IPGA
INTERNATIONAL
POLAR GUIDES ASSOCIATION

# EXTREME COLD MANAGEMENT GUIDELINES

## For guided polar expeditions and trips

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The purpose of these guidelines is to emphasise the necessity for all polar guides to prepare thoroughly for trips into extreme cold environments, including recommended clothing and equipment, usage, modifications and maintenance. The guidelines can be used to recognise, manage and prevent cold-related ailments and mitigate the detrimental effects of extreme cold on an expeditioner.

IPGA recognises that alternative techniques, strategies and equipment exist and that it is the choice of the Polar Guide to adopt those that apply best to their experience, knowledge and circumstances.

These guidelines are the result of an ongoing IPGA charter to document advances and improvements in skills and practices.

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# INTRODUCTION

### What is Extreme Cold?

Extreme cold on a polar expedition can be regarded as a dry-bulb or ambient temperature of -25°C / -13°F or colder. However temperatures of -25°C can be achieved at higher temperatures with the addition of wind know as *wind chill effect*. For example:

-10°C (14F) at 24m/s (48kn) = -25°C
-15°C (5F) at 7m/s (12kn) = -25°C
-20°C (-4F) at 1.5m/s (2.9kn) = -25°C

Wind chill equation

$$13.12 + (.6215 \times T) - (11.37 \times V^{0.16}) + (.3965 \times T \times V^{0.16})$$

The chilling effect can be exacerbated with the introduction of moisture on the skin (evaporative cooling), added either environmentally (rain, humidity) or locally (perspiration, submersion and snow melt).

### Cold-related ailments common on polar expeditions

| CONDITION | MECHANISM | SYMPTOMS | MANAGEMENT | PREVENTION |
|---|---|---|---|---|
| **Cold urticaria** Cold-related inflammation of blood vessels | Short-term exposure of skin to cold | Red, itchy welts on skin that appear within minutes after cold exposure, worsening as the skin warms. May also include swelling of hands. | Antihistamines | Avoid cold air. Antihistamines |
| **Chilblains (Pernio)** Cold-related inflammation of blood vessels | Longer-term exposure of skin to non-freezing cold. Can be caused by tight clothing, poor circulation, high moisture and pre-existing conditions such as Raynaud's and Lupus. | Itching, burning, red patches, swelling and blistering, typically on hands and can occur on feet | A topical corticosteroid (e.g, betamethasone) cream improves non-ulcerated rashes but should not be applied when condition has begun to ulcerate. If ulceration is present, apply a corticosteroid bandage or Granuflex. Proceed with general wound care. No antibiotics are necessary. | Avoid tight clothing. Minimise exposure to cold and keep dry. Slow rewarming. |

| CONDITION | MECHANISM | SYMPTOMS | MANAGEMENT | PREVENTION |
|---|---|---|---|---|
| **Polar Thigh** Polar expedition-related inflammation of blood vessels in the thighs, urticarial in appearance. | Mechanical abrasion of multiple clothing layers from frequent hip extension which stretches clothing covering the thigh, combined with air temperature fluctuations and variations in pockets of air trapped beneath clothing layers. | Red, itchy welts frequently (often urticarial in appearance) seen on the anterior thigh but can also appear on the medial and posterior thigh. | Treatment as per Chillblains | Use of long silk or merino under shorts which prevent mechanical abrasion and improve temperature regulation |
| **Immersion Foot Syndrome (Trench foot)** Numb and discoloured feet | Prolonged exposure of the feet to damp, unsanitary and cold conditions with little opportunity for ventilation | Initially red skin followed by blue skin due to poor blood supply. Many develop to necrosis, blistering, open wounds and fungal infections. | Regular changing of socks, airing and use of talcum powder | Use breathable footwear, avoid vapour barriers, regular changing os socks and use of talc |
| **Frostnip** Superficial nonfreezing cold injury | Caused by constriction of blood vessels (vasoconstriction). Common on extremities, nose and cheeks. | The skin will be pale and may have numbness. Common on exposed skin including the cheeks, ears, and nose. The skin is still pliable. | Warm immediately by covering exposed skin, applying skin to skin contact or applying a warm object (hot water bottle, hand warmer etc) | Cover and insulate vulnerable skin |
| **Frostbite** Formation of ice crystals in the skin or other tissues | Temperatures of -4C or colder can cause frostbite, most commonly on hands, feet and face, causing damage at a cellular level | Of increasing severity - loss of feeling, reddened border, blistering, hardening of skin, blood blisters, blue-grey discolouration, colourless skin, hard texture, painless rewarming | Place casualty in warm environment (tent), rewarming by placing affected part/s in underarm or groin or in warm water.<br>Aloe vera gel.<br>Ibuprofen for pain management.<br>Do not refreeze. | Use polar grade clothing and extreme cold management regime (see below) |
| **Hypothermia** Reduced body core temperature | due to exposure to extreme cold | Of increasing severity - vagueness, shivering, paleness, increasing respiration, confusion, loss of fine motor skills, shivering stops, fixed dilated pupils. May experience Paradoxical Undressing. | If mild, intake of warm fluid and food, add more clothing and increase activity rate.<br>If moderate, stop, pitch tent, place in sleeping bag with warm bottles.<br>If severe, place next to warm person, wrap completely in sleeping bags and add warm bottles. | Use polar grade clothing and extreme cold management regime |

