

# Ergonomics

## Environmental Risk Factors – Cold Stress

### Environmental Risk Factors Heat Stress **Cold Stress** Altitude

#### Inside This Issue

Page

1	What is Cold Stress?
1	How the Body Responds to Cold Environments
2	Types, Signs/Symptoms and Treatment of Cold Stress
4	Reducing Cold Stress
5	Cold Stress and Mining
6	What's Next?

### What is Cold Stress?

Cold stress is a very serious condition that occurs when the body can no longer maintain a normal temperature. The results can be serious cold-related illnesses and injuries, permanent tissue damage or death. Cold environments are defined as work conditions with low temperatures, high wind speed, humidity, and/or contact with cold water or surfaces. A cold environment forces the body to work harder to maintain its temperature as it draws heat from the body. It is easy to understand that below freezing temperatures combined with inadequate clothing puts you at risk for cold stress. However, it is important to realize that the presence of all four factors that define a cold environment can increase your risk for cold stress. This is why cold stress can be brought about by moderate temperatures combined with some rain and wind. This effect is called wind chill, which is the combined effect of air temperature and wind speed. For example, when the air temperature is 40°F, and the wind speed is 30 mph, your exposed skin receives conditions equivalent to an air temperature of 28°F (See Wind Chill Factor Chart to the left) (1). You are more likely to suffer from cold stress if you have a pre-existing condition, take certain medication, or are in poor physical health.

**Low Temperature + Wind Speed + Wetness = Cold Stress**

### How the Body Responds to Cold Environments

Humans are warm-blooded, which means that the body is able to maintain a relatively constant temperature (97-102°F) regardless of the temperature around us (2). The body begins to exhibit signs of cold related injury and illness if its temperature decreases by as much as a few degrees. So, the maintenance of body temperature is of particular importance, especially while working in cold environments.

The body generates heat in two ways:

- Metabolic Heat -- the body produces heat through the digestion of food and physical activity (shivering), and
- Environmental Heat - the body absorbs heat from the environment.

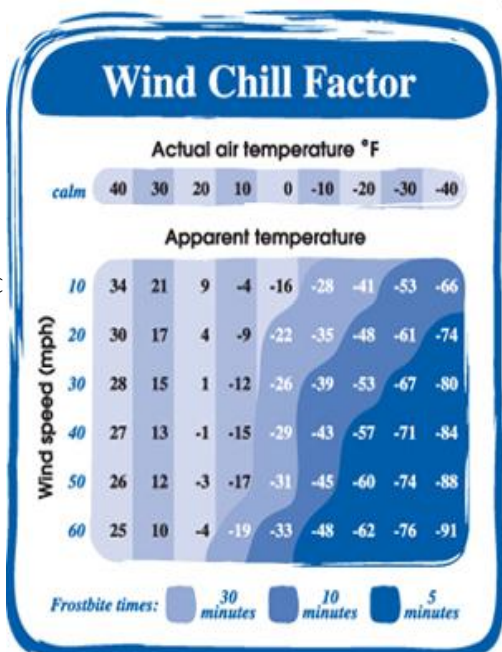


Chart from (1)

## How the Body Responds to Cold Environments Cont.

When in a cold environment, your body cannot absorb heat from the environment and instead will lose heat faster than it can be produced. The three major ways the body loses heat to the cold environment are radiation, convection, and conduction. To a lesser extent, your body also loses heat to the cold environment through evaporation.

- **Radiation** -- Your body continuously radiates heat into the surrounding environment. Factors important in radiant heat loss are the surface area exposed to cold and how great the temperature difference is between your body and its surroundings. Layering clothing that traps heat closer to the body helps reduce this loss.
- **Convection** -- Convection is the loss of heat from the body to the surrounding air as the air moves across the surface of the body. The rate of heat loss from the skin by contact with cold air depends on the air speed and the temperature difference between the skin and the surrounding air. The greater the air speed and the lower the temperature, the greater the loss of heat.
- **Conduction** -- Conduction is the loss of heat through direct contact with a cooler object. Heat loss is greatest if the body is in direct contact with cold water. The body can lose 25 to 30 times more heat when in contact with cold wet objects than in dry conditions or with dry clothing. Generally, conductive heat loss accounts for only 2% of overall loss, but with wet clothes, the loss is increased five times (5).

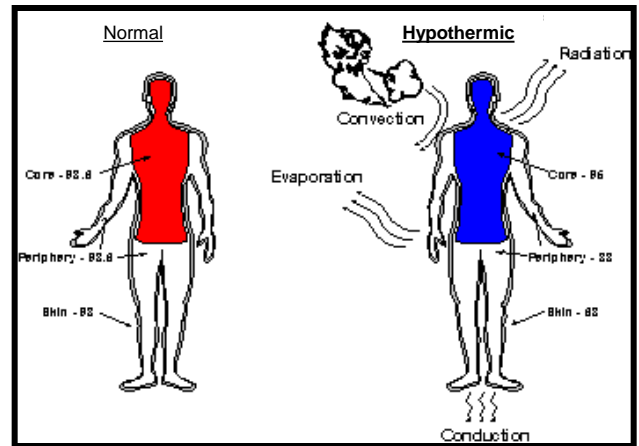


Image from (4)

## Types, Signs/Symptoms and Treatment of Cold Stress

Prolonged exposure to cold environments will eventually use most of your body's stored energy to keep your internal temperature warm. Over time, your body will begin to shift blood flow from your extremities (hands, feet, arms, and legs) and outer skin to the core (chest and abdomen). This allows exposed skin and the extremities to cool rapidly and increases the risk of frostbite and hypothermia. Combine this with cold water, and trench foot may also be a problem (6) (7).

