

# COLD STRESS GUIDELINES

## Legal Requirement

Employers in Nova Scotia have a duty under clause 13(1) of the *Occupational Health and Safety Act* to take every reasonable precaution to ensure the health and safety of persons at or near the workplace.

Under clause 2(3) of the *Workplace Health and Safety Regulations*, an employer must ensure compliance with the threshold limit values for exposure to physical agents, as listed in the latest version of the publication by the American Conference of Governmental Industrial Hygienists on Threshold Limit Values and Biological Exposure Indices (ACGIH TLVs and BEIs). Cold stress is covered as a physical agent with applicable guidance and the controls needed.

## Hazard Summary

Employees who work in or are exposed to cold and cold environments could be at risk of cold stress and related illnesses and injuries (hypothermia, frostbite, trench foot, chilblains, etc.). This applies to cold environments that occur both naturally (e.g. outdoor weather conditions) as well as artificially created (e.g. refrigerated environments).

## What is cold stress

Cold is a physical hazard and cold stress can impact workers who are not adequately protected against cold conditions. When the human body is unable to sufficiently warm itself, cold-related illnesses and injuries can occur that could lead to tissue damage and potentially death.

## What factors influence severity of cold stress

Environmental factors that influence the severity of cold stress and the perception of cold include air temperature, wind speed, and humidity. Personal factors include physical activity, work/rest timing, protective clothing, age, gender and medical conditions, etc.

## Symptoms and illnesses

The normal core temperature of the human body is 37 °C. The body maintains this by preventing heat loss and increasing heat production. In cold environments, the blood vessels in the skin and extremities constrict to minimize cooling of the blood and to keep the core/internal organs warm. Continued exposure can lead to the following injuries or illnesses:

Table 1 Cold Stress Illnesses and Symptoms

Illness/Injury	Symptoms
<b>Hypothermia:</b> When the human body is exposed to cold temperatures, it will eventually begin to lose heat more quickly than it can produce it and lead to a depletion of the body's	Early Stage <ul style="list-style-type: none"><li>• Shivering</li><li>• Confusion/disorientation</li></ul>

<p>stored energy resulting in an abnormally low body temperature (hypothermia). When the body temperature is too low it affects the brain, and can prevent self-rescue from the cold environment and possible death.</p> <p>Hypothermia is defined as a core body temperature below 35 °C.</p>	<ul style="list-style-type: none"> <li>• Fatigue</li> <li>• Loss of coordination</li> </ul> <p>Late Stage</p> <ul style="list-style-type: none"> <li>• Lack of shivering</li> <li>• Slowed breathing and pulse</li> <li>• Dilated pupils</li> <li>• Blue skin</li> <li>• Loss of consciousness</li> </ul>
<p><b>Frostbite:</b> Frostbite results from tissue freezing (temperature decreases below 0 °C). It causes a loss of sensation and color in the impacted areas. Areas most impacted are the nose, cheeks, chin, fingers and toes. It can cause permanent tissue damage and in extreme cases may require amputation of the affected tissue.</p>	<ul style="list-style-type: none"> <li>• Reduced blood flow to extremities (tissue in fingers and toes may freeze)</li> <li>• Numbness</li> <li>• Tingling or stinging sensation</li> <li>• Aching</li> <li>• Waxy skin that is bluish or pail</li> </ul>
<p><b>Trench Foot:</b> Trench foot/Immersion foot results when the feet are exposed to wet and cold conditions for an extended period. If feet remain wet, it can occur at temperatures as high as 16 °C as feet that are wet lose heat 25 times faster than those that are dry. The body reduces blood circulation in the feet to prevent heat loss resulting in tissue death due to lack of oxygen and nutrients/buildup of toxic products.</p>	<ul style="list-style-type: none"> <li>• Reddened skin</li> <li>• Numbness</li> <li>• Cramps in the legs</li> <li>• Swelling</li> <li>• Tingling pain</li> <li>• Skin blisters and/or ulcers</li> <li>• Bleeding or bruising under the skin</li> <li>• Gangrene (foot may eventually turn dark purple/blue/gray)</li> </ul>
<p><b>Chilblains:</b> Repeated exposure of skin to temperatures that are just above freezing up to (0 to 16 °C) can cause chilblains. The repeated cold exposure can cause permanent damage to the small blood vessels (capillaries) in the skin causing redness and itching that will return with subsequent exposures. This typically occurs on the cheeks, ears, fingers and toes.</p>	<ul style="list-style-type: none"> <li>• Redness</li> <li>• Itching</li> <li>• Inflammation</li> <li>• Blistering</li> <li>• Ulceration (severe cases)</li> </ul>