| CONDITION | MECHANISM | SYMPTOMS | MANAGEMENT | PREVENTION |
|---|---|---|---|---|
| **Dehydration.** A significant loss of body fluid with inadequate replacement | Inadequate supply of or difficult access to drinking fluids. Excessive perspiration. Can also manifest through diarrhea, vomiting and increased urination. | Of increasing severity - thirst, dry sticky mouth, minimal urination, dark urine, dry cool skin, headache, muscle cramps, rapid heartbeat and breathing, sunken eyes, confusion, irritability, fainting | Drink plain water and eat soupy meals, contain any vomiting, diarrhoea and perspiration | Use effective thermoses, store thermoses in accessible places (front of sled), drink regularly, eat soupy meals, avoid perspiration, vomiting and diarrhoea |

The following factors will assist in mitigating the detrimental effects of extreme cold:

- Use of high-quality, appropriate and well-maintained fabric, clothing and equipment
- Keep clothing as dry as possible; avoid perspiration, immersion and snow melt on clothing
- Avoid exposed skin
- Minimise wind exposure
- Stay hydrated
- Ensure adequate calorific intake
- Check exposed skin regularly, ask questions
- Carry spare critical clothing items such as mittens, goggles etc
- Minimise fatigue
- Maintain adequate sleep
- Create a warm sleep environment

# 1. CLOTHING

The following clothing and equipment items are the minimum required for exposed travel in extreme cold. Items need to be layered or combined in order to achieve the desired protective effect, particularly as temperature decreases.

### a. Headwear

| ITEM | COMMENT |
|---|---|
| Polar hat | windproof, generous ear protection |
| Liner beanie | can be worn under polar hat |
| Beanie | more breathability |
| Face mask | with adequate breathing holes while minimising skin exposure |
| Neck gaiter | take a spare that can be exchanged if it becomes too icy |
| Fur ruff | attached to shell hood |
| Sunglasses | UV-rated, minimal exposure, adequate ventilation to avoid icing |
| Goggles | UV-rated, adequate ventilation to avoid icing |
| OPTIONAL | |
| Balaclava | with adequate breathing holes |

Considerations:

- windproofing and skin coverage are increasingly important with increase in wind
- add nose guard to goggles and sunglasses to redirect breath away from eyewear
- facial protection often attached to bottom of goggles
- adequate ventilation reduces perspiration and icing
- items must be able to mesh together to create a barrier impervious to wind
- apply surgical tape to areas of exposed skin not covered by headwear
- use stick moisturiser to keep skin pliant (not cream in tube as it will freeze)

Avoid:

- cotton
- unlined neoprene
- non-UV blocking lenses
- breathing on eyewear when donning
- wearing goggles during breaks
- overdressing - results in excessive icicles on face-wear