### Grouse Creek Gold Mine BC, Canada



Image from (3)

Humid continental climate with the mean temperature of the coldest month below  $-3^{\circ}\text{C}$  ( $26.6^{\circ}\text{F}$ ) and at least four months with mean temperatures at or above  $10^{\circ}\text{C}$  ( $50^{\circ}\text{F}$ ).

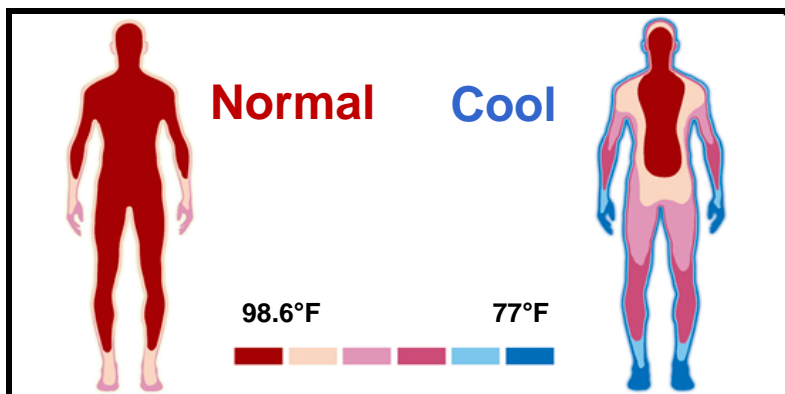


Image and text from (8)

The warm thermogram (left) shows the body at normal temperature of  $37^{\circ}\text{C}$  ( $98.6^{\circ}\text{F}$ ) (red) - the extremities are cooler (peach and pink areas). The cool thermogram (right) illustrates how the body diverts heat to the core organs to aid survival - the extremities are the coldest areas below  $25^{\circ}\text{C}$  ( $77^{\circ}\text{F}$ ) (dark blue).

## Types, Signs/Symptoms and Treatment of Cold Stress Cont.

### Hypothermia

Hypothermia means "low temperature" and is a potentially serious health condition. Hypothermia develops as a result of exposure to cold environments. This occurs when body heat is lost from being in a cold environment faster than it can be replaced. It is not the sudden onset of a condition (6) (7).



Image from (9)

**Remember:**  
Hypothermia develops in cold environments.

Signs/Symptoms	Treatment
<p><b>Mild</b></p> <ul style="list-style-type: none"> <li>•Shivering</li> <li>•Lack of coordination, stumbling, fumbling</li> <li>•Slurred speech</li> <li>•Memory loss</li> <li>•Pale, cold skin</li> </ul>	<p><b>Mild</b></p> <ul style="list-style-type: none"> <li>•Move to warm area</li> <li>•Stay active</li> <li>•Remove wet clothes and replace with dry clothes or blankets, cover the head</li> <li>•Drink warm (not hot) sugary drink</li> </ul>
<p><b>Moderate</b></p> <ul style="list-style-type: none"> <li>•Shivering stops</li> <li>•Unable to walk or stand</li> <li>•Confused and irrational</li> </ul>	<p><b>Moderate</b></p> <p>All of the above, plus:</p> <ul style="list-style-type: none"> <li>•Call 911 for an ambulance</li> <li>•Cover all extremities completely</li> <li>•Place very warm objects, such as hot packs or water bottles on the victim's head, neck, chest and groin</li> </ul>
<p><b>Severe</b></p> <ul style="list-style-type: none"> <li>•Severe muscle stiffness</li> <li>•Very sleepy or unconscious</li> <li>•Ice cold skin</li> <li>•Death</li> </ul>	<p><b>Severe</b></p> <ul style="list-style-type: none"> <li>•<b>Medical Emergency!</b></li> <li>•Call 911 for an ambulance</li> <li>•Treat the victim very gently</li> <li>•Do not attempt to re-warm -- the victim should receive treatment in a hospital</li> </ul>

### Frostbite



Image from (6)

### Frostbite

Frostbite is an injury caused by exposure to severe cold or by contact with extremely cold objects. It occurs when the skin freezes and loses water. In severe cases, amputation of the frostbitten area may be required. Frostbite typically affects the nose, ears, cheeks, chin, fingers or toes (6) (7).