Source: Adapted from NIOSH: Cold Stress – cold related illnesses.

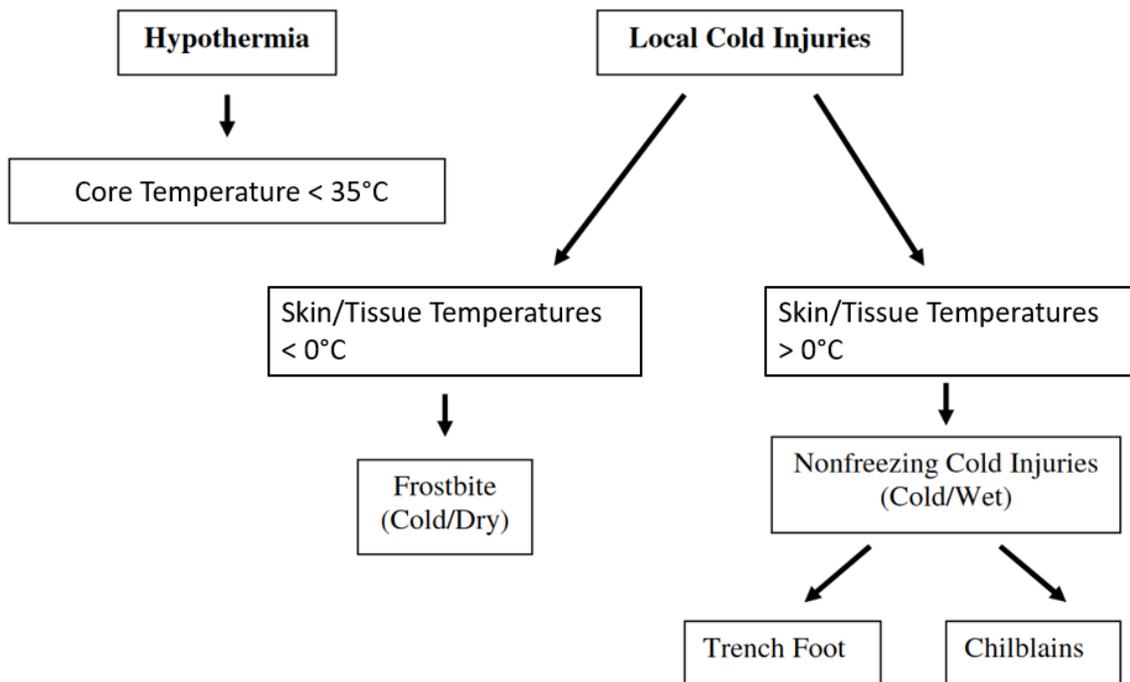


Figure 1: Types of Cold Injuries (Adapted from ACGIH TLVs and BEIs, Original source: US Department of the Army: Prevention and Management of Cold-Weather Injuries).

### How to prevent cold stress

The Workplace Health and Safety Regulations (WHSRs) outline the requirements for cold stress, referencing ACGIH's TLVs. These Threshold Limit Values (TLV) are specifically intended to protect workers from the most severe impacts of cold stress (hypothermia and frostbite) and to describe exposures to cold working conditions that it is believed nearly all workers can be repeatedly exposed without negative health effects. The TLV objective is to prevent deep body core temperature from falling below 36 °C and to prevent frostbite to body extremities.

