Cold Environments

Cold Environments - Control Measures

On this page

What factors modify our response to cold?

A cold environment challenges the worker in three ways: air temperature, air movement (wind speed), and humidity (wetness). In order to work safely, these challenges have to be counterbalanced by proper insulation (layered protective clothing), physical activity, and controlled exposure to cold (work/rest schedule).

Air Temperature: Air temperature is measured by an ordinary thermometer in degrees Celsius (°C) or degrees Fahrenheit (°F).

Wind Speed: Different types of commercially available anemometers can be used to measure wind speed or air movement. These are calibrated in metres per second (m/s), kilometres per hour (km/h), or miles per hour (mph). Air movement is usually measured in m/s while wind speed is usually measured in km/h or mph. The following is a suggested guide for estimating wind speed if accurate information is not available:

- 8 km/h (5 mph): light flag moves,
- 16 km/h (10 mph): light flag fully extended,
- 24 km/h (15 mph): raises dust and loose paper,
- 32 km/h (20 mph): causes blowing and drifting snow.

Humidity (wetness): Air humidity is measured by a hygrometer in percent relative humidity (%RH). As humidity increases, more moisture from the air can be absorbed by clothing, which reduces its ability to insulate. The absorbed moisture “wicks” away (evaporates) which can accelerate heat loss through conduction.

Physical Activity: The production of body heat by physical activity (metabolic rate) is difficult to measure. However, tables showing metabolic rates for a variety of activities are available in the literature. Metabolic heat production is measured in kilocalories (kcal) per hour. One kilocalorie is the amount of heat needed to raise the temperature of one kilogram of water by 1°C.

Work/rest schedule: The “work warm-up schedule,” as developed by the Saskatchewan Occupational Health and Safety Division identifies how many breaks are recommended when working in cold conditions. The schedule applies to any four-hour period with moderate or heavy activity and assumes that "normal breaks" are taken once every two hours. At the end of a 4-hour period, an extended break in a warm location is recommended.

Protective clothing: Check the section on “What should I know about personal protective equipment (PPE) for working in the cold?”

For information on the general effects of working in the cold as well as how the body adapts to cold, please see Cold Environments - Overview.

For information on the health effects and first aid for cold-related injuries and illnesses, please see Cold Environments - Health Effects and First Aid.

What is the wind chill temperature?

At any temperature, you feel colder as the wind speed increases. The combined effect of cold air and wind speed is expressed simply as the “wind chill” or "wind chill index". It is essentially the air temperature that would feel the same on exposed human flesh as the given combination of air temperature and wind speed. It can be used as a general guideline for deciding clothing requirements and the possible health effects of the cold.

Environment and Climate Change Canada has produced a Wind Chill Temperature Index and guides to help estimate wind chill and wind speed.

NOTE: Environment and Climate Change Canada's recommendations consider all individuals who may be outside, including young children and the elderly. These recommendations are helpful, they may not match exposure values or precautions developed by other organizations that have specifically made recommendations for working adults who are assumed to be in good general health.

The American Conference of Governmental Industrial Hygienists (ACGIH) developed recommendations to protect workers from the most severe effects of cold stress (hypothermia and frostbite). The recommendations also describe cold working conditions under which it is believed nearly all workers can be repeatedly exposed without adverse health effects. Included in these recommendations is the wind chill temperature index.

The Wind Chill Temperature (WCT) index estimates how cold it feels considering both air temperatures and wind speeds. The WCT table also provides the estimated time it would take a person walking at 3 kilometres per hour to experience freezing of exposed facial skin. Note that if the skin is wet and exposed to wind, the air temperature measurement used to determine the WCT should be 10°C lower than the actual temperature.

WIND CHILL TEMPERATURE INDEX
Frostbite Times are for Exposed Facial Skin

Air Temperature (°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

Source: Adapted from Threshold Limit Values (TLV) and Biological Exposure Indices (BEI) booklet: published by ACGIH, Cincinnati, Ohio, 2024, page 226.

What are some health concerns of working in cold temperatures?

