

Cold Stress: a chilling effect

When most people think of cold stress injuries such as frostbite or hypothermia, they think of frigid temperatures or blizzard-like conditions, however cold stress can occur any time of year. In fact, hypothermia occurs most often in the spring and fall, rather than in winter. Most cases of cold stress develop in air temperatures between -1°C (30°F) and 10°C (50°F).

For much of the year, large numbers of Ontario workers are exposed to cold work environments with the potential for developing a serious and even fatal injury. These workers include individuals who work outside in the winter months such as construction workers, firefighters, traffic police, forestry, postal and utilities workers to name a few. There are others who work indoors in artificially cold environments year-round such as workers in meatpacking plants, slaughterhouses, food processing plants, and dairies. Individuals working in garages and warehouses where the doors are left open in the winter are also exposed to cold, damp air.

What is cold stress?

Stress or the stress response is a means by which we adapt to our environment. Cold stress is the response of the body to cold conditions in the workplace.

Exposure to too much cold is a direct threat to the body. Cold stress can cause bodily or mental strain. It is important to note individuals will respond differently to stress not just in their visible or acute responses but also in the health problems that develop over time.

How does the body regulate temperature?

The body is constantly exchanging heat with the surrounding environment. It does this through conduction, convection, evaporation, radiation, and respiration. The rate of this heat exchange depends on the difference between the two temperatures.

In order for the human system to function normally it requires a constant body core temperature of 37°C (98.6°F). We are most comfortable when the temperature of the surrounding air is between 18°C and 22°C and the air's relative humidity is about 45 per cent. This range is neither too hot nor too cold.

When surrounding temperatures drop below 18°C body heat is lost. To maintain equilibrium the body adjusts itself by attempting to conserve heat by decreasing the blood flow to the skin's surface areas (ears, nose, fingers and toes), or by increasing heat production through involuntary muscle movement such as shivering.

The most dangerous and rapid heat loss occurs when clothing is wet, wind is high, surrounding surfaces are cold, or when the body is immersed in cold water. In fact, the body can lose 25 to 30 times more heat when in contact with cold wet objects than under dry conditions or with dry clothing.

What are the health effects?

The primary effect of cold stress is cooling of tissue. The severity of tissue cooling depends on the degree of cold, duration of exposure and wetness of tissue. Various studies on effects of cold on workers also show cold stress is a safety hazard. It impairs performance of both manual and complex mental tasks. Also, sensitivity and dexterity of fingers lessen in a cold environment. At lower temperatures still, cold affects deeper muscles, resulting in reduced muscular strength and stiffened joints. For all these reasons incidents are more likely to occur in very cold working conditions.

Workers exposed to cold environments are at risk of the following non-freezing cold injuries, occurring in localized areas of the body: frostnip, chilblain, trench foot, and immersion foot.

The two most severe cold stress injuries are frostbite and hypothermia.

Frostbite is caused by exposure to extreme cold or contact with extremely cold objects. It occurs when tissue temperature falls below the freezing point. Blood vessels may be severely and irreparably damaged, and blood circulation may stop in the affected tissue. The parts of the body most commonly affected are the face, ears, fingers and toes. Frostbitten skin is white and feels 'wooden' all the way through.

Hypothermia is caused by a decrease in core body temperature to a level at which normal muscle and brain functions are impaired. This occurs when metabolic heat production of the

body is not sufficient to replace heat lost by the body to the environment. Maximum severe shivering develops when body temperature has fallen to 35°C (95°F).

Lower body temperatures present the following signs and symptoms:

- Persistent shivering;
- Blue lips and fingers;
- Irrational or confused behaviour;
- Reduced mental alertness;
- Poor coordination, with effects on safety; and
- Poor decision-making.

Hypothermia can occur in relatively mild, particularly cool-wet climates even during hard physical work. It is also the most frequent cause of death in water immersion.

What is wind chill?

Wind chill is a significant factor in the assessment of worker exposures. At any temperature one feels colder as the wind speed increases. This colder sensation is wind chill – the combined effect of air temperature and wind. Also expressed as "equivalent chill temperature" (ECT), wind chill is defined as heat loss resulting from the effects of air temperature (measured by a thermometer as $^{\circ}\text{C}$) and wind velocity (measured by an anemometer as km/hr) upon exposed skin. This is essentially the air temperature (on a calm day) that would produce the same cooling effect on exposed flesh as the given combination of air temperature and wind speed.

Environment Canada has developed a new, easy-to-understand system to calculate wind chill. The new wind chill formula expressed as a temperature-like index (without the degree symbol) gives individuals a more accurate idea of how cold it really feels outside so the necessary precautions such as appropriate protective clothing can be used. For example, if the outside temperature is -10°C and the wind chill is -20°C , it means that your face will feel as cold as it would on a calm day when the temperature is -20°C .

Higher wind speed and lower temperatures increase the risk of adverse health effects and the need for protective clothing.

