; 16 kph: light flag fully extended; 24 kph: raises newspaper sheet; 32 kph: blowing and drifting snow.
- (3) If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be
 - (a) special warm-up breaks should be initiated at a wind chill of about 1750 W/m², and;
 - (b) all non-emergency work should cease at or before a wind chill of 2250 W/m². Wind chill cooling rate is defined as heat loss from a body expressed in watts per meter squared which is a function of the air temperature and wind velocity upon the exposed body.




In general, the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing are appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder range because windy conditions rarely prevail at extremely low temperatures.
- (4) These TLVs apply only for workers in dry clothing.

Table 4 Cold Weather Health Problems

Signs and Symptoms	Cause	Treatment	Prevention
<p>FROSTBITE</p> <p>Loss of sensation</p> <p>Cold, pale, waxy skin</p> <p>Formation of ice crystals (freezing) in tissue</p> <p>Usually affects nose, fingers, or toes</p>	<ul style="list-style-type: none"> • exposure to cold for an extended period of time with improper or no protection • touching very cold metal surfaces such as a fence, door handle, or tool • blood supply to extremities reduced or obstructed • contact with fluids such as gasoline, cleaning fluid, etc. that evaporate very quickly 	<ul style="list-style-type: none"> • affected areas should be warmed by placing warm hands against them (do not rub), by blowing on them, or by moving to a warm area • frostbitten tissue must not be thawed if there is any chance that it will refreeze • if the injury affects entire fingers or toes, they should be rewarmed by immersion in warm – not hot – water for approximately 20-30 minutes. The use of other heat sources such as flames and radiant heaters that may rewarm injured tissue unevenly or too quickly should be avoided • once seriously injured tissue has been rewarmed, it should be wrapped in soft material and the affected area elevated • medical help should be obtained as soon as possible 	<ul style="list-style-type: none"> • adequate clothing must be worn • exposure to cold should be limited • warm-up breaks should be taken • fellow workers should be warned of white waxy areas on skin


Signs and Symptoms	Cause	Treatment	Prevention
<p>TRENCH FOOT OR IMMERSION FOOT</p> <p>Minor – reddening of the skin, slight numbness</p> <p>Mild – swelling, numbness (reversible)</p> <p>Moderate – swelling, redness, bleeding into the skin, nerve damage</p> <p>Severe – swelling, bleeding into the skin, tissue death; intense foot pain, with swelling</p>	<ul style="list-style-type: none"> • results from continuously having wet feet in cold water at near-freezing temperatures • water temperature need not be below freezing to cause injury 	<ul style="list-style-type: none"> • warm and dry feet. Further exposure should be prevented and medical aid sought out 	<ul style="list-style-type: none"> • footwear should be comfortable, waterproof, and not too tight. Feet and socks must be kept dry • feet should not be allowed to remain wet for prolonged periods of time • a spare pair of dry socks should be available • boots and wet socks should be removed as soon as possible. Feet should be dried and massaged well to promote circulation
<p>HYPOTHERMIA</p> <p>Cold extremities which are numb and clumsy; severe shivering; reduced mental alertness with irritability; lack of concentration; unusual or bizarre behaviour</p> <p>The normal shivering response stops in severe hypothermia</p> <p>Loss of consciousness, coma and death can occur if not treated</p>	<ul style="list-style-type: none"> • overcooling of the body due to excessive loss of body heat • dehydration and fatigue are contributing factors 	<ul style="list-style-type: none"> • the person should be removed from the cold and further exposure prevented • wet clothing should be removed and the victim rewarmed by wrapping in blankets. In severe cases the victim's outer clothing should be removed and the victim placed in a sleeping bag or blanket with one or two warm people (so that the body heat of the warm people can warm up the victim). Medical aid should be contacted as soon as possible for advice and assistance • full body immersion in warm water at 38°- 40° C may be necessary in serious cases • a conscious victim should be given sips of warm, non-alcoholic drinks. Alcohol must not be given 	<ul style="list-style-type: none"> • adequate clothing must be worn to remain warm and dry • exposure to cold should be limited • workers must remain hydrated and well fed • warm-up breaks should be taken • if possible, working alone should be avoided and workers should watch for signs of hypothermia in their co-workers


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