The following chart from Environment Canada describes the health concerns and potential for frostbite when being outside at various temperatures.

NOTE: Environment Canada's recommendations consider all individuals who may be outside, including young children and the elderly. While these recommendations are helpful, they may not match exposure values developed by other organizations that have specifically made recommendations for working adults who are assumed to be in good general health.

Wind Chill Hazards and What To Do			
Wind Chill	**Exposure Risk**	**Health Concerns**	**What to Do**
0 to -9	**Low risk**	• Slight increase in discomfort	• Dress warmly • Stay dry
-10 to -27	**Moderate risk**	• Uncomfortable • Risk of hypothermia and frostbite if outside for long periods without adequate protection.	• Dress in layers of warm clothing, with an outer layer that is wind-resistant. • Wear a hat, mittens or insulated gloves, a scarf and insulated, waterproof footwear. • Stay dry. • Keep active
-28 to -39	**High Risk**: exposed skin can freeze in 10 to 30 minutes	• High risk of frostnip or frostbite: Check face and extremities for numbness or whiteness. • High risk of hypothermia if outside for long periods without adequate clothing or shelter from wind and cold.	• Dress in layers of warm clothing, with an outer layer that is wind-resistant • Cover exposed skin • Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated, waterproof footwear • Stay dry • Keep active
-40 to -47	**Very high risk**: exposed skin can freeze in 5 to 10 minutes (In sustained	• Very high risk of frostbite: Check face and extremities for numbness or whiteness.	• Dress in layers of warm clothing, with an outer layer that is wind-resistant.

Wind Chill Hazards and What To Do			
Wind Chill	**Exposure Risk**	**Health Concerns**	**What to Do**
	winds over 50 km/h, frostbite can occur faster than indicated.)	• Very high risk of hypothermia if outside for long periods without adequate clothing or shelter from wind and cold.	• Cover all exposed skin. • Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated, waterproof footwear. • Stay dry • Keep active.
-48 to -54	**Severe risk**: exposed skin can freeze in 2 to 5 minutes (In sustained winds over 50 km/h, frostbite can occur faster than indicated.)	• Severe risk of frostbite: Check face and extremities frequently for numbness or whiteness. • Severe risk of hypothermia if outside for long periods without adequate clothing or shelter from wind and cold.	• Be careful. Dress very warmly in layers of clothing, with an outer layer that is wind-resistant. • **Cover all exposed skin** • Wear a hat, mittens or insulated gloves, a scarf, neck tube or face mask and insulated, waterproof footwear. • **Be ready to cut short or cancel outdoor activities**. • Stay dry. • Keep active.
-55 and colder	**Extreme risk**: exposed skin can freeze in less than 2 minutes	• **DANGER!** Outdoor conditions are **hazardous.**	• **Stay indoors**.

From: "Wind Chill Index" Environment Canada (2017)

Are there exposure limits for working in cold environments?

In Canada, legislation from some jurisdictions provides a range of acceptable temperatures for specific circumstances. In other cases, occupational health and safety jurisdictions use the Threshold Limit Values® for cold stress as published by the American Conference of Governmental Industrial Hygienists (ACGIH). Some Canadian jurisdictions have adopted these TLVs as occupational exposure limits and others use them as guidelines.

Where there are no maximum or minimum exposure limits for cold working environments, there are guidelines that can be used to conduct risk assessments, create safe work plans, and monitor conditions to protect the health and safety of workers who may be exposed to cold temperatures. Where there are differences between the recommendations made by various organizations (and where there are no established limits or guidelines from your jurisdiction), employers are encouraged to choose a system that best provides protection for their workforce.

For example, ACGIH suggests a work-warming regimen when work is done continuously in the cold when the wind chill temperature is at or below -7°C (19.4°F). Heated warming shelters such as tents, cabins, or rest rooms should be made available nearby and used at regular intervals. Workers should be encouraged to use these shelters, depending on the severity of the exposure. If signs of cold stress are noticed, return to the shelter immediately.