### b. Handwear

| ITEM | COMMENT |
|---|---|
| Outer mitten | windproof, with long gauntlet |
| Inner mitten | wool or synthetic with adequate loft |
| Liner mitten | wool or synthetic |
| Liner glove | synthetic, for stove handling in tent |
| OPTIONAL | |
| Pogies | insulated hand covers worn on ski pole handles |
| Ski gloves | for those with good circulation, wool or synthetic liner, modular for drying |

Considerations:

- modularity (mitten layers must be detachable to assist in moisture reduction and drying)
- thumb loops on sleeves, wristlets or arm-warmer sleeves assist in increasing warmth
- prevent removal of outer handwear if hands are persistently cold
- use of chemical hand warmers if hands are persistently cold
- be judicious in use of pogies, may not be suited to some people and in circumstances where hands are required often (pressure ridges, crevasse fields etc.)

Avoid

- cotton
- moisture on fingers
- tight-fitting handwear
- use of glove liners, which prohibit finger warming through skin-to-skin contact
- vapour-barrier liner gloves
- overdressing - results in damp hands

Techniques for warming cold hands:

- windmilling arms
- shaking arms downward
- use of chemical hand warmers

### c. Footwear

| ITEM | COMMENT |
|---|---|
| Outer boots | flexible-soled, polar-rated boots, above-ankle gaiter |
| Removable liner | wool, felt, synthetic fill or foam |
| Foot bed | insulated |
| Liner sock | thin, fine weave |
| Warm sock | 2 minimum, wool or synthetic |
| Vapour-barrier sock | or impervious foam liner, for Arctic Ocean or winter/spring conditions |

Considerations

- modularity (boot layers must be detachable to assist with moisture reduction and drying)
- choose a boot size one or two sizes larger than usual, depending on make and model
- try Intuition liners for form-fitting, reduces likelihood of blistering
- warm the liners in sleeping bag or over stove before donning
- use of chemical foot warmers if persistently cold feet
- use protective tape to mitigate blisters
- keep toenails short
- be judicious in use of vapour barrier liners, not usually required on short trips (1-5 days) or on expeditions that benefit from solar warming

Avoid

- cotton socks
- tight-fitting footwear

Techniques for warming cold feet:

- create more space in boot
- additional foot bed
- use of chemical foot warmers

### d. Bodywear

| ITEM | COMMENT |
|---|---|
| Base top layer | 2 minimum, wool, synthetic |
| Mid top layer | 2 minimum, wool, fleece |
| Windproof shell jacket | with generous hood, storm collar and pit zips for ventilation, unlined |
| Puffer vest or jacket | fit over previous layers, down or synthetic |
| Insulated outer jacket | with hood, down |
| Base bottom layer | 2 minimum, wool, synthetic |
| Mid bottom layer | 2 minimum, wool, fleece |
| Shell overpants | windproof, full-length side zippers and/or zippered drop-seat, unlined |
| Insulated skirt, shorts or trousers | minimum knee length, to fit over previous layers, full-length side sipper/s, down or synthetic |

Considerations

- extensions on zip sliders to accommodate limited dexterity
- bib/brace on shell overpants to minimise exposure of waist
- thumb loops on base and/or fleece layer sleeves
- pockets located in convenient areas unhindered by sled harness
- fleece or windproof layer sewn to front of underpants, particularly for males
- add knee insulation to shell overpants
- minimise tape sealing on shell seams

Avoid

- cotton
- waterproof zippers
- 3-layer Gore-Tex
- mesh- or fleece-lined shells
- tight fitting clothing
- overdressing - results in excessive frost on outer clothing

## 2. REST AND SLEEP SYSTEMS

### a. For trips that benefit from solar tent warming

| ITEM | COMMENT |
|---|---|
| Inflatable mattress | combined 5+ R-Value |
| Foam mattress | |
| Sleeping bag | down, -40 rated |
| Sleeping bag liner | silk or fleece |
| Tent boots | down or synthetic, non-slip sole, with effective cinch to prevent slipping off |
| Tent socks | thick |
| Hot water bottle | Nalgene bottle filled with boiled water |
| Camp seat | assists in recovery |

Considerations

- thin foam tent footprint for added insulation
- a dark tent to minimise brightness (facilitate rest)

