Cold Environments

Cold Environments - Working in the Cold

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What factors modify our response to cold?

A cold environment challenges the worker in three ways: by 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), by physical activity and by 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 are 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 newspaper sheet,
- 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 are available in literature showing metabolic rates for a variety of activities. 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 shows the warm-up breaks required for working in cold conditions and the normal breaks to be provided every two hours. The schedule allows additional breaks for workers as the wind velocity at the work site increases and/or the temperature drops.

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 - General.

For information on the health effects and first aid for cold exposures, 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" temperature in degrees Celsius or Fahrenheit. 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.

In Canada, the term "wind chill" or "wind chill index" is used. This factor is a measurement of a heat loss rate caused by exposure to wind and is expressed in temperature-like units.

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 may not match exposure values developed by other organizations that have specifically made recommendations for working adults who are in good general health.

For working populations, the American Conference of Governmental Industrial Hygienists (ACGIH) also provides recommendations. These recommendations were developed to protect workers from the most severe effects of cold stress (hypothermia and frostbite). The recommendations also describe exposures to 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 following wind chill temperature index.

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, 2022, page 224.

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. These recommendations may not match exposure values developed by other organizations that have specifically made recommendations for working adults who are in good general health.

Table 2 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 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.

	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, the legislation from some jurisdictions provide 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/minimum exposure limits for cold working environments, there are guidelines that can be used to conduct work/task 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 (tents, cabins, rest rooms, etc) should be made available nearby. 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
- adjusted to include the weight and bulkiness of the clothing when estimating work performance and weights to be lifted by the worker
- arranged in such a way that sitting and standing for long periods is minimized
- 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 can be done to help prevent the adverse effects of cold?

For continuous work in temperatures below the freezing point, heated warming shelters such as tents, cabins or rest rooms should be available. The work should be paced to avoid excessive sweating. If such work is necessary, proper rest periods in a warm area should be allowed and employees should change into dry clothes. New employees should be given enough time to get acclimatized to cold and protective clothing before assuming a full work-load.

The risk of cold injury can be minimized by proper equipment design, safe work practices and appropriate clothing. The following is a summary of actions including some from recommendations from the ACGIH (American Conference of Governmental Industrial Hygienists).

Equipment Design

For work below the freezing point, metal handles and bars should be covered by thermal insulating material. Also, machines and tools should be designed so that they can be operated without having to remove mittens or gloves.

Surveillance and Monitoring

Every workplace where the temperature may fall below 16°C should be equipped with a suitable thermometer to monitor any further temperature changes. For example, for colder workplaces with temperatures below the freezing point, the temperature should be monitored at least every 4 hours and work adjusted as necessary. For indoor workplaces, whenever the rate of air movement exceeds 2 meters per second (5 miles per hour) it should be recorded every 4 hours. In outdoor workplaces with air temperature below the freezing point, both air temperature and wind speed should be recorded.

Emergency Procedures

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

Education

Workers and supervisors involved with work in cold environments should be informed about symptoms of adverse effect exposure to cold, proper clothing habits, safe work practices, physical fitness requirements for work in cold, and emergency procedures in case of cold injury. While working in cold, a buddy system should be used. Look out for one another and be alert for the symptoms of cold injury, including hypothermia.

What should I know about personal protective equipment (PPE) for working in the cold?

Clothing

Protective clothing is needed for work at or below 4°C. 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 body will become wet and the insulation value of the clothing will decrease dramatically. This reduction in insulation value increases the risk for cold injuries.

- 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. It also allows you to accommodate 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 polyesters 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 arm pits (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 the perspiration to escape. The insulating materials and socks will become wet more quickly than when wearing leather boots and increase the risk for 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 damper, 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 when they are compressed inside the boot. The foot would also be "squeezed" which would slow the blood flow to the feet and increase the risk for cold injuries. If the socks are too thin, the boots will fit loosely and may lead to blisters.

Face and Eye Protection

In extremely cold conditions, 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 eye wear that is appropriate for the work you are doing, and for protection against ultraviolet light from the sun, glare from the snow, blowing snow/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:

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

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

Prevent contact of bare skin with cold surfaces (especially metallic) below -7°C as well as avoiding skin contact when handling evaporative liquids (gasoline, alcohol, cleaning fluids) below 4°C. Sitting or standing still for prolonged periods should also be avoided.

Balanced meals and adequate liquid intake are essential to maintain body heat and prevent 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 the body 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, hot non-alcoholic beverages or soup are suggested. Caffeinated drinks such as coffee should be limited because it increases urine production and contributes to dehydration. Caffeine also increases the blood flow at the skin surface which can increase the loss of body heat.

Alcohol should not be consumed as it causes expansion of blood vessels in the skin (cutaneous vasodilation) and impairs the body's ability to regulate temperature (it affects shivering that can increase your body temperature). These effects cause the body to lose heat and thus increase the risk of hypothermia.

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

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