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What is the law?

Unfortunately, *Ontario's Occupational Health and Safety Act* is largely silent on the issue of working in cold conditions. It does however have a general duty clause which requires employers to "take every precaution reasonable to protect worker health and safety." This would include working in cold environments indoors or outdoors.

Although the regulations do not provide maximum limits for working in the cold, Section 129 (1)(b) of *Ontario's Regulation for Industrial Establishments* does specify that, "an enclosed workplace shall be no less than 18°C."

The Saskatchewan Department of Labour has developed a "work/warm-up" schedule for outdoor workers. This work/warm-up schedule has been adopted by the American Conference of Governmental Industrial Hygienists (ACGIH) and is used as Threshold Limit Values (TLVs) for working outdoors in the cold.

These guidelines recommend protective clothing and limits on worker exposure time. The recommended exposure times are based on the wind chill factor. Environment Canada has a wind chill formula that accurately calculates wind chill. For more information or to use their wind chill calculator visit the web site at: www.ec.gc.ca.

The TLVs work/warm-up 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) the schedule is applied one step lower. Also TLVs apply only for workers in dry clothing.

These guidelines assume that each individual is in top physical condition. They also do not take into account that individuals differ in how they react to a stressor such as cold.

How is cold stress prevented?

The best way to prevent cold stress is to avoid, whenever possible, work in cold, damp environments and direct contact with freezing cold objects. However, for many workers these conditions cannot be avoided. In these situations workplace representatives can begin by implementing the ACGIH TLVs for work/warm-up regimes and Environment Canada's wind chill index.

For continuous work in temperatures below the freezing point, heated warming shelters such as tents, cabins and rest rooms must be made available. The pace of work must not be so heavy as to cause excessive sweating. If such work is necessary, proper rest periods in a warm area must be provided. Further, time must be allowed for changing into dry clothes. New workers must be given enough time to get accustomed to cold and protective clothing before assuming a full work load.

The risk of cold injury can be minimized by: proper equipment design, protective clothing, training, and safe work practices.

Equipment design

Metal handles and bars should be covered by thermal insulating material for work below the freezing point. Also, machines and tools should be designed so they are easily operated without having to remove mittens.

Protective clothing

Protective clothing should be selected to suit the cold, the job and level of physical activity. Workers should be encouraged to do the following:

- Wear several layers of clothing rather than one thick layer;
- Wear synthetic fabrics such as polypropylene next to the skin because these wick away sweat (clothing shouldn't restrict flexibility);
- In wet, cold conditions ensure outer clothing is waterproof or water-repellent (wind-resistant fabrics may also be needed);
- Ensure clothing is kept clean, and dry;
- Wear hats (knitted wool caps or liners under hard hats) and hoods to prevent heat loss from the head and protect ears;
- Wear footwear large enough for one thick or two thin pairs of socks
- Wear gloves (where fine manual dexterity is not required).

Training

Before working in extreme cold, workers should be instructed in the following:

- Safe work practices;
- Risk factors for cold strain and cold injuries;
- Proper control measures and protective clothing;

- How to recognize signs and symptoms of frostbite and hypothermia;
- How to measure environmental conditions (wind chill, air temperature, wind speed); and
- First aid and emergency procedures (i.e. rewarming procedures).

Safe work practices

To prevent the risk of cold injury the following must be implemented:

- Ensure workers take frequent short breaks in a warm rest area;
- Use a buddy system;
- Avoid prolonged standing or sitting in cold temperatures;
- Monitor air speed in refrigerated rooms (it must not exceed one metre per second);
- Avoid contact of bare skin with cold surfaces (especially metallic) below -7°C;
- Avoid skin contact when handling liquids (gasoline, alcohol, cleaning fluids) below 4°C; and
- Implement flexible scheduling during inclement weather.

NOTE: The Workers Health & Safety Centre (WHSC) has a three-hour module on Cold Stress. For more information contact a WHSC office near you or visit www.whsc.on.ca.



RESOURCE LINES

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TABLE 3, TLVs Work / Warm-up Schedule for a 4-Hour Shift

Air Temperature—Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx.)	°F (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°	-15° to -19°	(Norm. Breaks) 1	1	(Norm. Breaks) 1	1	75 min	2	55 min	3	40 min	4
-29° to -31°	-20° to -24°	(Norm. Breaks) 1	1	75 min	2	55 min	3	40 min	4	30 min	5
-32° to -34°	-25° to -29°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35° to -37°	-30° to -34°	55 min	3	40 min	4	30 min	5	Non-emergency work should cease			
-38° to -39°	-35° to -39°	40 min	4	30 min	5	Non-emergency work should cease					
-40° to -42°	-40° to -44°	30 min	5	Non-emergency work should cease							
-43° & below	-45° & below	Non-emergency work should cease				Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease	

Taken from ACGIH 2002 TLVs and BEIs page 164.