For work at or below -12°C (10.4°F), work should include:

- constant observation (supervisor or buddy system)
- adjusting the pace or rate of work so that it is not too high and cause heavy sweating that will result in wet clothing
- time for new employees to become accustomed to the conditions
- adjustments to include the weight and bulkiness of the clothing when estimating work performance and weights to be lifted by the worker
- arrangements to minimize sitting and standing for long periods
- instructions in safe work practices, re-warming procedures, proper clothing practices, proper eating and drinking habits, recognition of cold stress/frostbite, and signs and symptoms of hypothermia or excessive cooling of the body (including when shivering does not occur)

What control measures can help prevent the effects of cold?

The risk of cold injuries and illnesses can be minimized by engineer controls, safe work practices, training and education, and appropriate clothing.

Engineering Controls

- Provide radiant heaters at outdoor stations
- Provide heated warming shelters such as tents, cabins, or rest rooms
- Shield workstations from wind or drafts
- Insulate materials such as metal handles on equipment when working in below-freezing conditions

Administrative Controls

- Have a buddy system so workers can look out for one another and help each other recognize the early symptoms of cold injuries and illnesses
- Pace the work to avoid excessive sweating
- Allow proper warming areas where workers can change into dry clothes if sweating cannot be avoided
- Give new employees enough time to acclimatize to the cold and the protective clothing before assuming a full workload
- Provide warm liquids to workers
- Schedule work that involves heavy physical activity during warmer parts of the day
- Rotate workers on tasks to decrease exposure to cold
- If working on board, the schedule shifts away from stormy conditions when workers may fall overboard

Emergency Procedures

Procedures for providing first aid and obtaining medical care should be outlined. At least one trained person should be assigned the responsibility of attending to emergencies for each shift.

Education

Workers and supervisors who work in cold environments should be informed about symptoms of cold stress, proper clothing habits, safe work practices, physical fitness requirements for working in cold, and emergency procedures in case of cold injury. They should also understand and look out for one another and be alert for the symptoms of cold injury, including hypothermia.

What personal protective equipment (PPE) can be used for working in the cold?

Clothing

Protective clothing is needed for work in cold environments. Clothing should be selected to suit the temperature, weather conditions (e.g., wind speed, rain), the level and duration of activity, and job design. These factors are important to consider so that you can regulate the amount of heat and perspiration you generate while working. If the work pace is too fast or if the type and amount of clothing are not properly selected, excessive sweating may occur. The clothing next to the body will become wet and the insulation value of the clothing will decrease dramatically. This reduction in insulation value increases the risk of cold injuries and illnesses.

- Clothing should be worn in multiple layers which provide better protection than a single thick garment. The air between layers of clothing provides better insulation than the clothing itself. Having several layers also gives you the option to open or remove a layer before you get too warm and start sweating or to add a layer when you take a break. Layers also allow you to accommodate the level of activity, changing temperatures and weather conditions. Successive outer layers should be larger than the inner layer, otherwise the outermost layer will compress the inner layers and will decrease the insulation properties of the clothing.
- The inner layer should provide insulation and be able to “wick” moisture away from the skin to help keep it dry. Thermal underwear made from wool, polyester, or polypropylene is suitable for this purpose. Polypropylene wicks perspiration away from the skin. It also keeps the second layer away from the skin.
- The additional layers of clothing should provide adequate insulation for the weather conditions under which the work is being done. They should also be easy to open or remove before you get too warm to prevent excessive sweating during strenuous activity. Outer jackets should have the means for closing off and opening the waist, neck, and wrists to help control how much heat is retained or given off. Some jackets have netted pockets and vents around the trunk and under the armpits (with zippers or Velcro fasteners) for added ventilation.
- For work in wet conditions, the outer layer of clothing should be waterproof.