### Hyperthermia Prevention

Hyperthermia is defined as a core body temperature below 95°F (35°C). The physiological changes that occur as the temperature goes below this value are presented in Table 2. In an occupational setting, workers should be protected from cold exposure so that the deep core temperature does not fall below 36°C (96.8°F); lower body temperatures can result in reduced mental alertness and rational decision making. As the core body temperature goes below 33°C (91.4°F), workers can become severely debilitated.

Table 2 Core Temperature and Associated Physiological Changes that Occur as Core Temperature Falls. Individuals Respond Differently at Each Level of Core Temperature

Stage	Core Temperature (°F)(°C)	Physiological Changes
Normothermia	(98.6) (37.0)	
Mild Hypothermia	(95.0) (35.0)	Maximal shivering; increased blood pressure
	(93.2) (34.0)	Amnesia; dysarthria; poor judgment; behavior change
	(91.4) (33.0)	Apathy; ataxia (lack of muscle control or coordination of voluntary movements)
Moderate Hypothermia	(89.6) (32.0)	Stupor
	(87.8) (31.0)	Shivering ceases; pupils dilate
	(86.0) (30.0)	Cardiac arrhythmias; decreased cardiac output
	(84.2) (29.0)	Unconsciousness
Severe Hypothermia	(82.4) (28.0)	Hypoventilation; ventricular fibrillation (heart beats out of rhythm) likely;
	(80.6) (27.0)	Loss of reflexes and voluntary motion
	(78.8) (26.0)	Acid-base disturbances; no response to pain
	(77.0) (25.0)	Reduced cerebral blood flow
	(75.2) (24.0)	Hypotension; bradycardia; pulmonary edema
	(73.4) (23.0)	No corneal reflexes; areflexia
	(66.2) (19.0)	Electroencephalographic silence
	(64.4) (18.0)	Asystole(cardiac arrest)
(59.2) (15.2)	Lowest infant survival from accidental hypothermia	
(56.7) (13.7)	Lowest adult survival from accidental hypothermia	

Source: adapted from ACGIH TLVs and BEIs

Hyperthermia is a life-threatening condition and must be treated promptly. Supervisor and workers should be aware of these early symptoms so that proper preventative measures can be taken. Exposure to cold should be stopped immediately for any workers when severe shivering becomes evident.

Cold, wet, and windy weather poses the greatest risk for developing hypothermia. Whole body protection must be provided.

Cold-water immersion can cause life-threatening hypothermia in a matter of hours if proper protection is not worn. Table 3 presents the amount of time that an average person can be immersed based on the water temperature and depth.

Table 3 Cold-Water Immersion Time Limits (Hours) for Reaching a Core Temperature of 35.5°C at Different Water Temperatures and Immersion Depths. For Immersion Times Greater than 6 Hours, the Risk of Non-Freezing Cold Injury Substantially Increases

Water Temperature (°F)(°C)	Knee-Deep (Hours)	Waist-Deep (Hours)	Chest-Deep (Hours)
(50-54)(10-12)	12.8	1.9	1.3
(55-59)(13-15)	15.6	7.5	2.2
(60-64)(16-18)	22.2	10.2	7.9
(65-69)(18-21)	33	13.8	10.5

Source: adapted from ACGIH TLVs and BEIs. Original source: Department of the Army: Prevention and Management of Cold-Weather Injuries.

Risk factors for hypothermia include inactivity, energy depletion, endocrine disorders, age, burns and skin disorders, trauma, neuropathies, and drug/alcohol use.

### Frostbite Prevention

Frostbite occurs when tissue temperature decreases below 32 °F (0°C). Frostbite is most common in exposed skin (nose, ears, cheeks, exposed wrists), but also occurs in the hands and feet. Wet skin cools faster. Instantaneous frostbite can occur when the skin comes in contact with supercooled liquids, such as petroleum products, oil, fuel, antifreeze, and alcohol, all of which remain liquid at temperatures of -40 °F (-40°C). Contact frostbite can occur by touching cold objects with bare skin (particularly highly conductive metal or stone), which causes rapid heat loss. To prevent contact frostbite, the workers should wear anti-contact gloves.