Signs/Symptoms	Treatment
<ul style="list-style-type: none"> <li>•Cold, tingling, stinging or aching feeling in the frostbitten area followed by numbness</li> <li>•Skin color turns red, then purple, then white or very pale</li> <li>•Skin is cold to the touch</li> <li>•Blisters occur in severe cases</li> </ul>	<ul style="list-style-type: none"> <li>•Call 911 for an ambulance</li> <li>•Warm frostbitten area gradually with body heat – DO NOT RUB</li> <li>•Do not thaw hands or feet unless medical aid is distant and there is no chance of refreezing</li> <li>•Apply sterile dressings to blisters to prevent breaking</li> </ul>

## Types, Signs/Symptoms and Treatment of Cold Stress Cont.

### Trench Foot

Trench foot, also known as immersion foot, is an injury of the feet resulting from prolonged exposure to wet and cold conditions. Skin tissue begins to die because of lack of oxygen and nutrients and from the buildup of toxic products (6) (7).

Signs/Symptoms	Treatment
<ul style="list-style-type: none"> <li>•Reddening of the skin</li> <li>•Numbness</li> <li>•Leg cramps</li> <li>•Swelling</li> <li>•Tingling pain</li> <li>•Blisters</li> <li>•Bleeding under the skin</li> <li>•Gangrene (the foot may turn dark purple, blue, or gray)</li> </ul>	<ul style="list-style-type: none"> <li>•Remove shoes/boots and wet socks</li> <li>•Dry feet</li> <li>•Avoid walking on feet, as this may cause tissue damage</li> </ul>

Trench Foot



Image from (10)

### Chilblains

Chilblains are caused by the repeated exposure of skin to temperatures just above freezing to as high as 60 degrees F. The cold exposure causes damage to the capillary beds (groups of small blood vessels) in the skin and is often accompanied by redness and itching. This damage is permanent and redness and itching will return with additional exposure. The areas most affected by chilblains are the cheeks, ears, fingers, and toes (6) (7).

Signs/Symptoms	Treatment
<ul style="list-style-type: none"> <li>•Redness</li> <li>•Itching</li> <li>•Possible blistering</li> <li>•Inflammation</li> <li>•Possible ulceration in severe cases</li> </ul>	<ul style="list-style-type: none"> <li>•Avoid scratching</li> <li>•Slowly warm the skin</li> <li>•Use corticosteroid creams to relieve itching and swelling</li> <li>•Keep blisters and ulcers clean and covered</li> </ul>

Chilblains



Image from (11)

## Reducing Cold Stress

Cold stress occurs when the body temperature cannot be controlled. Exposure to cold environments, however, can be controlled by wearing protective clothing, following safe work practices and utilizing engineering controls. All of these can eliminate or reduce the risk of cold stress.

### Protective Clothing

Wearing the right clothing is the most important way to avoid cold stress. The type of fabric also makes a difference. Cotton loses its insulation value when it becomes wet. Wool, on the other hand, retains its insulation even when wet.



Image from (12)



## Reducing Cold Stress Cont.

### Protective Clothing Recommendations

- Wear *at least three layers* of clothing:
  1. An inner layer to wick moisture away and to allow ventilation.
  2. A middle layer to absorb sweat and provide insulation even when wet.
  3. An outer layer to break the wind and allow some ventilation. If in a wet environment, the outer layer should be water resistant.
- Wear a hat. Up to 40% of body heat can be lost when the head is left exposed (13).
- Wear gloves and insulated boots (ensure boots are water proof if in wet environments).
- Keep a change of dry clothing available in case work clothes become wet.
- Change your socks regularly to ensure they remain dry.
- Do not wear tight clothing. Loose clothing allows better ventilation and does not restrict movement.

### Work Practices

- Fluid Intake -- Drink plenty of liquids, avoiding caffeine and alcohol. It is easy to become dehydrated in cold weather.
- Work Schedule -- If possible, heavy work should be scheduled during the warmer parts of the day and/or alternate indoor and outdoor activities. Take breaks in warm areas.
- Buddy System -- Try to work in pairs to keep an eye on each other and watch for signs of cold stress.

### Engineering Controls

- Radiant heaters may be used to warm workers.
- Shield work areas from drafts or wind.
- Use insulating material on equipment handles, especially metal handles, when temperatures drop below 30° F (13).
- Heated cabs and operator booths may be used to keep workers warm.

### Personal Protective Equipment

- Hand and foot warmers
- Heated footwear



## Cold Stress and Mining

Surface and underground mines can become cold environments due to seasonal weather or geographical location and can put workers at risk of cold stress. In addition, many underground mines are wet by nature, and if the mine is vented with cold outside air, can be very cold. The risk of cold stress on miners can be reduced by controlling exposure to cold environments through protective clothing, work practices and engineering controls. Left unchecked, cold stress can adversely affect performance, leading to serious injury, illness or death.



## Cold Stress and Mining Cont.

Miscellaneous pictures of mines with cold stress conditions.



## What's Next

The next newsletter will discuss the environmental risk factor of altitude. Working at high altitudes can put you at risk for acute altitude sickness if you do not take precautions to acclimate yourself to the new altitude slowly. Altitude sickness occurs because of the lower levels of oxygen and air pressure as you ascend in altitude. Individuals vary in their susceptibility to acute altitude sickness and may develop symptoms at different levels of altitude.

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