### b. For trips that do not benefit from solar tent warming

| ITEM | COMMENT |
|---|---|
| Inflatable mattress | combined 5+ R-Value |
| Foam mattress | |
| Sleeping bag | synthetic or combined down/synthetic, -40 rated |
| Sleeping bag liner | silk or fleece |
| Vapour barrier liner | For expeditions longer than approximately 10 days |
| Tent boots | synthetic, non-slip sole, with effective cinch to prevent slipping off |
| Tent socks | thick wool or synthetic |
| Camp seat | assists in recovery |

Considerations

- thin foam tent footprint for added insulation

## 3. STOVE FUEL ALLOCATION

Different environments and expeditions have different stove fuel requirements depending on available sun for tent-warming. An expedition that does not benefit from solar tent-warming generally requires more fuel to cater for clothing drying, hot water bottles and tent-warming.

The following allocations pertain to fuel usage of a properly functioning MSR XGK EX stove assuming vigilant snow melting and water heating of 6 litres per person per day.

MSR state that, under optimum conditions, their XGK-EX stove will boil 1.5 litres of water per 29.6 millilitres of fuel, which equates to:

1 litre of boiled water per approximately 20 millilitres of fuel
6 litres of boiled water per approximately 120 millilitres of fuel

1 litre = 10 decilitre = 1000 millilitre

### a. For trips that benefit from solar tent warming

| VOLUME (ml) per person per day | COMMENT |
|---|---|
| 180 | requires extremely frugal usage and zero spillage |
| 200 | recommended minimum, not including reserve |
| 250 | recommended maximum |

### b. For trips that do not benefit from solar tent warming

Such trips usually require more stove fuel for clothes drying, hot water bottles and tent warming

| VOLUME (ml) per person per day | COMMENT |
|---|---|
| 250 | requires extremely frugal usage with zero spillage |
| 300 | recommended minimum, not including reserve |
| 450 | recommended maximum |

Methods of increasing stove efficiency / reducing fuel consumption

- keep the stove in optimum working condition
- use a heat exchanger or reflector to conserve your stove's thermal output
- ensure an adequate oxygen supply to the flame
- do not melt snow without some liquid in the pot
- have everything prepared once the water has reached the desired temperature - open thermoses, meal pouches open etc

- reserve bringing water to the boil only for reconstituting meals and for hot water bottles
- consider closing the fuel control valve each time you take the pot off the stove
- firm fitting lids on pots and kettles
- pots with a dark and wide base are more efficient
- being vigilant

## 4. ENERGY AND HYDRATION

In order to combat extreme cold an expeditioner must be adequately fed and hydrated. The following figures are based on 12 hours of outside exposure, 8 hours of movement and 20km of distance on good terrain with an 80kg sled traveling at an average speed of 2.5km/h.

### a. Daily energy intake

1 kilocalorie (kcal) = 1 Calorie (Cal) = 4184 Joules (J) = 4.184 Kilojoule (kJ)

| DURATION (days) | DAILY ENERGY REQUIREMENT (kcal) |
|---|---|
| up to 5 | 3500 to 5500 |
| 5 to 14 | 4000 to 6000 |
| more than 14 | 4500 to 6500 |
| For expeditions consistently on convoluted terrain requiring greater workload eg. Arctic Ocean | |
| more than 14 | 5500 to 7500 |

Considerations

- Based on the 1986 findings of polar adventurer and physician Dr Mike Stroud, baseline recommendations of energy intake per kg of body weight is as follows:
  - 2 grams of protein per kg
  - 4 grams of fat per kg
  - 6 grams of carbohydrate per kg
  - 65 calories per kg
- Protein:Fat:Carboydrate ratio and actual energy amount required will vary from person to person based on their sled weight compared to other team members, terrain, efficiency of movement, fluid intake/loss, resilience to cold, metabolism and gender.
- Intake is often increased to higher amounts during a long journey
- Cater food that is easy to manage and consume

Signs of low energy

- heightened sensitivity to cold
- lethargy
- lack of motivation
- constipation/dry stools
- irritability
- shakiness and sweating related to low blood glucose (hypoglycaemia)

### b. Daily fluid intake

Including consumption of all liquids throughout the day - water, sports drinks, tea and coffee, soup, meals