Risk factors for frostbite include temperature, wetness, wind chill, constrictive clothing, race, sex, hypoxia, Raynaud’s syndromes, and vasoconstrictor for drugs. Raynaud’s disease is a peripheral vascular disorder more prevalent in women than men.

ACGIH uses the Wind Chill Temperature (WCT) Index for defining temperature criteria (as per Tables 4, 5 below). The WCT Index integrates temperature and wind speed to provide an estimate of the overall cooling power of the cold environment. The WCT standardizes the cooling power of the environment to an equivalent air temperature for calm conditions. WCTs are specific in their correct application, only estimating the danger of cooling for the exposed skin of persons walking at 3 mph. Wind does not cause an exposed object to become cooler than the ambient temperature, but instead wind causes exposed objects to cool toward ambient temperature more rapidly than without wind. Wind speeds obtained from weather reports do not take into account man-made wind. The WCT presents the relative risk of frostbite and the predicted times to freezing (Tables 4, 5) of exposed facial skin. Facial skin was chosen because this area of the body is typically not protected. Frostbite cannot occur if the air temperature is above 32 °F (0°C). Wet skin exposed to the wind will cool faster and if the skin is wet and exposed to wind, the ambient temperature used for the WCT table should be 10 °C(50°F) lower than the actual ambient temperature. When cold surfaces below -7°C(19.4°F) are within reach, a warning should be given to each worker by the supervisor to prevent inadvertent contact by bare skin.

If the air temperature is  $-17.5^{\circ}\text{C}$  ( $0^{\circ}\text{F}$ ) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Table 4 Wind Chill Temperature Index. Frostbite Times are for Exposed Facial Skin

WIND CHILL TEMPERATURE INDEX												
Frostbite Times are for Exposed Facial Skin												
Air Temperature ( $^{\circ}\text{C}$ )												
Wind Speed (km/h)	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50
5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47	-53	-58
10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63
15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66
20	1	-5	-12	-18	-24	-30	-37	-43	-49	-56	-62	-68
25	1	-6	-12	-19	-25	-32	-38	-44	-51	-57	-64	-70
30	0	-6	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72
35	0	-7	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73
40	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74
45	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75
50	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63	-69	-76
55	-2	-8	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77
60	-2	-9	-16	-23	-30	-36	-43	-50	-57	-64	-71	-78
65	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79
70	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-80
75	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80
80	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81

#### FROSTBITE GUIDE

Increasing risk of frostbite for most people in 10 to 30 minutes of exposure

High risk for most people in 5 to 10 minutes of exposure

High risk for most people in 2 to 5 minutes of exposure

High risk for most people in 2 minutes of exposure or less

Sources: adapted from ACGIH TLVs and BEIs. Original source: National Weather Service: Wind Chill Temperature Index.

Table 5 Time in Minutes Until the Occurrence of Cheek Frostbite in the Most Susceptible 5% of Military Personnel

Wind Speed (mph/kph)	Air Temperature (°F/°C)											
	10/-12	5/-15	0/-21	-5/-21	-10/-23	-15/-26	-20/-29	-25/-32	-30/-34	-35/-37	-40/-40	-45/-43
5/8	>120	>120	>120	>120	31	22	17	14	12	11	9	8
10/16	>120	>120	>120	28	19	15	12	10	9	7	7	6
15/24	>120	>120	33	20	15	12	9	8	7	6	5	4
20/32	>120	>120	23	16	12	9	8	8	6	5	4	4
25/40	>120	42	19	13	10	8	7	6	5	4	4	3
30/48	>120	28	16	12	9	7	6	5	4	4	3	3
35/56	>120	23	14	10	8	6	5	4	4	3	3	2
40/64	>120	20	13	9	7	6	5	4	3	3	2	2
45/72	>120	18	12	8	7	5	4	4	3	3	2	2
50/81	>120	16	11	8	6	5	4	3	3	2	2	2

Note: Wet Skin could significantly decrease the time for frostbite to occur.