- If the work area cannot be shielded against wind, an easily removable windbreak garment should be used.
- Under extremely cold conditions, heated protective clothing should be made available if the work cannot be done on a warmer day.
- Wear a hat suitable for the conditions, including being able to keep the ears warm. If a hard hat is required, a knit cap or a liner under a hard hat can reduce excessive heat loss. Consult with the hard hat supplier or manufacturer for appropriate liners that do not compromise the protection provided by the hard hat.
- Clothing should be kept clean since dirt fills air cells in fibres of clothing and destroys its insulating ability.
- Clothing must be dry. Moisture should be kept off clothes by removing snow before entering heated shelters. While the worker is resting in a heated area, perspiration should be allowed to escape by opening the neck, waist, sleeves, and ankle fasteners or by removing outerwear. If the rest area is warm enough it is preferable to take off the outer layer(s) so that the perspiration can evaporate from the clothing.
- If fine manual dexterity is not required, gloves should be used below 4°C for light work and below -7°C for moderate work. For work below -17°C, mittens should be used.
- Cotton is not recommended. It tends to get damp or wet quickly and loses its insulating properties. Wool and synthetic fibres, on the other hand, do retain heat when wet.

Footwear

Felt-lined, rubber-bottomed, leather-topped boots with removable felt insoles are best suited for heavy work in cold since leather is porous, allowing the boots to “breathe” and let perspiration evaporate. Leather boots can be “waterproofed” with some products that do not block the pores in the leather. However, if work involves standing in water or slush (e.g., fire fighting, farming), then waterproof boots must be worn. While these protect the feet from getting wet from cold water in the work environment, they also prevent perspiration from escaping. The insulating materials and socks will become wet more quickly than when wearing leather boots and increase the risk of frostbite.

Foot Comfort and Safety at Work has some general information about how to select footwear. (Also, when trying on boots before purchase, wear the same type of sock that you would wear at work to ensure a proper fit.)

Socks

You may prefer to wear one pair of thick, bulky socks or two pairs - one inner sock of silk, nylon, or thin wool and a slightly larger, thick outer sock. Liner socks made from polypropylene will help keep feet dry and warmer by wicking sweat away from the skin. However, as the outer sock becomes more damp, its insulation properties decrease. If work conditions permit, have extra socks available so you can dry your feet and change socks during the day. If two pairs of socks are worn, the outer sock should be a larger size so that the inner sock is not compressed.

Always wear the right thickness of socks for your boots. If they are too thick, the boots will be “tight,” and the socks will lose much of their insulating properties are compressed inside the boot. The foot would also be “squeezed” which would slow the blood flow to the feet and increase the risk of cold injuries. If the socks are too thin, the boots will fit loosely and may lead to blisters.

Face and Eye Protection

Where face protection is used, eye protection must be separated from the nose and mouth to prevent exhaled moisture from fogging and frosting eye shields or glasses. Select protective eyewear that is appropriate for the work you are doing, and for protection against ultraviolet light from the sun, glare from the snow, blowing snow or ice crystals, and high winds at cold temperatures.

What are some additional prevention tips?

To prevent excessive sweating while working, remove clothing in the following order:

- remove mittens or gloves (unless you need protection from snow or ice),
- remove headgear and scarf.
- open the jacket at the waist and wrists, and
- remove outer layers of clothing.

As you cool down, follow the reverse order of the above steps.

Balanced meals and adequate liquid intake are essential to maintaining body heat and preventing dehydration. Eat appropriately (balanced nutrition) and frequently. Working in the cold requires more energy than in warm weather because the body is working to keep itself warm. It requires more effort to work when wearing bulky clothing and winter boots especially when walking through snow.

Drink fluids often especially when doing strenuous work. For warming purposes, warm non-alcoholic beverages or soup are suggested. Caffeinated drinks such as coffee should be limited because they increase urine production and contributes to dehydration. Caffeine also increases blood flow at the skin surface, which can increase the loss of body heat.

Do not consume alcohol when exposed to cold. Alcohol produces a deceptive feeling of warmth. Under the influence of alcohol, you may expose yourself to fatal cold conditions without being aware.

In refrigerated rooms, the airspeed should not exceed 1 meter per second. If workers are simultaneously exposed to vibration or toxic substances, reduced limits for cold exposure may be necessary.

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