1 litre (L) = 0.264 US Gallon = 0.219 Imperial Gallon = 1.05 US Quart

| VOLUME (L) per person per day | COMMENT |
|---|---|
| minimum 3 | poor hydration or dehydration may lead to poor performance or evacuation |
| maximum 6 | over-hydrating with inadequate sodium levels in the body can cause Hyponatremia |

Considerations

- every liquid intake - water, sports drinks, tea and coffee, rehydrated meals - contributes to hydration
- take in fluid every time you eat
- bottles/thermoses that are easy to use with limited dexterity promote fluid intake

Avoid

- perspiring
- long breaks between drinking
- eating without drinking
- poor-functioning thermal flasks
- spillage

Signs of poor hydration

- thirst
- dry mouth
- little or no urine
- dark urine (the lighter/clearer your urine, the more hydrated you are. Sports drinks rich in vitamin B will mask urine colour)
- headache
- constipation/dry stools

Signs of Hyponatremia (low sodium concentration in blood)

- decreased ability to think and concentrate
- lethargy
- loss of appetite
- nausea
- vomiting

### c. Daily schedule

An expeditioner should eat and/or hydrate every 60 to 90 minutes.

## 5. RECOVERY

A well-rested expeditioner is better able to combat the debilitating effects of prolonged exposure to extreme cold.

### a. Sleep

Adequate sleep on a polar expedition is imperative for optimum functionality, daily consistency, happiness and general well-being.

The average person requires 8 hours of sleep per day, give or take an hour.

Sleep deprivation can cause numerous short term physical and mental conditions including memory issues, mood changes, poor concentration, high blood pressure, as well as long-term conditions such as weakened immunity, poor balance and increase risk of heart disease. These can all lead to either the body's inability to cope with extreme cold or the increased risk of poor decision-making leading to cold injury.

### b. Circadian rhythms

A circadian rhythm, also know as sleep/wake cycle, is a roughly 24-hour cycle that is running in the background of your brain and cycles between sleepiness and alertness at regular intervals.

Darkness (which sends a signal to your brain that it's time to sleep) seems to play the largest role in setting your circadian 'clock', which in turn contributes to good sleep.

As most polar expeditions are conducted during 24-hour daylight, it is important to negate the effects of over-exposure to light on the eyes.

Considerations

- every person is different but the provision of 8 hours sleep per night will cater for most people
- use eye shades and/or a dark tent if exposed to 24-hour daylight
- use ear plugs if not in an environment where hearing external sounds is important (ice cracking, polar bears etc)
- for international travellers, allow jet lag to pass before starting an expedition

Avoid

- over-exposure of light on the eyes
- caffeine after lunch (it promotes alertness and effects can last up to 7 hours after intake)
- stimulation and blue light from devices before sleep
- big meal just before sleep
- dehydration
- inadequate sleeping bag and mattress

### c. Rest breaks

Regular short rest breaks with associated recovery and intake of fluid and calories are important in mitigating the effects of extreme cold.

Allowing approximately 5 minutes rest per hour with additional time allocated to lunch encourages recovery.

In order to minimise break times it is recommended to standardise the following practices amongst team members:

- ski/break durations and schedule
- prior preparation of food eg, unwrapped bars, pre-mixed drinks etc
- quick access to food and fluid
- whether team members remove skis
- which break constitutes lunch

## 6. MONITORING

### a. Guide vigilance

A guide must take responsibility for all aspects of team management, including active monitoring of all team members' ability to tolerate extreme cold.

Regular checking of team members' condition and behaviours is paramount to mitigating injury:

| CHECK | SIGN / REMEDY |
|---|---|
| facial skin colour and condition | frost injury, discolouration |
| extremities | behaviour, ask questions, check extremities in tent |
| ice build-up from perspiration | over-dressing |
| consumption of allocated food and fluid | watch, ask questions |
| eating and drinking regularly | monitoring intake during breaks |
| adequate rest and sleep | ask questions, monitor energy levels and cold tolerance |
| cold lethargy | quiet, hunched over, unable to use hands during breaks |
| cold agitation | moving too fast in an attempt to generate heat |
| correct use of clothing and equipment | correct venting, layering etc |
| condition of clothing and equipment | effect repairs and modifications quickly but effectively |