FROSTBITE RISK

Severity	Color	Description
Low	Green	Freezing possible but unlikely
Moderate	Yellow	Freezing could occur in 10-30 minutes
Severe	Red	Freezing could occur in 5-10 minutes
Extreme	Black	Freezing could occur in <5 minutes

Sources: adapted from ACGIH TLVs and BEIs. Original source: Department of the Army: Prevention and Management of Cold-Weather Injuries.

Manual dexterity is an important attribute in occupational settings. Manual dexterity is the ability to make coordinated hand and finger movements to grasp and manipulate objects. Special protection (as follows) is required to prevent accidents to the hands:

- 1, When fine work is required with bare hands (for more than 10-20 minutes at a time) in a setting that is less than 16 °C, controls should be implemented to keep hands warm. This may include warm air jets, radiant heaters, and warming plates. Additionally, all metal handles/tools should be covered in insulating material at temperatures below -1 °C(30.2 °F).
- 2, If fine manual dexterity is not required, gloves should be worn if temperature falls below 16 °C (sedentary work), 4 °C (light work), or -7 °C (moderate work).

## Acute Cold-Water Exposure

Sudden immersion into cold water causes a cold shock response. Bodily responses to sudden immersion include gasping, hyperventilating, narrowing of blood vessels in hands and feet, and increased heart rate and blood pressure. Generally, the core temperature falls to 35 °C in about 1 hour in 5 °C water, in 2 hours in 10 °C water, and in 3-6 hours in 15 °C water. The progression from cold shock to hypothermia can be summed up in the “1-10-1” rule. This states that the cold shock response with increased water aspiration occurs in the first minute; in 10 minutes the skeletal muscle temperatures decline to a point that muscle function is severely impaired, and in 1 hour, core temperature begins to fall to levels that are dangerous.

## Cold-Weather Clothing

Cold-weather clothing protects against hypothermia and peripheral cold injuries by reducing heat loss. Imposing a single standard ensemble for an entire group could result in overheating and sweating during work in some, while others would not be kept warm; therefore, people should adjust clothing according to their own needs.

If exposed areas of the body cannot be protected sufficiently to prevent sensation of excessive cold or frostbite, protective items should be supplied in auxiliary heated versions.

If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work should be modified or suspended until adequate clothing is made available or until weather conditions improve. Feet are susceptible to peripheral cold injuries. All workers should be provided with appropriately rated footwear for the conditions they are working in.

## Work-Warming Regimen

When work is continuously performed in an environment with a WCT of less than -7 °C, heated warming shelters should be available nearby. Workers should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. Hot beverages and soups should be provided at the work site as they provide calories and increase morale.

For work at or below a WCT of -12 °C, the following additional steps should be implemented:

- 1) A buddy system / all worker should be constantly supervised while working in the cold.
- 2) Adjusting the work rate to avoid heavy sweating that would result in wet clothing. If heavy workloads are required, rest periods (in heated shelters) should be taken as well as the opportunity for changing into dry clothing.
- 3) New employees should be provided time to adjust to working conditions and the required protective clothing. They should not be required to work full time hours in a cold environment in the initial days of their employment.
- 4) Adjust for the weight and bulkiness of clothing when estimating work performance and required weights to be lifted by worker.

- 5) Work should ensure that excessive periods of sitting still or standing still is avoided, metal chairs should not be used, and workers should be protected from drafts as much as possible.
- 6) Workers should be provided with a training program and includes instruction in, at a minimum:
  - re-warming procedures and first aid treatment
  - clothing practices
  - eating and drinking habits
  - recognition of frostbite
  - recognition of signs/symptoms of impending hypothermia or excessive cooling of the body even when the shivering does not occur
  - safe work practices

### Cold Risk Management Strategy

Fatal exposures to cold among workers have almost always resulted from accidental exposures involving failure to escape from low environmental air temperatures or from immersion in low temperature water. Preventing cold injuries is best done through a risk management controls to mitigate the effects of the cold environment. Figure 2 presents a risk management strategy to use in cold environments that assesses and mitigates cold hazards.

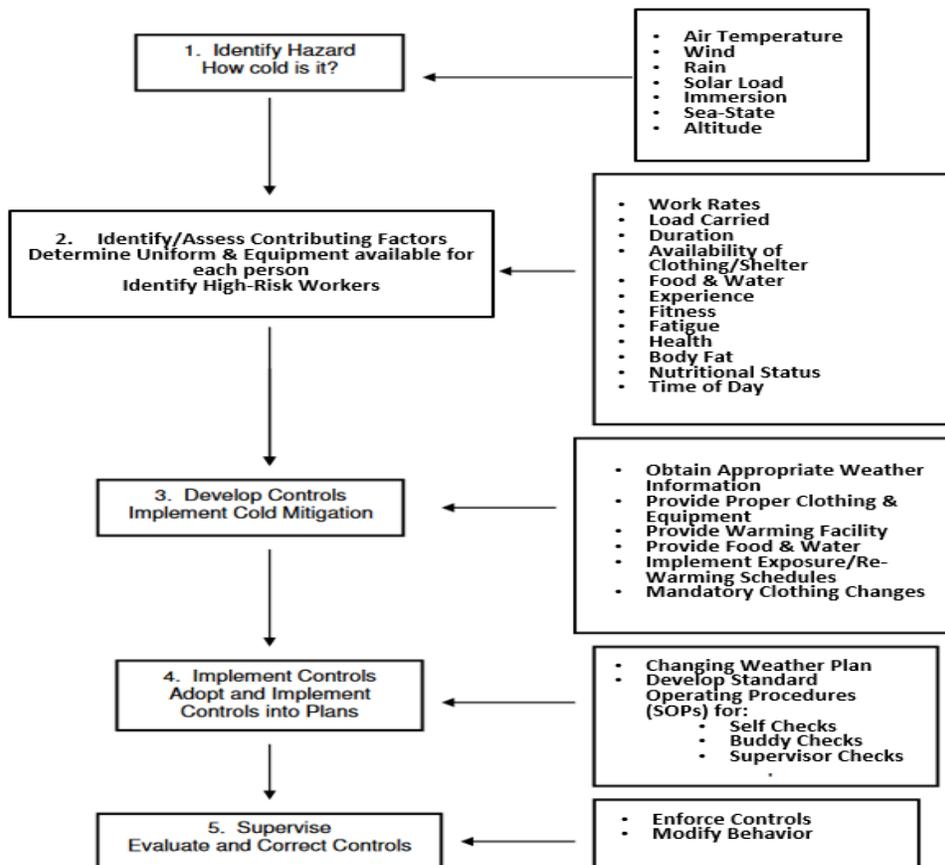


Figure 2: Risk Management Process for Evaluating Cold Stress (Adapted from ACGIH TLVs and BEIs, Original source: US Department of the Army: Prevention and Management of Cold-Weather Injuries)

### **What to do if you or someone else is suffering from Cold Stress**

If you believe you or another person may be subject to a cold stress related illness/injury in the workplace (particularly hypothermia or frostbite), seek first aid immediately and notify your supervisor.

### **Your rights under the OHS Act**

Everyone has a right to a safe working environment and if the supervisor does not respond to your concern, you should raise the issue with the Joint Occupational Health and Safety Committee or Representative. If this still does not satisfy your concern, you may contact the OHS Division at 1-800-9LABOUR (952-2687). You have a right to refuse to work in the conditions if you believe there is a risk to your health or safety due to cold stress.

### **Other Resources**

- 1) **ACGIH:** <http://www.acgih.org/home.htm> (documents available for purchase)
- 2) **NIOSH:** <https://www.cdc.gov/niosh/topics/coldstress/default.html>
- 3) **Government of Canada:** <https://www.canada.ca/en/employment-social-development/services/health-safety/reports/thermal-stress-work-place.html>
- 4) **CCOHS:** [https://www.ccohs.ca/oshanswers/phys\\_agents/cold\\_working.html](https://www.ccohs.ca/oshanswers/phys_agents/cold_working.html)